The Emergence and Development of Ergonomics Capability: Case Studies of Innovation in Product Design and Development

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CAROLINE SLAPPENDEL

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Abstract

The aim of this study was to examine how and why ergonomics capability emerges and develops within organisations. This study suggests that these changes in capability can be interpreted as involving complex innovation processes which are shaped by a combination of forces both internal and external to an organisation. This perspective differs from that adopted in earlier research which has focused on the general problem of ergonomics knowledge utilisation in organisational settings.

A case study approach was used to conduct the research. The case study design consisted of six organisations (three pairs) operating from a manufacturing base in New Zealand. Each organisation pair operated in one of the following product-markets: petrol pumps, electric ranges and office seating. Data were collected from in-depth interviews, documents, archival sources and through observation. The case analysis focused primarily on ergonomics capability in relation to product design and development.

This study supports the need for a more dynamic conceptualisation of ergonomics knowledge use - one which recognises that as knowledge is used within an organisation, knowledge is also created. Accordingly, the analysis focused on those processes associated with the *emergence* and *development* of in-house ergonomics capability. The interpretation of these processes was informed by theories and concepts relating to organisational learning and innovation. The analysis also revealed that the emergence and development of ergonomics capability was encouraged and constrained by a range of contextual factors which included top management goals, product strategy, organisation structure and resources. Furthermore, government policy was found to be a dominant external force through its diffuse and indirect impact on the knowledge environment and industry structure.

The case analysis culminates in the presentation of a general framework for understanding the emergence and development of ergonomics capability in product development. While ergonomics capability is a core concept in the model, four other major elements are identified. These are staffing routines, top management orientation, organisational configuration and history, and the external environment. Twelve propositions are presented and various implications are drawn for ergonomic practice as well as for innovation theory.

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Table of contents

Abstract		ii
Acknowledgements		iii
Introduction		1
Chapter One	**The utilisation of ergonomics knowledge within organisations**	4
	Introduction	4
	Individual factors influencing utilisation	5
	Organisational factors influencing utilisation	8
	Innovation in organisations	14
	Perceived newness	16
	Innovation as object, practice and idea	18
	The innovation process	21
	Summary	23
Chapter Two	**Perspectives on innovation in organisations**	25
	Introduction	25
	Perspectives on action as an overview framework	25
	The individualist perspective	29
	The structuralist perspective	36
	Conceptual issues in research characterised by the dominant perspectives	47
	The interactive process perspective	51
	Summary	58
Chapter Three	**Research design and methods**	60
	Introduction	60
	Research questions	60
	Research strategy	62
	Negotiating access	66
	Data collection methods	68
	Data analysis and presentation	73
	Summary	75

Chapter Four **Ergonomics capability in six manufacturing organisations** 77

Introduction 77
PEC 77
Fuelquip 81
RDD 85
Atlas 91
Formway 94
Feltex Furniture 98

Chapter Five **The emergence and development of ergonomics capability: Innovation and learning** 104

Introduction 104
Ergonomics capability 105
Capability emergence: A new recruitment routine 107
Capability development: The continued employment of industrial designers 112
Learning about the ergonomics domain 122
Learning about ergonomic design 130
The transference of ergonomics capability 139
Summary 143

Chapter Six **The organisational context of ergonomics capability** 145

Introduction 145
Social control and managerial support 146
Organisation structure and integration 151
The goals and aspirations of top management 157
Organisational history and product strategy 167
Discontinuity in product strategy: Change of ownership 173
Strategic diversions: Managerial attention and financial resources 174
Summary 177

Chapter Seven **Ergonomics capability and the knowledge environment** 179

Introduction 179
The external environment 180
Import control and technological dependence 186
Trade policy liberalisation 191
Export promotion 197
R&D expenditure and encouragement 198
Education for industry and the training of industrial designers 202
The New Zealand Industrial Design Council 209
The impact of standards 214
Professional networks 217
Summary 221

Chapter Eight **Conclusion** 223

Introduction 223
A study of process and context 224
Ergonomics capability in product design and development: A process framework 225
Implications for innovation theory and ergonomic practice 236
Managerial implications 239

Bibliography 245

List of tables

3.1	Case names of six organisations from three product-markets	65
7.1	Commodity composition of New Zealand's exports and imports, 1967-1990	187
7.2	Full-time equivalent (FTE) business enterprise R&D personnel per thousand labour force, 1989	199

List of figures

1.1	The organisational context of human factors	9
2.1	Perspectives on action in organisation theory	27
2.2	An overview framework based on three perspectives on action	29
2.3	Structural variables affecting the initiation and implementation of innovations	45
5.1	The collection of interrelated routines which support the development of ergonomics capability	121
7.1	The external environment associated with changes in a firm's ergonomics capability	180
8.1	Ergonomics capability in product design and development: A process framework	226
8.2	Four stages in the emergence and development of ergonomics capability	240

Introduction

Advocates of specific knowledge bases and disciplinary perspectives will usually be actively concerned to see that these ideas are accepted and used in some way by others. The extent to which advocates will be successful in their change efforts will vary, however, and where levels of acceptance and usage are perceived to be relatively low, this may lead to a search for an improved understanding of the main factors influencing this situation. This search may result in descriptive accounts which can, in turn, provide a basis for normative theories to guide attempts to increase the use of specialist knowledge.

This general concern for knowledge use is evident among groups which advocate the application of ergonomics (and human factors) in organisational settings. These groups include professional ergonomists and human factors engineers, as well as various other professional groups such as occupational health nurses, occupational physiotherapists, industrial engineers, and industrial designers. While individuals from these groups may express their misgivings about the extent to which ergonomics knowledge is applied in practice, the problem has, over the years, also been the focus of research. However, while some excellent studies on this topic have emerged, few have used concepts drawn from the field of organisation studies and/or locate the problem in a broader organisational and environmental context. Similarly, few studies have examined the problem from a historical dimension. Having identified these lacunae, this study proposes that the use of ergonomics knowledge can be understood as a dynamic *process of innovation* which is shaped by a

combination of forces both internal and external to an organisation. This argument is developed in the eight chapters which follow.

Chapters 1 and 2 provide the theoretical and methodological background to the empirical study which is introduced in Chapter 3. Chapter 1 reviews key research studies which have focused on factors which influence the utilisation of ergonomics knowledge. In particular, a contrast is made between those studies which have dealt with organisational factors and those which have focused primarily on variables relating to individuals. While this literature provides a base upon which to build further research on the use of ergonomics knowledge, this study differs from earlier work in that its general sense of direction was informed by concepts drawn from the innovation literature. As a variety of meanings have been assigned to the term 'innovation', Chapter 1 will discuss this concept in some detail.

Chapter 2 builds on the discussion of innovation definitions by presenting an overview of the research literature on innovation in organisations. This overview is organised so as to reflect three main theoretical perspectives which are represented in this body of literature. These perspectives stem from differing assumptions in relation to human behaviour and the ontological status of organisations and are referred to in this study respectively as the individualist perspective, the structuralist perspective and the interactive process perspective. This delineation of perspectives serves in particular to highlight the close linkage between theoretical perspectives on the one hand and methodological considerations on the other. Consequently, the issues discussed in Chapter 2 lay a foundation for the research design and procedures that were adopted in the fieldwork.

Chapter 3 starts by outlining the research questions which were to guide the empirical investigation and then proceeds to identify the research strategy and methods used. Given the focus of the study on processes and contexts, the comparative case study method was considered to be an appropriate strategy. Various decision criteria guided the case study design and the selection of cases. In particular, it was decided to focus the study primarily, but not exclusively, on ergonomics in relation to product development. In all, three pairs of organisations were selected with each pair operating in one of the following product-markets: electric ranges, petrol pumps and office seating. The comparative analysis of the case study evidence obtained from interview,

observation, and documentary sources, commences in Chapter 4 with an introduction to the six cases. For each case, a brief descriptive chronology is provided of key events surrounding the emergence and development of ergonomics capability.

Chapter 5 operationalises the concept of ergonomics capability which, it is argued, more fully encompasses the complex changes observed in the six cases than does a term such as 'knowledge use'. In this study, ergonomics capability is not only used to refer to knowledge consumption but it also takes into account the processes of knowledge creation and learning which may take place within an organisation. With this in mind, Chapter 5 then proceeds to identify and interpret patterns in the emergence and development of ergonomics capability across the six cases. Throughout the analysis, the perspective adopted is that organisational action is neither solely determined by structural factors nor by the highly rational choices of managers and designers, rather attention is given to how these influences may interrelate. Furthermore, it is assumed that action is guided by routines as well as by goals.

While Chapter 5 interprets the emergence and development of ergonomics capability as a process of innovation and learning, Chapters 6 and 7 place these changes within their broader contexts. Chapter 6 examines the organisational context and highlights the role of top management goals and product strategy. Chapter 7 then extends the contextual analysis by focusing on environmental factors. In this chapter, government policy emerges as a dominant force through its impact on the knowledge environment and industry structure.

Finally, Chapter 8 presents the conclusions to this study. This chapter pulls together the key findings into a model which explains the emergence and development of ergonomics capability in product design and development. This chapter also comments on the implications of this study for the practice of ergonomics as well as for innovation theory.

Chapter One

The Utilisation Of Ergonomics Knowledge Within Organisations

Introduction

Ergonomists and human factors engineers have occasionally questioned why knowledge from their discipline has not been more widely applied (see Liker *et al.*, 1984; Simpson, 1985). In order to address their concern, ergonomists and human factors engineers have produced a small body of literature consisting of descriptive and experimental studies. These studies have identified a variety of factors which can inhibit or facilitate the use of ergonomics knowledge in the design process. These factors can be grouped into two general categories: there are those that relate to the attributes of individuals, and there are those factors that relate to the wider organisation.

This chapter will initially identify the individual factors so as to prepare the ground for a discussion of organisational issues. In making the transition from the individual level to the organisational, the chapter will highlight the views of Perrow (1983) who has suggested that more attention ought to be given to understanding the organisational context in which ergonomics knowledge is used. Taking this line of argument further, the chapter proceeds to identify what appears to be a novel and valid theoretical anchor for further research efforts. This anchor rests in the concept of innovation. However, as a variety of meanings have been assigned to the term 'innovation', this concept will be discussed at some length in the final sections of the chapter.

Individual factors influencing utilisation

When considering individual factors and how they influence the use of ergonomics informational inputs, the 'individual' of interest must be clearly defined. The need for clarification arises because the design of a product or system rarely involves a single person. There may be many individuals making inputs to the design process including customers, specialists, and design managers. On the other hand, there is usually an engineer who is responsible for specific components of the design. This individual often has to trade off various inputs against one another until a decision is made about the final configuration. Where these inputs can include human factors information, the behaviour of this person is critical.

The above description is still too broad in that it may encompass electronics engineers and mechanical engineers whose decisions rarely affect the external configuration of a system or product. Instead, our concern lies with those engineers whose decisions directly shape the way in which the end-user will interface with the system or product. Thus, we are interested in those 'design engineers' who translate design requirements into drawings of physical equipment configurations. For this reason, this definition does not include draughtspersons (who work on aspects of detailed design under instruction), or design managers (who have overall responsibility for the configuration but who may not do any drawing as such).

Design engineers, as defined above, occupy a pivotal role in the design process. The final design will often be shaped by the decision-making processes of these professionals who are influenced, in turn, by their propensity to use particular information inputs. For a variety of reasons, a design engineer may choose to use (or alternately ignore) the information contained in reference books, or the advice conveyed through verbal contacts with other designers or specialists.

For the human factors specialist, the relationship with the design engineer (subsequently also referred to as the 'designer') is problematic. As a result, 'much has been written' (Meister, 1971: 240) about the need to improve the *communication* between the two professional groups. According to Meister, this explanation of the problem has led to rather simplistic recommendations being put forward including the one which argues that human factors specialists should learn to communicate their inputs to the design engineer in the latter's language.

However, while such recommendations may have stemmed from 'deep hidden suspicions as to the effectiveness of communication between the two disciplines', Meister and Farr (1967: 71) were more concerned that 'almost nothing is known about how designers use human factors information (or, for that matter, other specialty information, such as reliability and maintainability)'. It was this gap in understanding that led Meister, in collaboration with several colleagues, to undertake a series of experimental studies (Meister and Farr, 1966; 1967; Meister and Sullivan, 1967; Meister 1971). These studies will be described in some detail as they represent the earliest comprehensive attempt to understand the characteristics of design engineers, their attitudes to human factors engineering, and their approach to the design process.

Using an experimental format, Meister and Farr (1967) asked a sample of ten design engineers to individually perform three separate tests consisting of realistic design problems. In two of the tests, the designers were required to draw an equipment configuration demanded by the design specifications that they had been provided with. As they worked on the test, their behaviour was observed. In the third test, the designers were required to respond verbally to a variety of design and attitudinal situations. This test revealed information about the design process, the use of human factors inputs, and designer attitudes towards human factors engineering. With respect to the behaviour of their designer subjects, Meister and Farr (1967) were able to make several conclusions. Firstly, the degree of design analysis performed by the designers was minimal; almost immediately after examining the problem, they started to design hardware without performing much deliberate, systematic analysis. Secondly, the designers tended to rely on design solutions which they had used in the past. This reliance on experience actually prevented the designer from considering novel approaches. Thirdly, the main source of information used by the designers was the design specification; even where other sources of information were available the designer was much less likely to use them. Fourth, the designers preferred to design with a minimum of advice and/or constraint by others, including the customer. Lastly, the designers had little or no interest either in human factors information, or in the incorporation of human factors criteria in their designs.

According to Meister and Farr (1967), the designer cannot be blamed entirely for not using human factors inputs: some fault also lies with the human factors

specialist. Human factors information is often presented too late and even then it may be irrelevant or it may be presented in an inappropriate format. Thus, even if designers were to make a concerted attempt to apply information from handbooks, a proportion of the required information would be relatively unavailable to them.

While these situations are unfortunate, there is still a considerable amount of human factors information that is applicable and relatively easy to apply. Given this, Meister and Farr (1967: 86) argue that designers could be encouraged to use this information through the design specification. This document proved to be the main information source used by designers and Meister and Farr suggest that human factors specialists should participate in the writing of more detailed design specifications that, in particular, clearly describe the human factors analyses that should be performed.

In 1979 - more than a decade after his experimental studies - Meister (1982b) took the opportunity, while surveying human factors specialists about the effect of government policies on their work, to ask questions about the relationship between the designer and the human factors engineer. 76 percent of the sample agreed that designers do not solicit human factors engineering assistance. Respondents suggested a number of reasons for this including the designer's wish to function with complete autonomy, the prevalent view that human factors requirements were merely additional constraints, and the poor reputation of human factors groups. Human factors engineers may also have difficulty communicating their ideas to designers. Slightly more than half (57%) of the human factors specialists surveyed felt that there was still considerable resistance on the part of designers to the inclusion of human factors inputs in design. An important reason cited by 72 percent of the respondents was that engineers may find human factors inputs to design to be insufficiently precise and quantitative. Furthermore, unless the human factors data is translated by human factors engineers into specific design terms the input is merely seen as an additional burden.

The survey results, however, had a positive side. Three of the four respondents felt that, over the years, design engineers have shown an increasing appreciation of human factors. This was given further confirmation in a second survey conducted by Meister (1982b) in which 90 percent of the respondents considered that engineering/public awareness of human factors was generally increasing.

In his attitudinal studies of designers and human factors engineers, Meister has consistently adopted the position that a better understanding of how the designer actually designs is needed. More recently, Meister (1987) has reiterated this concern: he argues that an understanding of the cognitive basis of design is a prerequisite for the development of new methods of communication with the designer. New techniques such as support aids and computerised information systems will only be effective if they match the designer's design processes. However, 'empirical data describing how the engineer designs are sparse' (Meister, 1987: 230) and the literature tends to be dominated by prescriptive models of the design process. Given that 'design is a major area of concern for human factors', Meister (1987: 243) finds this situation 'extraordinary'.

Organisational factors influencing utilisation

Meister's research, with its focus on designer characteristics and cognitive theories of design, contrasts with the analysis provided by Charles Perrow in his 1983 article, titled 'The Organizational Context of Human Factors Engineering' and published in *Administrative Science Quarterly*. In the third edition of his classic text *Complex organizations: A critical essay*, Perrow (1986: 146) writes that this article was 'casually begun as a short background paper for the presidential commission investigating the accident at the Three Mile Island nuclear power plant'. In the article, which takes the form of an essay, Perrow acknowledges that human factors engineers lack influence in most military and many industrial organisations, and that, in particular, they have a great deal of trouble influencing design engineers. However, from his own position as an organisational analyst, Perrow (1983: 524) then argues that designer behaviour can only be considered a 'proximate explanation' for the neglect of human factors in the design process. This 'downgrading' of the significance of designer variables is expressed as follows (Perrow, 1983: 524):

> An organizational analyst would place little value on explanations that design engineers ignore or neglect HFs [Human Factors] because they are unaware of them, are contemptuous of them, do not want to be bothered with them, or are somehow or other incapable of appreciating them.

Rather that focus on designers and their characteristics, an organisational analyst would look to the 'organisational context' for insight. According to Perrow (1983: 523), the organisational context of human factors should

> include not only the limited sequence of the HFE influencing the design engineer, which in turn influences the equipment the operator uses, but how all of these are influenced by the social structure of the organization and influence it in turn.

Figure 1.1 presents this web of influences in diagrammatic form. Arrows 4, 1, and 2 respectively indicate the influence of the social system on the operator, the design engineer, and the human factors engineer. For each of these arrows there is an opposite effect which can be interpreted as the creation and reproduction of the social structure by the actions of human factors engineers, operators, and design engineers.

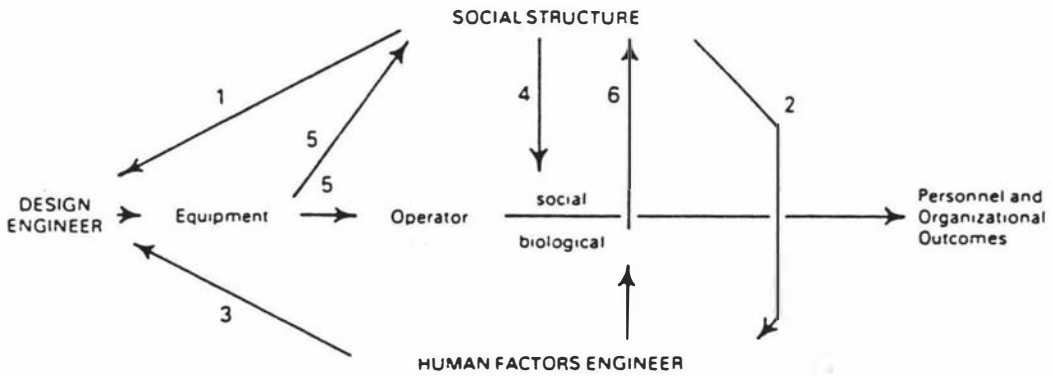

Figure 1.1 The organisational context of human factors
(Source: Perrow, 1983: 524)

Perrow (1983: 523) is of the view that the influence of the social structure on the design engineer (indicated by arrow 1 in Figure 1.1) 'is most pertinent to the question of why ... the principles of human factors engineering are so neglected'. Given the significance of this relationship, attention should be directed towards identifying which aspects of the social structure have significant impact. These aspects may include (Perrow, 1983: 523-524)

> top management goals and perspectives, the reward structure of the organization, insulation of design engineers from the consequences of their decision, and some aspects of organizational culture.

The potential influence of management should, in particular, not be underestimated (Perrow, 1983: 524):

> Top management can, if it wishes, inform designers of the existence of information about the principles of HF engineering, can require that these principles be utilized, and can structure the reward system so that it encourages designers to take these principles into account.

In some organisations, however, top managers may not feel a need to promote human factors (or ergonomics). Perrow suggests that this may be particularly the case where managers are unaware of the consequences of poor design and the costs that have to be borne by end-users on a daily basis in the form of frustration, excessive fatigue, or disability. The complaints of end-users in regard of these costs may, for various reasons, not be heard. For example, due to impaired organisational communication, top management might only hear of complaints faintly or not until after the next project has commenced. This situation, in turn, tends to reinforce the position of engineers in a part of the organisation where they are almost entirely insulated from the consequences, or externalities, of their decisions.

Even where management is aware that their products are lacking as far as human factors are concerned, they may still judge the cost of poor design to the organisation and their careers to be relatively low. To illustrate this point Perrow (1983: 525) compares two transport systems: air and marine. On the one hand, in air transport systems, managers will find it hard to ignore human factors considerations. This is because failures generally receive extensive media coverage and the determination of causes has legal and insurance consequences.

By contrast, managers in the marine transport system may find it easy, and even profitable, to ignore human factors. Marine transport is characterised by weak regulatory agencies, weak unions and deficiencies in accident investigation. According to Perrow (1983), economic losses are absorbed with little notice and passed on to the final consumer, while human losses are restricted to the officers and the crew.

In addition to top management goals and perspectives, other organisational aspects that may impact on the influence of human factors engineering include the small size of the human factors group, lack of resources, and the tendency for human factors engineers to be perceived as 'defenders of operators'. The latter perception exists because human factors engineers often attribute the causes of an operator's performance failures to deficiencies in the design of the equipment or the system. This view tends to be at odds with the social structure which prefers to attribute failures to operator error, and not to designer errors or management errors. According to Perrow (1983: 530) the 'concern of HFEs with operators ... may result in top management and designers associating them with error-prone operators and discounting their recommendations'.

Although Perrow alerts human factors engineers to the ways in which the organisational setting can limit their influence, it can be demonstrated that before the appearance of his 1983 article organisational factors had already been signalled in the ergonomics literature. For instance, Shackel (1980) observed that 'the structural situation' may have greater influence on the application of ergonomics than other factors such as the presentation of data for designers in usable form. The structural situation is characterised by six factors including the extent of human involvement regarding the type of product, the size of organisation, and legislation. Kvalseth (1980) on the other hand, asked subjects to rank the relative importance of a list of factors, both internal and external to the organisation, which could influence the use of ergonomics in workplace design. Also, Meister (1982a; 1982b; 1982c) has commented that supportive management, the availability of funding, and the weight given to human factors by the customer (often the government) may influence the scope and manner of human factors involvement in military systems design. Furthermore, in *Human factors: Theory and practice*, Meister (1971) dedicates an entire chapter to a description and evaluation of structural alternatives for human factors groups in large organisations.

Both Shackel and Meister openly state that their observations are based largely on personal experience. Thus Shackel (1980: 817) emphasises that there is 'no substantive evidence' to prove his suggestions which are based on 'subjective appraisal of past and present experience', while Meister (1971: 310) admits that the assumptions which underlie his recommendations relating to the structure of human factors groups are based 'both on logic and experience'. Whereas a reliance on experience should not be a reason to discount the value of the insights put forward by these authors, their contributions are nevertheless weakened by a lack of explicit reference to theoretical frameworks or perspectives which have been used to understand similar problems, particularly in the field of organisation studies.

The failure of researchers to relate their understanding of factors influencing ergonomics knowledge to organisation theory may be explained by their disciplinary backgrounds. For example, the work of Meister and Shackel has tended to be informed by the academic disciplines of cognitive psychology and ergonomics. These backgrounds contrast with that of Perrow who, from his position as an *organisational analyst*, has been able to bring his understanding of organisation theory to bear on the analysis of factors influencing the design of large complex systems. It is Perrow's emphasis on *organisation theory* that makes his insights into the use of ergonomics knowledge distinctive as well as a challenge to future research in this area.

Perrow's insights, however, may not have universal application. The focus of his field observations were risky systems such as nuclear power plants, weapons systems, air transport, chemical plants, and the factors that hinder the use of human factors in these settings may not be the same as in organisations that design and manufacture products with less catastrophic potential. Furthermore, different factors may play a role in organisations of smaller size; the risky systems studied by Perrow would only generally be developed by organisations where a group of human factors specialists might work alongside at least fifty design engineers (see Meister, 1971: 309).

Although Perrow's ideas could be extended further or tested in different settings, more recent studies focusing on organisational factors and their impact on the use of ergonomics knowledge have tended to mention Perrow only briefly (e.g. Meister, 1987) or not cite his work (e.g. Evans and Chaffin, 1986; Eklund, 1988). One reason for this may be that, as a group, ergonomists have been

relatively slow to learn of Perrow's article because it appeared in a journal not commonly read by them. With respect to the latter, it is interesting to note that the article has received significantly more attention from sociologists and organisation theorists (e.g. Blackler and Brown, 1986; Dwyer, 1988; Marcus, 1988; Hirsch-Kreinsen and Schultz-Wild, 1990: Dwyer and Raftery, 1991). However, rather than focusing on relationships between the social structure, design engineers and human factors engineers (arrows 1, 2 and 3 in Figure 1.1) these researchers were mainly drawn to Perrow's comments in relation to the operator, equipment and the social structure (arrows 4, 5 and 6 in Figure 1.1). In the latter context, Perrow has been cited in support of the criticism that ergonomics is a somewhat narrow discipline that fails to consider the impact of social factors on human performance (see Blackler and Brown, 1986; Dwyer and Raftery, 1991).

As mentioned above, Meister (1987: 237) has acknowledged Perrow, albeit it only briefly in the proceedings of a workshop on the psychology of system design. At this workshop, both the nature of designers and the organisational context were put forward as key issues for discussion (Rouse and Boff, 1987). However, while organisational factors were acknowledged, many of the presenters (e.g. Rouse, 1987; Martin, 1987; Boff, 1987) were primarily interested in the designer. Meister's contribution to the workshop was, in a way that is consistent with his previous writings, still mainly concerned with understanding the designer's cognitive design processes.

By comparison, Perrow's article was referred to more extensively in reports of research activity associated with the introduction of an ergonomics programme into an automotive transmission parts plant (Liker *et al.*, 1984; Liker and Joseph, 1986; Joseph *et al.*, 1986). As a result of these studies, Liker *et al.* (1984) were able to identify six obstacles to the use of ergonomics knowledge. These were: lack of general ergonomics knowledge, lack of specific job knowledge, poor inter-departmental communication, perceived cost-benefits, organisational politics, and emotions and attitudes toward change. This identification and analysis of obstacles was informed by a knowledge of Perrow's (1983) essay as well as the literature on managing change.

Besides the literature on managing change, other clusters of concepts from the field of organisation studies also appear to have explanatory potential. One such cluster is found in the research literature on innovation in organisations. This

'voluminous' literature (Kimberly and Evanisko, 1981: 689) has examined the adoption and implementation of a variety of objects and practices (e.g. types of social service, and new technologies) in a wide range of organisational settings (e.g. research and development laboratories, health and welfare organisations, and school systems). More significantly, given the context of the present discussion, this literature also includes studies of innovations which have a 'disciplinary' character. For instance, the innovation literature has focused on the adoption of the marketing concept in New Zealand, Canadian and Australian organisations (McDougall, 1974), the introduction of methods from operations research-management science into U.S. government and business organisations (Radnor *et al.*, 1968; Radnor *et al.*, 1970; Bean *et al.*, 1975), and the evolvement of Taylorism (Clark and Staunton, 1989). In light of these research topics, it seems reasonable to approach the problem of ergonomics knowledge use from an innovation perspective. In order to work forward from this position, the concept of innovation will now be examined in more depth.

Innovation in organisations

The origins of the study of innovation in organisations can be traced back to the various traditions of diffusion research described by Everett Rogers in *Diffusion of innovations* (1962). Rogers' aim was to bring together the extensive literature on the diffusion of innovations that existed at the time. Until then, almost every behavioural science had had some interest in the problem of diffusion, yet scholars from the various traditions remained largely unaware of each other's findings. With some irony, Rogers noted that the 'diffusion of diffusion research' had been inadequate (1962: 22). Having reviewed over 500 research reports for his book, Rogers was able to delineate six main diffusion research traditions: anthropology, early sociology, rural sociology, medical sociology, education, and industrial. Of the research traditions, the one that had generated the greatest research output was rural sociology, which had developed during the 1940s as scholars became interested in factors influencing the transfer of farm innovations from agricultural scientists to farmers.

Much of the diffusion literature reviewed by Rogers was concerned with individuals and their 'innovativeness', as measured by the degree to which they were relatively earlier in adopting new ideas than other members of their social system. On this basis, individuals could be classified into one of several

'adopter categories' ranging, for example, from early adopter to later adopter. However, of particular interest to diffusion researchers were the correlates of innovativeness, that is, those individual characteristics which explain why some people are more likely to take up a new idea in advance of others. A range of factors were studied in this way and evidence seems to indicate that early adopters are of younger age and higher social status than later adopters. There is also evidence that early adopters are also more cosmopolite, and have more opinion leadership (Rogers, 1962).

The emphasis on individuals that characterised much of the diffusion literature was not evident in the 'industrial tradition' identified in *Diffusion of innovations*; instead, the 'industrial firm is most often the unit of analysis' (Rogers, 1962: 43). Aside from this larger unit of analysis and the focus on new technical ideas, the industrial tradition still employed concepts such as innovativeness and adopter categories. Rogers was only able to find 12 publications that could be located within this tradition, and most of these had only appeared since the mid-1950s. Thus the industrial diffusion tradition, when compared to others, was relatively youthful. However, just at the time when *Diffusion of innovations* was being published, research on industrial innovation was being stimulated by societal change in attitudes towards technology and science. There was a growing recognition in some industrialised countries that economic development was closely linked to the rate of technological innovation. The latter was considered to be inadequate, particularly in the wake of the Sputnik launch, and there was concern in many quarters regarding national policies for science and technology (Jamison, 1989). These concerns were addressed in part in a burst of government sponsored research outputs of which the studies by Myers and Marquis (1969) and the economist Mansfield (1968a; 1968b) are exemplary. Typically, these industrial studies used large samples and employed statistical techniques to analyse the innovative behaviour of firms and industries in terms of measurable structural characteristics.

During the late 1950s and the 1960s, the work of organisation theorists also reflected a growing interest in innovation in organisations. Some of these researchers followed the quantitative and cross-sectional approach of the innovation economists, while others took a decidedly different path in terms of research methodology and underlying assumptions of rationality. Two important works of the time illustrate this difference. Firstly, the publication *The management of innovation*, in which Burns and Stalker (1961) develop their

typology of mechanistic and organic systems of management, is a qualitative study of technological innovation in twenty Scottish and English firms which had invested in electronics development. Secondly, in the book *Organizations*, March and Simon (1958) developed a behavioural model of innovation. This model was based on an analysis of 'how the cognitive limits on rationality affect the processes of organizational change and program development' (March and Simon, 1958: 172).

It is this early work by organisation theorists, rather than the research undertaken by the innovation economists, that provided the foundations for the body of literature on innovation in organisations. This legacy is acknowledged in *Innovations and organizations* (Zaltman *et al.*, 1973). This book provided the first comprehensive overview of this emerging area of study.

Perceived newness

In *Innovations and organizations*, Zaltman *et al.* (1973: 10) define an innovation as 'any idea, practice, or material artifact perceived to be new by the relevant unit of adoption'. The authors then proceed to establish the connection between this definition and the one used in *Communication of innovations* (Rogers and Shoemaker 1971: 19). In the latter work, an innovation is considered to be 'an idea, practice, or object perceived as new by the individual'. The only substantial difference between the two definitions is the term used to refer to the adopter of the innovation. Zaltman *et al.* (1973) have chosen to replace 'the individual' by the phrase 'the relevant unit of adoption', thereby allowing for those circumstances in which decisions about innovations are made by units that are larger than an individual. Zaltman *et al.* (1973), after all, were interested primarily in the study of innovation in organisations where larger units of adoption are more liable to exist. A common feature of both definitions is their emphasis on the *perception* of the potential unit of adoption. This, it is argued, is what determines whether an idea or object should be classified as an innovation. As long as the idea or object is new to the unit of adoption, then it does not matter how many other organisations have adopted it, or how long it has been in existence. As Rogers and Shoemaker (1971: 19) have argued:

> It matters little, so far as human behavior is concerned, whether or not an idea is "objectively" new as measured by the lapse of time

> since its first use or discovery. It is the perceived or subjective newness of the idea for the individual that determines his reaction to it. If the idea seems new to the individual, it is an innovation.

Furthermore, Rogers and Shoemaker (1971: 19) are careful to differentiate between the perception of newness and merely being aware of the idea. While a person might have been aware of an idea for some time, he or she may not have developed a favourable or unfavourable attitude toward it, or indeed a judgement about newness.

Other innovation theorists have taken a similar stance to Rogers and Shoemaker (1971) and Zaltman *et al.* (1973). For example, Shepard (1967: 470) considers that when an organisation 'learns to do something it did not know before, and then proceeds to do it in a sustained way', innovation has occurred. This approach tends to emphasise the novelty of an idea in terms of an organisation's own history. Thus, provided a particular change has not occurred before in an organisation, it is an innovation. However, while Shepard emphasises newness *in relation to the organisation*, he does not focus on newness as perceived by the relevant unit of adoption. As a result, Shepard's definition does not allow for the scenario where an idea might be perceived to be new to a particular adoption unit even though it has already been introduced into another part of the same organisation. The latter situation is accommodated by the definition by Zaltman *et al.* (1973).

Some researchers, however, do not agree with these particular views of newness. They argue that an idea or object should only be considered an innovation if it is new *in relation to the environment of an organisation.* Knight (1967: 478), for example, defined innovation as 'the adoption of a change which is new to an organization and to the relevant environment'. Similarly, Becker and Whisler (1967: 463) proposed that innovation should be viewed 'as the first or early use of an idea by one of a set of organizations with similar goals'.

In defining innovation relative to the environment as opposed to the organisation, some innovation researchers wish to preserve a clear distinction between the concept of organisational innovation and organisational change. Becker and Whisler (1967) argue that there are differences between innovation and change in terms of the costs of search and risks taken. As a result, they consider that a definition of innovation which includes all change that is new to

an organisation 'sterilizes' the term and 'constitutes a loss to that part of organization theory dealing with the transactions of the organization with its environment' (Becker and Whisler, 1967: 463). Marquis (1982), on the other hand, has convincingly argued against a too narrow conception of innovation. He (Marquis, 1982: 42) has found that 'many enterprises have been profoundly changed by innovations from other organizations and even other fields'. Narrow definitions of innovation might result in these important industry transformations being overlooked. Similarly, Zaltman *et al.* (1973) consider perceptions of newness provide a sufficient and significant basis for differentiating between innovation and change. They argue that while all innovations imply change, not all change involves innovation 'since not everything an organization adopts is perceived as new' (Zaltman *et al.* 1973: 158).

Innovation as object, practice and idea

In everyday usage, the word innovation is frequently used to describe a new piece of technical apparatus such as a microcomputer, or a late model car. There is, however, general agreement among innovation theorists that an innovation may take on other forms as well and various classification schemes have been developed to make sense of the diversity. One of the simplest approaches, based on Evan (1966), is to differentiate between technical innovations and administrative innovations. Technical innovations are generally taken to be ideas, practices or objects that become part of the organisation's technical system and are related to its primary work activity (Damanpour and Evan, 1984: 394). Hence, new products or services developed by an organisation are considered to be technical innovations. The teletex system developed by France Telecom (Benghozi, 1990) or the new business opportunities described by Burgelman and Sayles (1986) are examples of this type. In addition, there are technical innovations which impact on the organisation's production processes such as advanced programmable manufacturing systems (Ettlie, 1986), electronic automation in process control systems (Cullwick, 1979), microprocessors (Robertson and Gatignon, 1987), and word processing (Johnson and Rice, 1987). Administrative innovations, on the other hand, occur in the social system of an organisation and may involve changes in policies of recruitment, allocation of resources and the structuring of tasks, authority and rewards. Examples include staff continuing-education programmes, job rotation, and flex-time (Damanpour and Evan, 1984: 400).

The administrative-technical classification scheme can be misleading. For example, in trying to measure administrative innovation, Kimberly and Evanisko (1981) appear to confuse changes that occur within the administrative function with those that occur in the organisation's social system: in their study of hospital organisations the use of electronic data processing systems in various areas of hospital administration was employed as a measure of administrative innovation. Besides misinterpretation of this nature, the distinction between administrative and technical innovation overlooks the fact that many innovations have interdependent technical and administrative components. For example, the introduction of a computerised information system will usually bring about changes in the social structure. According to Van de Ven (1986: 592), an appreciation of the close connection between the technical and administrative dimensions of innovations is a prerequisite for the successful development of these systems.

The dichotomy of administrative versus technological innovations fails to provide for a separate category of innovations which mainly takes the form of ideas. Although innovations have been recognised as having the form of *practices, material artifacts and ideas* (Zaltman *et al.*, 1973: 10), administrative innovations and technical innovations are mainly linked to practices and material artifacts respectively. In other words, 'idea innovations' are not explicitly accounted for.

A separate category of 'idea innovations' has, nevertheless, been clearly delineated in the literature. In an article which focused specifically on the problem of knowledge utilisation, Zaltman (1979: 82-83) argued that 'knowledge itself is an innovation' and then proceeded to establish the concept of 'knowledge innovation'. In describing this type of innovation, Zaltman had two considerations in mind. Firstly, he wished to differentiate between an innovation which has a manifestation as a program or physical object, and an innovation which does not have such an overt expression. Secondly, he used the term to refer to innovations which may be the 'basic research idea underlying an overtly expressed innovation' (Zaltman, 1979: 83).

Besides the argument for a distinct category of innovation called 'knowledge innovation', it has also been suggested that innovations may have a *knowledge component*. Rogers and Shoemaker (1973: 21), for example, noted that it was

possible, and indeed highly likely, that an innovation could be a combination of two or more forms.

> An innovation may have two components: (1) an *idea* component, and (2) an *object* component (that is, the material or physical product aspect of the idea). All innovations must have the ideational component, of course, but many do not have a physical referent.

More recently, researchers have built further on this notion by referring to the *centrality* of an innovation's idea or knowledge component. Clark and Staunton (1989: 56), for example, place 'disembodied' knowledge at the heart of an 'innovation configuration framework' which identifies four possible types of knowledge embodiment: the knowledge that is incorporated into equipment, raw materials, the built environment, and into standardised operating procedures.

Drawing on this framework, Clark and Staunton (1989: 55) emphasise that an innovation usually consists of a 'bundle' of the configuration's five elements. In other words, an innovation will be a combination of disembodied knowledge and one or more embodiments. Moreover, Clark and Staunton argue that rather than being fixed and tight, the configuration will tend to change over time as a result of the following mechanisms. Firstly, the perceptions of what innovations are and the bundle of elements they represent are likely to vary between individuals. Secondly, what would appear to some people to be a tight bundle of elements may be unbundled by potential users who select only particular elements. Thirdly, the innovation may be 'reinvented' (see Rice and Rogers, 1980) as new elements are introduced.

The focus on knowledge in Clark and Staunton's model is indicative of a broader trend which sees more attention being given to the role and quality of firm-specific knowledges with the resulting surfacing of terms such as 'human capital' (Hage, 1988), 'competence' (Winter, 1987), and 'competencies' (Prahalad and Hamel, 1990). Out of this research has come the realisation that knowledge may be the root source of a company's competitiveness. Thus, rather than take the view that a company's competitive edge derives from the price/performance attributes of its products, it is argued that competitiveness over the long term will depend on the ability of an organisation to develop and use knowledge. Abernathy and Clark (1985: 5) describe this relationship between knowledge and competitive advantage:

> It is important to note that the product features themselves, and the firm's position with them, are not and of themselves the fundamental source of advantage. Such a position is the immediate, outward manifestation of a more fundamental, internal reality. The foundation of a firm's position rests on a set of material resources, human skills and relationships, and relevant knowledge. These are the competencies or competitive ingredients from which the firm builds the product features that appeal to the marketplace.

Given the significance of knowledge, the problems that organisations face in relation to the acquisition, revision and updating of this resource are of great interest. These problems are in turn greatly exacerbated by the growth in knowledge during the twentieth century (Hage, 1988; Clark and Staunton, 1989). According to Hage (1988: 2), the growth in knowledge means that business organisations must constantly innovate and upgrade their operations. If an organisation does not heed these 'new' rules, it will not survive.

While the foregoing discussion has established that an innovation may take the form of an object, practice, or even a knowledge-base (such as ergonomics), the term 'innovation' is also frequently used to refer to a process that results from the combining of events over time. This usage of the term will now be discussed.

The innovation process

The process of innovation centers on the temporal sequence of activities that occur over time as new ideas, objects and practices are developed and then implemented. In its broadest conceptualisation, the *innovation process* embraces periods of design and development, adoption, implementation and diffusion. The innovation process model proposed by Marquis (1982) is a prominent example of this view. This model suggests that an innovation begins with the recognition of the technical feasibility and demand for a new idea. The process then moves through a series of stages involving idea formulation, problem solving, solution, development, utilisation, and diffusion. A closer examination of these six stages reveals that the emphasis in this model is on the design and development phases rather than on adoption or implementation aspects. As such, this model of innovation is rather hard to distinguish from general models of the product development process (see, for example BSI, 1988).

By subsuming the initial development phases within a separate *invention process*, other innovation theorists have been able to limit the scope of the innovation process. This separation between the processes of invention and innovation is argued for on two grounds. Firstly, the two processes are deemed to involve quite different activities. Thus Becker and Whisler (1967: 463) argue that invention is 'fundamentally the creative act of an individual' while innovation is 'fundamentally a co-operative group action'. Secondly, invention and innovation processes often appear to be separated in time and space. In this context, Becker and Whisler (1967: 463) argue that innovation is 'a process that follows invention but can be separated from it in time and location'. According to this view, innovation takes place within an organisational setting, whereas invention occurs in a location that is often remote from the eventual site of use.

As well as differentiating between invention and innovation, Becker and Whisler (1967) also describe a 'common' view of the innovation process which is based on their assessment of several other papers that appeared in a special issue of *The Journal of Business*. Becker and Whisler found general agreement that the innovation process consisted of four stages: stimulus, conception, proposal and adoption. Typically, an individual in the organisation would become aware of a new idea or product (stimulus). He or she would then devise a plan of action that the organisation should pursue (conception) and this proposal would then be presented for approval. The process terminates with the adoption phase which involves the agreement to pursue, or reject, the proposal.

According to Zaltman *et al.* (1973), the tendency to terminate the innovation process at the point of adoption derives from early diffusion theorists, of whom the work of Rogers (1962) and Rogers and Shoemaker (1971) is representative. The main concern of the latter theorists was whether or not an individual took up an idea; they were not greatly concerned with what happened after that. In the study of innovation in organisational settings however, there is considerable interest in how innovations are implemented once they have been adopted (Van de Ven and Rogers, 1988: 632). This interest is evident in the two-stage model of the organisational innovation process developed by Zaltman *et al.* (1973: 62) in which an 'implementation' stage follows on from the 'initiation' phase. The initiation phase is concerned with how people in the organisation become aware of the innovation, how attitudes to it form, as well as the decision to adopt or reject the innovation. As such, this initiation phase embraces most of Becker

and Whisler's process model. The implementation phase, on the other hand, is concerned with 'the actual mechanics of managing the changes that innovation may imply' (Zaltman *et al.*, 1973: 59) during the period of initial utilisation as well as later, when the innovation becomes a routine feature of the organisation.

The significance of the implementation phase is now widely recognised in innovation research, to the extent that some innovation researchers have chosen to operationalise innovation as 'the implementation of an idea'. This approach, according to Damanpour and Evan (1984), allows the researcher to discount those innovations which are adopted by management but subsequently fail to be implemented. However, while the interest in the implementation phase has opened up the study of innovation to bodies of research literature which focus on utilisation (Rich, 1991), institutionalisation (Pfeffer, 1982: 246), implementation, and planned change (Zaltman *et al.*, 1973: 59), the 'stage-wise' models of the innovation process discussed in this section have attracted mounting criticism. The nature of this criticism will be addressed in the next chapter.

Summary

This chapter started by introducing studies that have focused on individual and organisational factors which impact on the use of ergonomics knowledge in organisations. From this discussion, Perrow's (1983) statement - which highlighted the crucial importance of organisational factors - emerged as a significant departure from earlier studies. Perrow cast doubt on the salience of individual factors (such as the values and attitudes of design engineers) and noted that human factors engineers (and ergonomists) had generally failed to appreciate the organisational context in which ergonomics knowledge is applied. Furthermore, Perrow suggested that human factors engineers could benefit from understanding the organisational context of which they are part.

To follow up Perrow's 'challenge' to ergonomists, the chapter proceeded to introduce the innovation literature. This literature, it was argued, offers a possible avenue by which the use of ergonomics knowledge in organisational settings could be further analysed. Indeed, the innovation literature provides a range of analytical tools which enable ergonomics to be thought of as a specific example of innovation. As such, ergonomics knowledge may constitute an 'idea innovation' or 'knowledge innovation' (Zaltman, 1979). Alternately, following

the argument of Clark and Staunton (1987), ergonomics knowledge may underlie more 'objectified' innovations such as products and practices. Finally, the *process* of using ergonomics knowledge might also be considered from an innovation perspective.

One of the central arguments of this study is that the understanding of ergonomics knowledge may be enhanced by perceiving ergonomics as a form of innovation. In pursuing this direction, the extensive innovation literature can be mobilised to provide a framework in which to study the utilisation of ergonomics knowledge in organisations. The innovation literature will be discussed more fully in Chapter 2. This chapter will delineate major theoretical perspectives and indicate the various methodological strategies that have been employed to study innovative practices. As theoretical viewpoints and methodological concerns are often intimately linked, the next chapter will also lay the foundations for the procedures that were adopted during the fieldwork.

Chapter Two

Perspectives on Innovation in Organisations

Introduction

The previous chapter has argued that the use of ergonomics knowledge in organisational settings may be regarded as a specific case of innovative activity. To this end, the concept of innovation was introduced and in particular a distinction was made between innovation as an idea or object, and innovation as a process. This chapter will continue to examine the innovation literature in more detail although, in doing so, the scope will be limited to studies which have focused on the factors and processes which impact on the use of innovations in organisational settings. Furthermore, rather than attempt to provide an exhaustive review of this extensive literature, the chapter aims to highlight the key theoretical perspectives which have informed research in this field. This objective will, in turn, shed light on some of the methodological issues that need to be addressed in innovation research. In particular, the chapter will show that, while the innovation literature has in the past been dominated by cross-sectional, quantitative studies which have focused on the *determinants* of an organisation's innovative response (or 'innovativeness'), there is an increasing interest in studies which interpret the innovation process as a dynamic and complex phenomenon.

Perspectives on action as an overview framework

The literature on organisational innovation can be organised in several ways. One approach would be to discuss the literature according to topic headings

associated with a particular concept or group of concepts. For example, all the research dealing with 'complexity' could be brought together under one heading, while all findings with respect to 'organisation size' could be reviewed under another. There are some difficulties with this approach, however. The segmentation of the literature under topic headings may lead to an unbalanced coverage with some areas being overemphasised while others are neglected. More importantly, topic headings often obscure the range of theoretical and methodological orientations which are brought to bear in organisational research. Within the domain of organisation theory, for example, several theoretical perspectives are represented. Their presence can generally be attributed to the interdisciplinary character of the field, with its contributions from the disciplines of sociology, psychology, anthropology, economics, political science and mathematics. Each of these disciplines has its own dominant theoretical perspective and preferred level(s) of analysis.

The shortcomings of topic headings as a framework for mapping out the field of organisation theory have been noted by Burrell and Morgan (1979) and Pfeffer (1982). As an alternative, these authors advocate the development of overviews based on major theoretical perspectives, particularly those that relate to opposing views about the nature of individual behaviour or action. In this chapter, theoretical perspectives, rather than topic headings, will be used to map out the literature that has focused on innovation in organisations. The framework to be used is based on the 'perspectives on action' described in Pfeffer (1982), Van de Ven and Astley (1981), Astley and Van de Ven (1983), and Burrell and Morgan (1979). The use of theoretical perspectives as an organising framework sets this chapter apart from an earlier review (King, 1990) which organised the same literature under the methodological themes of 'antecedent research' and 'process research'.

In the organisation studies literature, three major 'perspectives on action' can be identified. Two of these perspectives were identified by Astley and Van de Ven (1983) in their two-dimensional mapping of the organisation theory domain. These researchers suggested that not only could organisation theories be categorised according to their level of analysis, they could also be differentiated according to the 'relative emphasis placed on deterministic versus voluntaristic assumptions about human nature' (Astley and Van de Ven, 1983: 246). Thus, as is shown in Figure 2.1, a voluntaristic perspective on action is evident alongside a perspective that is more deterministic.

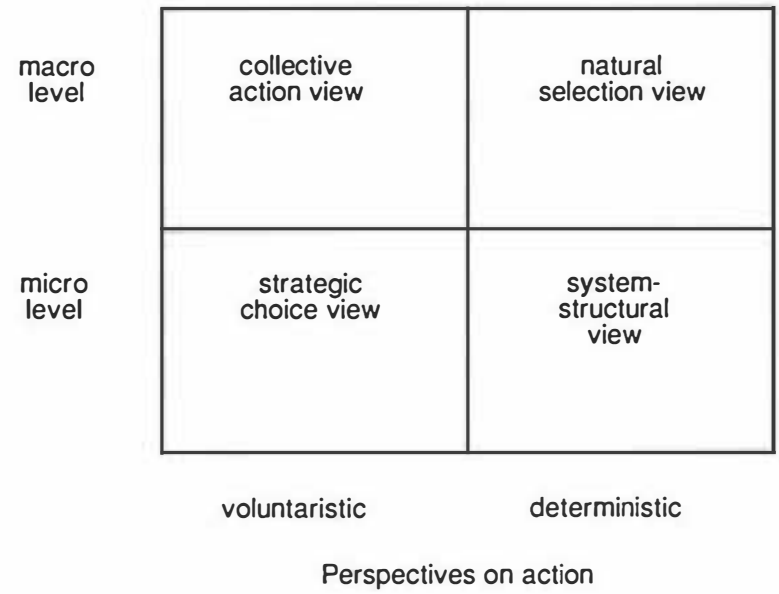

Figure 2.1 Perspectives on action in organisation theory (adapted from Astley and Van de Ven, 1983: 247)

In establishing these two perspectives, Astley and Van de Ven follow other authors in referring to 'the classical duality between social determinism and free will - the view that human beings and their institutions are either determined by exogenous forces' and the contrary view that they are 'autonomously chosen and created by human beings' (Astley and Van de Ven, 1983: 246). Located at the voluntaristic end of this dimension are those theories which assume that intentional individual action is the main source of change in organisations. Examples cited include action theory and strategic management. A deterministic orientation, on the other hand, sees individual action as being determined by and reacting to structural properties. Systems theory and structural functionalism are characteristic of this orientation.

Astley and Van de Ven's (1983) framework also differentiates between organisational analysis at the micro and macro level. Micro level research and theory tends to focus primarily on individual organisations whereas, at the macro level, populations of organisations are the unit of interest. This particular micro-macro distinction allows economic and political theories to be accommodated within the analytic scheme.

Pfeffer (1982: 5) added a third view of action to the voluntaristic and deterministic perspectives identified by Van de Ven and Astley (1981). In his own categorisation, Pfeffer (1982: 13) refers to this third perspective as 'emergent, almost-random, dependent on process and social construction'. Although this 'process perspective' may not be as homogeneous as the other two, its major characteristic is that it 'fundamentally denies either an internally directed or an externally determined rationality of behavior' (Pfeffer, 1982: 9). Instead, this perspective emphasises that action has to be understood in terms of an unfolding process in which different actors participate to varying degrees over time. Rationality may not necessarily direct individual action in this process, as goals, preferences and meanings may only emerge or be assigned retrospectively. In other words, the action of individuals may not always be *intentional* (also see Giddens, 1984: 8-12).

Although Pfeffer has used these three theoretical perspectives of action to map out the field of organisation theory, the same perspectives, and the methodological problems that arise from them, are manifest in the literature on organisational innovation (Becker and Whisler, 1967: 467). Pierce and Delbecq (1977: 34), for example, have noted that organisational innovation can

> be seen from *three perspectives*. The deterministic structural model has captured the most attention; i.e., structure and context cause innovation. Alternately, member values and attributes can be cast as the primary rival causal force in determining organizational innovation; i.e., elite values favorable to change best predict organizational innovation. Finally, the relationship between organization and innovation may be interactively influenced by both structure and membership. [emphasis added]

In the following overview of the literature on innovation in organisations, the three perspectives on action described above will be used as an organising framework. These will be referred to as the individualist perspective, the structuralist perspective, and the interactive process perspective (see Figure 2.2). The individualist and structuralist perspectives will be dealt with initially as they represent dominant approaches to the study of innovation. There are, however, several conceptual issues which arise in relation to these two perspectives and these will be highlighted in a separate section. That section, in turn, provides a basis for the discussion of the interactive process perspective toward the end of this chapter.

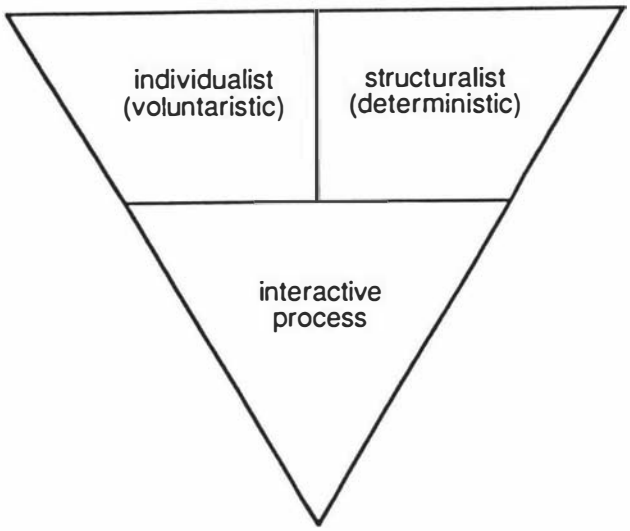

Figure 2.2 An overview framework based on three perspectives on action

The individualist perspective

An individualist perspective on action assumes that individuals are a major source of change in organisations. The actions of individuals are not seen to be constrained by external factors, instead individuals are perceived to be self-directing agents who are guided by the goals that they set. In addition, this view holds that individuals are rational and make decisions in order to maximise value or utility. In the literature on organisational innovation the individualist perspective most frequently finds expression in studies that try to identify individual-level antecedents of innovation. These antecedents may be defined in terms of individual characteristics, or individual-level concepts such as values, personality, and goals.

A range of individual characteristics have been tested for their effect on innovation behaviour where decisions are made by a single individual. Rogers (1962), for example, provides an extensive review of studies that have tested for the effect of age, sex, financial position, etc. on the innovativeness of an individual. It is, however, not that straightforward to relate the findings of these studies to the organisational setting. Firstly, innovation decisions in organisations rarely involve a single person. Secondly, the effect of organisational *role* may overshadow individual characteristics, as Baldridge and Burnham (1975: 167) in their study of innovation in schools have demonstrated. These researchers found that individual characteristics such as age, sex, educational level and cosmopolitanism did not explain why some school staff were leaders in organisational innovation, while other staff were not. Instead, Baldridge and Burnham found that the involvement of a person in the innovation process could be explained in terms of their organisational position and role: in the study, chairmen and administrators were more influential than teachers.

As Baldridge and Burnham (1975: 168) indicate, the concept of role is a sort of a 'bridge' between the organisational and the individual level. It represents a shift in thinking away from the purely individualistic perspective outlined above, to one which recognises that behaviour is socially mediated. Roles are conferred on people; they represent the set of behaviours that others expect a person in a particular position to exhibit. In conforming to roles, individuals appear no longer to be entirely free and autonomous, instead they appear to be subject to a degree of constraint.

One of the roles that has been linked to innovation is that of leader. The influence of leaders may be direct as in the case where it is the leader who becomes aware, through her or his search activities, of new ideas, and who then decides to introduce them into the organisation. Even if they do not introduce innovations themselves, leaders may influence the innovation climate through the setting of goals, by encouraging innovation initiatives from subordinates, and through their decisions with respect to innovation adoption or rejection (Daft, 1978). However, while some leaders appear to stimulate innovation, others do not. Reasons for the difference have been tested for in research studies which correlate leader attributes with innovation adoption. Kimberly and Evanisko (1981) in their study of technical and administrative innovations in hospitals, measured the individual characteristics of hospital administrators and chiefs of medicine. Four variables were measured - job tenure, cosmopolitanism,

educational background and the nature of organisational involvement of leaders - and, of these, only educational level was a significant predictor of adoption for both types of innovation. Similarly, Mohr (1969) found that the 'motivation' of health officers, as expressed by a combined 'activism-ideology' score, was only a moderate predictor of the innovativeness of local health departments, as expressed either in the number of programs adopted or as increments in resources devoted to these programs.

While recent prescriptive writings (e.g. Tichy and Ulrich, 1984; Bass, 1985; Bennis and Nanus, 1985) have attempted to relate innovative activity to the characteristics of individual leaders, it has also been suggested that attention could be given to the beliefs and values shared by *groups* of elites. In their study of elite values and innovation in health and welfare organisations, Hage and Dewar (1973: 281) suggest 'that the argument for the primacy of élite values maintains that organizations are seldom led by one person ... Usually there is some group, an élite, and it is their values that set organizational policy'. Hage and Dewar tested this argument by comparing the relative influence of elite values, leader values and member values on the number of new programs introduced. The results showed that the values of the inner elite were more important than those of either the executive director or the entire staff in predicting innovation, although leader values were still significant. Furthermore, elite values were slightly stronger predictors than structural variables. According to Hage and Dewar (1973: 287) this 'supports the view that élites are not totally determined by the kind of organization they lead, but are able to manipulate their organizations, at least for innovation'.

The idea that all 'relevant' participants in the organisational decision-making unit should be studied is also supported by Robertson and Wind (1983). In a study of the effect of the cosmopolitanism variable on innovation in hospitals, these researchers found that the highest innovativeness was exhibited by hospitals characterised by a 'cosmopolitan' professional and a 'local' oriented administrator. The lowest level of innovativeness occurred in the situation where both the professional and the administrator were local in orientation. Thus, according to Robertson and Wind (1983), rather the focusing on the characteristics of a single organisational member, prediction of innovativeness would be improved by focusing on the 'pattern' of cosmopolitanism among members of the decision-making unit.

Howell and Higgens (1990) note that several writers have conceptually linked innovation with the presence of 'transformational' leaders who are able to inspire their followers to transcend their own self-interest for a higher collective purpose. In their own questionnaire and interview study, Howell and Higgens (1990) found that transformational leader behaviours were exhibited by champions of technological innovations. The role of champion as originally defined by Schon (1963: 84) is somebody who identifies 'with the idea as their own, and with its promotion as a cause, to a degree that goes far beyond the requirements of their job'. According to Howell and Higgens (1990: 317) a 'multitude of field and case studies have found strong support for Schön's contention that innovation success is closely linked with the presence of a champion'.

Saren (1987: 136) has suggested that the focus on leaders, elites and champions has been rather 'one-sided'. He argues that while innovation researchers have tended to emphasise the role of those individuals who promote innovation, it is just as important to understand why other individuals resist innovative activity (see Zaltman *et al.*, 1973: 85-103 for studies on resistance). Saren (1987) also argues that the role of innovative individuals cannot be divorced either from the activities of these other individuals or from the organisation structure within which they must operate. This contrasts with popular management literature and some empirical studies on innovation which present individuals as rational beings who are able to introduce innovations with relative ease. From the latter work, writes Van de Ven (1986: 594) 'one often gets the impression that inventors or innovators have superhuman creative heuristics or abilities to "walk on water"'. A more realistic view, Van de Ven suggests, is presented by those innovation theorists who emphasise the limited capacity of human beings to handle complexity and pay attention to non-routine issues.

The emphasis on a form of individual action that is 'boundedly rational' can be found in the early work of decision-making theorists such as Simon, March and Cyert. While these theorists challenge the notion of rational choice, Pfeffer (1982: 6) concludes that much of their work leaves the basic assumptions of the rational individualist model intact. It is still assumed, for instance, that decisions are made prospectively, and, that while they may not be value maximising in an absolute sense, they will be value satisficing. Consequently, Pfeffer (1982: 6) suggests that this work represents 'a subset of theories of rational choice' (Pfeffer, 1982: 6). A similar position is taken by Pettigrew, who finds in the

work of March and Simon (1958) a tendency to approach organisational processes largely from an individualist perspective. Pettigrew (1985: 20) comments:

> March and Simon's (1958) tendency to project individual processes of choice into statements about organisational processes of decision-making means there is a liberal bias to reconstructing the organisation from the perspective of the individual, and not enough on demonstrating how the organisation structures the perspective and interests of the individual.

The comments above are significant given that in March and Simon (1958) we find the most comprehensive application of the principle of bounded rationality to a theory of organisational innovation. In this work (March and Simon, 1985: 174-175), innovation is viewed as being

> present when change requires the devising and evaluation of new performance programs that have not previously been a part of the organization's repertory and cannot be introduced by a simple application of programmed switching rules.

March and Simon argue that there will be no increase in the rate of innovation as long as the present course of action is considered to be satisfactory. As long as individuals and organisations can reach established criteria for success (e.g. share of market, total profits, rate of return) they need only consider change where inaction does not achieve this. After all, there is 'ordinarily little or no limit to the amount to inaction an organization can "undertake"; inaction does not absorb resources' (March and Simon, 1958: 175).

Where performance is considered to be unsatisfactory, the rate of innovation will increase. This discrepancy between actual performance and what is considered satisfactory, which has been referred to by Downs (1966) as a 'performance gap', will lead to more active search for new alternatives. The process of search will bring the organisation into contact with new ideas. Wider search may increase the rate at which opportunities for more satisfactory performance are encountered, whether by accident or design (March and Simon, 1958: 183).

However, March and Simon (1958: 180) suggest that search activities will usually be limited in scope:

> In the search for possible courses of action, alternatives will be tested sequentially. That is to say, there will be no attempt at the first round of search to exhaust "all possible alternatives". Instead, as soon as a few possible alternatives have been found, these will be evaluated. If one proves satisfactory, when tested against the problem criteria, it will be accepted as a solution to the problem, and search will terminate.

This 'simple-minded' characteristic of search behaviour also features in the behavioural theory of the firm developed by Cyert and March (1963). This general theory, as the authors themselves suggest, 'is of considerable relevance to the prediction of innovations' (Cyert and March, 1963: 278). Furthermore, in the context of the present discussion, the work of Cyert and March contributes to our understanding of innovation in two important ways. Firstly, Cyert and March modify the theory that failure induces innovation, in light of contrary evidence collected by Mansfield. They predict that organisations will innovate 'both when successful and when unsuccessful' (Cyert and March, 1963: 279). In the case of success, organisations may have slack resources which can be channeled towards innovative activity. In a subsequent review article by Knight (1967), these two types of non-routine innovation were identified as 'distress' innovation and 'slack' innovation. Secondly, Cyert and March's theory extends the idea of search by linking it explicitly with the concept of 'organisational learning'. Cyert and March assume that organisations learn and that this is evidenced in adaptive behaviour over time at the 'aggregate level' of the organisation. While this view of the organisation as an aggregate is not without its limitations, Cyert and March emphasise that organisations may revise the search procedures as a function of their experience. Specifically, they (Cyert and March, 1963: 124) hypothesise that

> when an organization discovers a solution to a problem by searching in a particular way, it will be more likely to search in that way in future problems of the same type; when an organization fails to find a solution by searching in a particular way, it will be less likely to search in that way in future problems of the same type.

Empirical support for Cyert, March, and Simon's ideas on problem-oriented search is provided by an extensive study of decision-making in service

organisations which concluded that most decision processes studied were 'solution centered, which seemed to restrict innovation, limit the number of alternatives considered, and perpetuate the use of questionable tactics' (Nutt, 1984: 414). In this research, Nutt constructed case studies for 78 projects from multiple interviews with executives. Analysis of the data revealed that projects could be classified as belonging to one of five process types: historical model processes, off the shelf, appraisal, search and 'nova' processes. While the first four processes involved different types of search routines, all were undertaken with the intention of finding a solution in the form of an existing practice. By contrast, nova processes were an attempt to generate new ideas without specific reference to the practices of others. Nutt found that nova processes, which are widely advocated by organisation theorists, were only used in 15 percent of the cases studied. This, according to Nutt (1984: 445), is because executives 'prefer to copy the ideas of others or to search for ready-made solutions instead of seeking innovation'. These 'satisficing' approaches were the means by which decision-makers created an 'artificial certainty' out of the uncertain conditions which they generally found intolerable.

This conservatism among managers may be fostered by reward systems which closely align individual rewards with organisational outcomes. Under these circumstances, managers will generally avoid innovating, as failure will generally be recognised to have greater implications for their advancement than would the pursuit of new ideas. Despite this, March (1981) has argued that within most organisations, some level of innovation will still occur due to such mechanisms such as organisational slack, symbolic action and ambiguity. For instance, managers will innovate to some degree because the ideology of modern management associates managers with the introduction of new ideas. As Nutt (1984: 446) has indicated, managers may overcome their basic conservatism particularly when they wish to 'set a new mood':

> Some risk taking is justified when a new leader arrives on the scene, to demonstrate that the organization is being revitalized, and this may be one of the few instances in which an organization willingly initiates an innovation-seeking process.

The final area of literature to consider which brings an individualist perspective to the study of innovation is that which deals with strategic management. Sandelands and Drazin (1989) argue that this literature frequently assumes that

individuals are a main cause of organisational change. In this view, managers are ascribed a high degree of rationality and purposiveness. They are seen to proactively bring about innovative activity and other changes in organisational 'climate' and structure through the formulation of strategic plans and their controlled implementation.

The structuralist perspective

Whereas the individualist perspective seeks to explain innovative behaviour in terms of the characteristics and actions of organisational participants, the structuralist perspective assumes that innovation is determined by organisational characteristics. In the literature on innovation in organisations, the prevalence of the latter view can be attributed to the pervasive influence of structural functionalism and derivative schools of thought such as open systems theory and structural contingency theory. While there is some debate as to how these schools interrelate (see Burrell and Morgan, 1979), they all 'share a common deterministic orientation by which organizational behavior is seen to be shaped by a series of impersonal mechanisms that act as external constraints on actors' (Astley and Van de Ven, 1983: 248). The approach taken is usually to understand these constraining mechanisms by studying 'the systemic characteristics of organisations which, in turn, are viewed as sub-systems of more inclusive systems (i.e. economy, 'society')' (Silverman, 1970: 66). These 'more inclusive systems' are widely referred to as the 'environment' of an organisation. The organisation stands in 'open' relationship to the environment through the exchange of materials and information.

The structuralist perspective presumes that organisations have goals, of which the most important, in the face of environmental change, is survival. The function of the organisation and its subsystems is to work towards the achievement of this overall aim. Similarly, the task for managers is to manage (reactively) the relations between an organisation and its environment to ensure optimal performance. According to this view (Astley and Van de Ven, 1983: 248), the manager

> must perceive, process, and respond to a changing environment and adapt by rearranging internal organizational structure to ensure survival or effectiveness. The focus of managerial decision making,

> therefore, is not on choice but on gathering correct information about environmental variations and on using technical criteria to examine the consequences of responses to alternative demands.

The disadvantages and advantages of a structuralist perspective have been commented on at length elsewhere (Silverman, 1970: 66-67). The main advantage of this perspective is that it overcomes a narrow concern with the organisation itself by drawing attention to the interrelation of organisation and environment. The main disadvantage is that there is a tendency to treat organisational features as objective realities whose factual character is unchallenged. However, through the practice of reifying organisational features such as technology, strategy, differentiation, and so on, the processes by which organisational structures and patterns are generated and sustained are ignored, or, at best, simple assumptions about action are held to be valid; e.g. individuals are rational and goal-oriented (Benson, 1977: 8). While other criticisms have been expressed, these will be dealt with as part of the following overview that considers in turn those organisation features or patterns (e.g. strategy, structural variables, and structural types) which have been linked with innovation. Initially, however, some attention will be given to the organisational environment.

The environment of an organisation is generally viewed as comprising of a range of factors which are external to the organisation's boundary. However, as many of the factors may not impact directly on the organisation, the narrower concept of the task environment is often employed. The task environment extends to those specific components of the environment which are relevant to the decision making processes in an organisation. These components usually include customers, suppliers, competitors, socio-political factors and technology (Duncan, 1972). Each of these areas have been associated with innovation, particularly in relation to the question of what causes innovation. In the area of technological innovation there is evidence that consumer demand is a more important stimulus than the technology itself. This idea is reflected in Marquis' (1982: 47) Lesson No 2 which is drawn from his study of over 500 innovations: 'Recognition of demand is a more frequent factor in successful innovation than recognition of technical potential'. This conclusion is also supported by Utterback (1982: 30) who reviewed seventeen large scale retrospective studies of technological innovation and concluded that

> 60 to 80 percent of important innovations in a large number of fields have been in response to market demands and needs. The remainder have originated in response to new scientific or technological advances and opportunities.

Von Hippel (1982; 1988) and Mantel and Meredith (1986) have noted the significance of end-users as a source of ideas and even inventions. The contribution of customers to the innovation process will, however, depend on their 'sophistication' and this may differ from industry to industry (Crocombe *et al.*, 1991). The importance of demand sophistication is borne out in an empirical study by Parkinson (1984) which compared user-manufacturer interactions in the British and German machine tool industries. Parkinson found that West German customers tended to be more sophisticated, and were more likely than British customers to suggest ideas for product modification or for entirely new products. Parkinson also found that the German manufacturers were more likely to involve the user in the product design and development process. Rothwell and Zegfeld (1982) suggest that collaboration with users may be one of the reasons for the contribution of small and medium firms to scientific instrument innovation in the UK. These firms often contain limited scientific, technological and design expertise and by involving users the firm can complement its limited in-house resources.

While customers are an important source of ideas, other sources have also been shown to be important. For instance, of the 567 technological innovations studied by Marquis (1982), 128 involved key products and processes which were brought into the organisation from outside. In this process, the role of suppliers can be critical in bringing about awareness of new ideas (Utterback, 1982). Furthermore, a recent study has demonstrated the importance of suppliers to implementation success. Ettlie (1986) interviewed 55 respondents who were either users of programmable manufacturing innovations or suppliers, and found that the nature of the supplier-user relationship was the factor most frequently cited as accounting for success or failure in the implementation of the systems.

Besides 'friendly' relationships with suppliers and users, rivalry between competitors is also frequently associated with innovative activity (Crocombe *et al.*, 1991). Competition, according to Marquis (1982: 43), often explains why the minor, 'nuts and bolts' type of innovation takes place.

> So long as your competitors do it, so must you. If your competitor comes out with a better product, you must make a technical change in your own - innovate - to get around the advance in his. Thus, this sort of innovation is more intimately paced by economic factors than is innovation of the systems type or of the break-through type.

Where there is a lack of competition (as under monopolistic conditions), innovation may be stifled because the incentive for change may be judged too low. However, while innovation may be facilitated by moderate levels of competitive intensity, there is likely to be a point beyond which the financial resources in an industry become depleted, thereby limiting further innovative activity (Robertson and Gatignon, 1987).

While government policy is likely to have an indirect influence on innovation through industry competition levels, it is significant that socio-political factors have rarely been acknowledged in the literature on organisational innovation (*cf.* King, 1990). This situation contrasts with the emphasis on government R&D policy that is evident in those literatures which focus more directly on R&D management and technological innovation. Baker and Sweeney's (1978) inclusion of government policy as an exogenous input in their innovation model was influenced by this literature (particularly the work of Rosenbloom).

Besides the component areas of the environment described above, several other environmental characteristics have been linked to organisational innovation. These include environmental heterogeneity, environmental change, environmental uncertainty, and information.

According to Baldridge and Burnham (1975), a heterogeneous environment surrounding an organisation makes numerous demands that may stimulate innovation. Indictors of environmental heterogeneity in their study of schools supported this predicted relationship. On the other hand, Robertson and Gatignon (1987) have noted that a high degree of industry heterogeneity can also hinder innovation. Under these complex external conditions, communication breaks down due to a lack of common focus and innovation suffers.

In relation to environmental change, Mohr (1969) and Zaltman and Wallendorf (1979) have noted that an organisation may be more likely to innovate when its environment is rapidly changing. Zaltman *et al.* (1973: 110) suggest that

changes in markets and more intense competition tend to create 'a *situation* of stress or pressure to which the adoption unit must respond if it is to remain in a relationship of "dynamic equilibrium" with the environment'.

In a rapidly changing environment, decision-makers are likely to experience a high degree of uncertainty (Duncan, 1972). This environmental uncertainty has a positive effect on the rate of innovation (Mohr, 1969; Pierce and Delbecq, 1977). Ettlie and Bridges (1987) suggest that environmental uncertainty will increase the likelihood of radical innovation by stimulating organisations to embrace a more progressive technology policy.

Innovation also appears to be linked to a high degree of communication between an organisation and its environment (Saren, 1987). It has been suggested that the more 'open' and willing an organisation is to accept and even seek out new ideas from its external environment, the more innovative it is. Conversely, as Zaltman and Wallendorf (1979: 242) note:

> The organisation which is relatively closed to its environment is a late adopter of innovations, responding only when circumstances make it difficult not to change. Such firms use fewer sources of information and rely heavily on what actions they notice their more successful competitors are taking.

Organisations which are innovative are more likely to use a range of information channels including external consultants (Utterback, 1982), personal contacts (Myers and Marquis, 1969), and boundary spanning individuals (Tushman and Scanlan, 1981a; 1981b). Robertson and Gatignon (1987) have noted that some industries can be very closed in revealing information or may deliberately send ambiguous or potentially misleading information. These researchers suggest that communication openness and information sharing are likely to increase the available information about innovations and to ease the adoption process.

Relationships between innovation and a range of structural variables including size, complexity, differentiation, professionalism, formalisation, centralisation have been hypothesised in the literature (see, for example, Pierce and Delbecq, 1977). As will become apparent from the following discussion of empirical studies, the relationships are often found to be complex and contradictory.

Several studies dealing with the organisation size variable have shown this to be positively related to innovation (Mohr, 1969; Baldridge and Burnham, 1975; Damanpour and Evan, 1984; Kimberley and Evanisko, 1981; Fennell, 1984). However, findings of positive correlations between innovation and organisation size do not necessarily address the issue of whether large organisations adopt disproportionately more innovations than smaller organisations. Mansfield (1968b) did test for this effect and found it to hold in some industries, but not in others. Kimberly and Evanisko (1981: 700) suggest that 'it is conceivable that size is related to adoption behavior in a curvilinear fashion'. While the relationship between adoption behaviour would be approximately linear at the low end of the size distribution, at some point, organisations will acquire most or all innovations. Size increments beyond this level are not likely to lead to increased adoption.

The increased rate of innovation adoption with increasing size is usually explained using the concept of critical mass. Larger size may produce a critical mass of people who would benefit from the adoption of a particular programme. Thus, for example, a small school district is unlikely to have enough handicapped students to justify the initiation of special programmes, whereas a large district can be expected to have many students that demand such programmes (Baldridge and Burnham, 1975: 170). Similarly, large size can create problems of co-ordination and control which stimulate the organisation to adopt new practices. Finally, the adoption of innovations stimulated by these critical masses may be facilitated by the slack resources that may be available in large organisations.

However, while size may encourage innovation, it has also been suggested that innovation may also be stifled in large, bureaucratic, organisations. Thompson (1965) comments that the conditions within bureaucracy which emphasise productivity and control are inappropriate for creativity. There is too much emphasis on conformity, and the conflict necessary for innovation is absent. However, while this view is popularly held and expresses itself in the observation that 'a new idea has never come out of a large corporation', Child (1988: 221) has suggested that the evidence for this claim is not forthcoming.

It has also been argued (Mohr, 1969: 121) that 'size itself is not related to innovativeness by logical necessity' and that it is only important in terms of its *indirect* effects on organisation structure. Larger size, for example, may affect

innovation by promoting increased complexity, centralisation and differentiation.

Complexity has been defined in various ways by innovation researchers. Hage and Aiken (1970) suggest that it refers to the level of knowledge and expertise in an organisation, whereas Blau and McKinley (1979: 208) consider that it can be 'conceptualised both in terms of how differentiated the structure is and how numerous are the tasks'. Extending on this latter definition one may expect that a highly complex or differentiated structure which consists of a diversity of subunits will generally require a range of specialists to perform specialised tasks. These specialists are likely to introduce, through their external contacts, information about new ideas into the organisation. In addition, the range of different perspectives and opinions that surface among the various occupational specialties may foster the adoption of innovation. This line of argument often supports hypotheses for positive relationships between complexity and innovation (Hage and Dewar, 1975; Aiken and Hage, 1971; Baldridge and Burnham, 1975). However, some researchers have found that structural complexity impedes innovation (Blau and McKinley, 1979), while Fennell (1984) found that the impact of complexity depended on the type of innovation. One reason suggested for the adverse effect of complexity is that it brings about conflict which then makes it more difficult for an organisation to implement the innovation. Furthermore, specialisation can lead to problems of integration, with functional departments such as marketing, production, and research, all pursuing their own ends rather than that of the total organisation. As integration between departments is generally required for successful innovation (Lawrence and Lorsch, 1967), excessive 'segmentation' will inhibit innovation (Kanter, 1985).

While the degree of professionalism of organisation members is often related to innovation through its use as a measure of complexity (Hage and Aiken, 1970; Hage and Dewar, 1973), Pierce and Delbecq (1977) have identified professionalism as a distinct structural variable that is likely to be positively related to organisational innovation. These researchers note that professionals bring to their employing organisations the following qualities: richness of experience, self-confidence, ideational inputs from external sources, increased boundary spanning activity, standards of professionalism, and psychological commitment to moving beyond the status quo. As many of these qualities conform to the notion of the 'cosmopolitan' orientation, professionalism is often measured in this way. Although there is some empirical support for a positive

relationship between professionalism and innovation (Hage and Dewar, 1973; Evan and Black, 1967), there are also instances of studies which have found no relationship (Blau and McKinley, 1979; Fennell, 1984) or indeed a reverse effect (Corwin, 1972). Drazin (1990) in a recent review of the subject area, has identified the source of this apparent contradiction. He notes that the structuralist perspective tends to assume that professions represent a relatively homogeneous community, consisting of individuals who adhere to a set of collectively shared values and interests. An alternate, more radical view, would emphasise that professions are 'proactive, vested interest groups composed of members primarily concerned with the maintenance of their power and status' (Drazin, 1990: 255). Consequently, professionals will tend to resist innovations particularly where these are supported by other competing professional groups.

Formalisation refers to the degree to which jobs are codified in an organisation (Hage and Aiken, 1970: 43). Codification is expressed in written, or informally understood, rules and procedures. Hage and Aiken predicted an inverse relationship between formalisation and innovation and noted that few studies had looked specifically at this relationship despite the commonplace observation that bureaucracies are resistant to change. In their study of welfare organisations, Hage and Aiken (1970: 44-45) found a moderate negative correlation between a job codification measure and program change. Other empirical studies by Hage and Dewar (1973) and Blau and McKinley (1979) failed to find a significant correlation between formalisation measures and innovation.

Centralisation, according to Zaltman *et al.* (1973: 143), refers to the locus of authority and decision-making in an organisation. The higher in the organisation that decision-making takes place and the less the participation in decision-making that exists in the organisation, the greater the centralisation. Hage and Aiken (1970: 38) have hypothesised that the higher the centralisation the lower the rate of program change. However, these authors qualify their hypothesis by stating that this applies only to the initiation of new programs, and not to their implementation. It appears that the concentration of power in the hands of a few may stifle innovation for at least two reasons. Firstly, people with power have the potential to block attempts to introduce change in the organisation, particularly where this change is likely to threaten their position. Secondly, an organisation that is highly centralised provides less opportunity for the circulation of ideas and for the emergence of conflict which can stimulate

change. A high degree of centralisation may, however, be assisted by a high degree of centralisation. According to Zaltman *et al.* (1973: 146) 'more strict channels of authority can reduce potential conflict and ambiguity that could impair implementation'.

Beside the differential impact of centralisation on initiation and implementation, it also seems that the effect of centralisation depends on the type of innovation. Moch and Morse (1977), for example, found that decentralisation was significantly associated with the adoption of innovations that were compatible with the interests of lower-level decision-makers. Centralisation, however, did not appear to affect the adoption of 'incompatible' innovations. Similarly, Kimberly and Evanisko (1981: 697) found that centralisation was a more effective predictor of technological innovations than of administrative innovations. However, in studies which have correlated a range of structural variables with innovation, centralisation is usually found to be a much weaker predictor of innovation than complexity or size (Kimberly and Evanisko, 1981; Hage and Dewar, 1973; Moch and Morse, 1977).

The foregoing discussion has shown the effects of structural variables such as centralisation, complexity and formalisation to be contradictory. Attempts to untangle this situation have led to two approaches, firstly, controlling more carefully for different types of innovation, and secondly, relating the effects of these structural variables to different phases of the innovation process. The significance of the latter approach was highlighted by Wilson (1966) who noted that the same diversity and complexity that increased the awareness and proposing of innovations could in fact reduce the proportion of innovations that were adopted. This 'dilemma' was further illustrated by a study of large department stores which found that diversity in department store reward and task structures facilitated the conceptualisation and presentation of innovation proposals (Sapolsky, 1967). However, the diversity in department store structural arrangements, combined with the decentralisation of decision-making authority, frustrated attempts to implement these proposals. Building on these results, Zaltman *et al.* (1973) attempted to resolve the innovation 'dilemma' by constructing a theory of innovation in which structural variables were linked to the two main stages of the innovation process (i.e. initiation and implementation). According to this theory (shown in Figure 2.3), the gathering and processing of information, which is crucial at the initiation stage, is facilitated by high complexity, low formalisation, and low centralisation.

Initiation stage	Implementation stage
Higher complexity	Lower complexity
Lower formalisation	Higher formalisation
Lower centralisation	Higher centralisation

Figure 2.3 Structural variables affecting the initiation and implementation of innovations (adapted from Zaltman *et al.*, 1973: 159)

In the implementation phase, higher levels of formalisation and centralisation, combined with low complexity are likely to reduce role conflict and ambiguity which could impair innovation. Consequently, Zaltman *et al.* (1973) argue that an organisation must be able to shift its structure as it moves through the various stages of innovation. An organisation's ability to change its degree of complexity, formalisation and centralisation will however be mediated by two factors: the ability to deal with conflict and the ability to manage interpersonal relationships. In conclusion, Zaltman *et al.* (1973: 155) make the link between innovation and different 'structural types':

> the organization must shift its structure as it moves through the various stages of innovation; at the earlier initiation stage a more-organic or less-bureaucratic structure seems most appropriate. Then, as the organization moves to the implementation stage, more-bureaucratic structure becomes appropriate.

This particular view of structural types and innovation draws on the classic work of Burns and Stalker (1961). Subsequent to a field study, these researchers identified two ideal structural types which appeared to be appropriate under particular environmental conditions. A 'mechanical' or 'mechanistic' organisational structure was found to be appropriate in stable environments, whereas 'organic' organisational structures existed best under uncertain and

turbulent conditions. In terms of the structural variables defined earlier in this chapter, a mechanistic structure would be characterised by the precise definition of rules and procedures (high formalisation), a hierarchical structure of authority and control (high centralisation), and the fragmentation of tasks (low complexity). By comparison, in an organic structure, responsibilities are defined loosely (low formalisation), control and authority relationships take the form of a network (low centralisation), and there is a reliance on the expertise and skill of specialists (high complexity) (Hage and Aiken, 1970: 69).

While some researchers state that there is empirical support for the notion that organic organisations are more innovative (Hage and Aiken, 1970; Aiken and Hage, 1971, Hage and Dewar, 1973), this view was not supported by the results of Project SAPPHO which sought to identify the causes of failure and success in industrial innovation (Science Policy Research Unit, 1972). Furthermore, the theory by Zaltman *et al.* (1973) described above contradicts this position in that it suggests that an organic structure is required for the initiation of innovations, whereas successful implementation may require a mechanistic structure.

An even more recent challenge to the usefulness of structural typologies in explaining innovation has emerged in the form of 'dual-core' models of organisational innovation. Daft (1978), for example, has suggested that innovation action takes place in two different areas of the organisation - the technical core and the administrative core - and each core will tend to be interested in different types of innovations. Moreover, organisations may 'vary in the relative innovativeness and degree of coupling' between these 'dual cores' (Daft, 1978: 207). Therefore, rather than seeing an organisation as either organic or mechanistic in nature, recognition should be given to the possibility that within a single organisation, different departments may exhibit different structures along an organic-mechanistic continuum. Kanter (1985) in her 'change masters' research has built on this notion. She suggests that innovation may be facilitated by 'parallel structures' in which task forces operate alongside a core structure concerned with more routine operations.

The final variable to be considered in this section is strategy. Although strategy and its ability to influence innovation is often attributed largely to individual action, there are some studies which present strategy as an objective reality which possesses identifiable and measurable characteristics. Typical of this approach is Johne's (1984) study of the innovation performance of 16

manufacturers of test instruments. In this study, the strategic type of an organisation (as measured by expert opinion) was found to be an important determinant of the pace and type of technological innovation. Johne found that manufacturers pursuing a follower strategy placed more emphasis on process innovation whilst manufacturers pursuing a leader strategy placed more emphasis on product innovation. Strategic types were also employed by Nicholson *et al.* (1990) who, on the basis of case study profiles of eight organisations, concluded that there were, as expected, high levels of innovation in the successful prospector-like companies. Saren (1987), however, considers it doubtful that strategy itself is a prime determinant of innovation, citing the possible interconnectedness of various determining factors such as structure, environment, technology as a major impediment to understanding the role of strategy in the innovation process.

This chapter has, thus far, used the individualist and structuralist perspectives as a means of organising the extensive literature on innovation in organisations. The overview, however, also reveals that these two perspectives have tended to encourage and support research studies which focus predominantly on the identification of the key determinants of innovation and use particular research methodologies. This type of research activity has been referred to as 'antecedent research' (King, 1990). The following section will address some the conceptual problems that relate to this research.

Conceptual issues in research characterised by the dominant perspectives

The structuralist and individualist perspectives are reflected in the extensive literature which has built up in relation to the determinants of innovation in organisational settings. In spite of the effort made, however, the results of this research have not been cumulative in the sense that they might provide a basis for developing accurate generalisations about innovation. Rather, it has been argued that there is 'no real theory that permits us to predict confidently the extent to which - or the time at which - a given organization will adopt a given innovation' (Downs and Mohr, 1979: 380). A central problem is the apparent lack of stability in results (Downs and Mohr, 1976: 700):

> Perhaps the alarming characteristic of the body of empirical study of innovation is the extreme variance among its findings, what we call

> instability. Factors found to be important in one study are found to be considerably less important, not important at all, or even inversely important in another study.

While Downs and Mohr (1976) suggest that there are four sources of instability - variation among primary attributes, interaction, ecological inferences, and operationalisations of innovation - only two sources are emphasised in later work by the same authors (Downs and Mohr, 1979; Mohr, 1982). These sources - interaction and inconsistency - warrant some explanation.

Interaction - the dependence of the impact of one phenomenon on the presence or level of another - is a major impediment to theoretical development not only in innovation, but in other fields as well. Mohr (1982: 15) even goes as far to suggest that interaction is 'the greatest single problem facing social theory at this stage of development'. In relation to innovation research, interaction effects may explain why determinants which may be important for specific types of innovation, are found not to be relevant for other types. It appears that many determinants possess no single, unique effect, instead their level of impact is contingent on other variables. For example, organisational wealth may impact more significantly on decisions surrounding the adoption of a costly innovation, such as a mainframe computer, than on those concerning a relatively costless innovation, such as the introduction of new office procedures (Downs and Mohr, 1979: 382) Interaction effects may also explain variations in the impact of the same determinant from innovation to innovation (Downs and Mohr, 1979: 382). For example, an organisation's degree of centralisation can depend on whether the innovation under consideration is an administrative or technological innovation. Thus, the properties of organisation cannot be measured accurately without reference to the organisation. Similarly, an innovation often cannot be classified without reference to the organisation for the reason that different organisations may classify the same innovation into different categories (Downs and Mohr, 1976: 704). Thus an innovation that costs x dollars, may represent a major cost to one organisation yet it may be a low cost to another.

The contradictory results found in the innovation literature stem from a failure to account for these various interaction effects. Rather than merely calling for more research, a more fruitful approach, according to Downs and Mohr (1976: 701), would be to reject the pursuit of a single (and all explaining) theory of innovation. Instead, the view should be adopted that alternative theories for

different types of innovations coexist. Theory development would also be achieved by focusing on the innovation *in relation to a particular organisation*, rather than by taking either the innovation or the organisation as the unit of analysis (Downs and Mohr, 1976).

Inconsistency in the rendering of variables is the other main source of instability in innovation research. There has been a widespread tendency to use the same name to refer to two or more quite different variables. This is particularly evident in the treatment of the concept of 'innovation' itself. Frequently used as the dependent variable in research studies, innovation can be operationalised in at least three different ways (Downs and Mohr, 1976: 709). These include the time of adoption, a binary score based on adoption or non-adoption, or the extent of implementation. The use of different operationalisations, each of which measures a different aspect of innovation, places obvious limits on attempts to generalise across studies. Finally, innovation researchers have also experienced considerable difficulty in operationalising and measuring structural variables (Van de Ven and Rogers, 1988: 636).

Besides messy operationalisation, inconsistencies also stem from confusion between variance theory and process theory. Variance theory is characterised by explanations of outcomes in terms of necessary and sufficient causes. These causes are expressed as (independent) *variables*, hence the term variance theory. By contrast, process theory is concerned with explaining outcomes in terms of the *probabilistic rearrangement* of discrete states and events. Unlike in variance theory, the time ordering among the contributing events is generally critical for the outcome.

According to Mohr (1982), difficulties arise where the two fundamentally distinct types of theory are mixed. For instance, there is a tendency for researchers to 'think process and write variance' (Mohr, 1982: 13). The other tendency is to try to force process theory into the variance theory mould, especially to bend it to the requirements of the statistical techniques so favoured by structural functionalist and structural contingency theorists. Burrell and Morgan (1979) note that while these theorists adhere to an open systems approach which is essentially processual in nature, in their empirical research they tend to equate the organisation to temporary structural characteristics such as technology and bureaucratisation. Consequently, in measuring these characteristics the processual nature of the organisation system is generally overlooked (Burrell and Morgan, 1979: 180):

> The incongruence between theory and method which this reflects is a fundamental problem facing social systems theorists in general. The processual nature of 'system' does not lend itself to meaningful study through the use of quantitative snapshots of objectified social structures.

While most studies of organisational innovation have attempted to contribute to variance theory by testing independent variables for their effect on innovation or innovativeness, process theories of innovation have been developed by researchers including Zaltman *et al.* (1973: 62) and Hage and Aiken (1970: 113). In these models the processual nature of innovation is conceptualised as a sequence of functional stages, or phases (also see Chapter 1).

According to Schroeder *et al.* (1986) there is a striking similarity between innovation process models and those models which deal with individual decision-making, and group and organisational development. Not surprisingly therefore, process models of innovation have drawn the same criticism as have many other staged models of organisational processes. Pettigrew (1985: 16) considers staged innovation process models to be severely limited because of the highly rational and linear theories which drive them, while Mohr (1982: 53) considers that they are

> incomplete from the standpoint of theory in that they simply rehearse a series of steps; they lack the lines of action - either causal or probabilistic - that must be present to convey a sense of explanation.

Schroeder *et al.* (1986: 503) add to this criticism by commenting that a 'growing body of evidence suggests that organisational innovation and change processes are considerably more complex' than the stage-wise models would tend to indicate. On the basis of their own research findings, Schroeder *et al.* (1986: 521) argue that innovation is characterised by a 'much more complicated multiple progression process of divergence, parallel, and convergent streams of activities'. In a final blow, Schroeder *et al.* (1986: 503), suggest that most process models of innovation and change in the literature are

> normative prescriptions without adequate empirical evidence to substantiate their validity. With the exception of retrospective case histories of organizational innovations, very little longitudinal empirical study has been conducted to evaluate these process models.

Mohr (1982: 213) predicts that in the future the process-theoretic approach will gain substantially relative to variance theory. Not only, as the quote immediately above would suggest, does this call for different methodologies to be employed, but also it lends itself to an interactive process perspective on action.

The interactive process perspective

The study of organisational innovation has been dominated by a focus on the structural and individual determinants of innovation. However, since the publication of a critical review by Downs and Mohr (1976), there has been increasing interest in process research on innovation in organisations. Even the celebrated Everett Rogers has recently called for more research on the innovation process, particularly where this research will move beyond 'a stage-to-stage conception of the innovation process, to a dynamic, continuous conception of change over time' (Van de Ven and Rogers, 1988: 638).

The type of 'process research' which Van de Ven and Rogers (1988) advocate, involves the description of the temporal sequence of activities that occur in the development and implementation of innovations. The subsequent analysis of these processes may shed light on questions relating to how and why innovations develop over time. As stated in the previous section, the aim in process research is not to establish 'efficient causes', but rather to explain change in terms of the *probabilistic rearrangement* of discrete states or events over time (Mohr, 1982: 38). More specifically, Mohr (1982: 45-46) states that the resulting process theory should explain

> the pairing or other rearrangement of mutually autonomous objects, such as the bets of the players and the number on the roulette wheel, whose individual courses are determined independently of one another by forces external to the core of the theory.

In organisational settings, the 'objects' to which Mohr refers will usually be events or states that are associated with different levels of analysis. For instance, some events and states may relate directly to the purposive actions of individual actors, while others may emanate from external structural influences. However, in attempting to generate theories that will specify the conditions under which these multi-level events will join or separate, there is an implicit need to address the complex, and paradoxical, relationship between action and structure. In particular, attention needs to be given to understanding how action and structure interrelate. It is this particular requirement which sets the interactive process perspective apart from the individualist and structuralist perspectives. The latter have seen innovation as *either* being caused by individual actions *or* by objective structures.

A focus on the interconnection of action and structure is distinct from mere multi-variate analysis. While some innovation studies have correlated variables from more than one level of analysis with measures of an organisation's innovativeness (see Hage and Dewar, 1973, Baldridge and Burnham, 1975; Pierce and Delbecq, 1977; Kimberly and Evanisko, 1981), they have not operationalised the notion of interconnection of action and structure over time. Rather, in these cross-sectional studies, the predictive power of discrete independent variables was of greater interest than an understanding of how the various factors impacted on one another.

Although the interconnection of action and structure is a crucial feature of the interactive process perspective, the reconciliation of action and structure in social and organisation theory has not been without problems (see Ranson *et al.*, 1980; Giddens, 1979). Van de Ven and Poole (1988) suggest that these difficulties might potentially be addressed in four ways. Firstly, the underlying paradox can be addressed by acknowledging the existence of both deterministic and voluntaristic aspects of social systems. For example, the two opposing perspectives on action could be employed separately to provide different 'lenses' with which to view the same phenomenon. Secondly, action and structure may be reconciled by spelling out the various levels of analysis and clarifying the connections between them. Thirdly, time can be used to relate action and structure. For instance, theories may be developed which link varying levels of interaction between action and structure with different phases in a temporal sequence. Fourth, new theories of the action-structure relationship can be

developed and used to inform analysis. An example of such a theory is structuration theory (Giddens, 1979).

The first of these approaches, which involves accepting the existence of both deterministic and voluntaristic aspects in the innovation process, is the most basic means of addressing the action-structure paradox and hence is reflected in most innovation process studies. Some studies, however, do not progress much further from this position. The 'descriptive model of the intra-firm innovation process' proposed by Knight (1967) illustrates this point. In his model, Knight identifies four different types of innovation and provides a general model of the organisational search process. Then, in a separate section, 'the innovator' is discussed in terms of two important attributes: the desire to innovate and the power to innovate. While the model does identify factors at different levels (i.e. the innovator and the organisation), Knight does not explicitly set out to link them.

By contrast, Normann's (1971) research into thirteen product development projects demonstrates a more concerted attempt to connect factors from different levels. Although the stated objectives of the research involved the description and analysis of the actual processes involved in product development, as well as a description of aspects of the organisational context including the formal organisation, communication systems and the external environment, Normann (1971: 203) recognised the need to link the levels:

> In describing the process of product development ... it is necessary to distinguish between the levels of environment, product, and organization; furthermore, the description of one level must take the other two into account.

In his analysis, Normann examined the political actions of individuals as well as the cognitive systems by which people in the organisation get information about the external environment and perceive events in it. These factors were then related to the main characteristics of the environment and to two types of new product configuration. Normann found that one product configuration type (called a variation) can be accommodated within the existing political and cognitive systems of an organisation, whereas another type (called a reorientation) tends to be associated with changes in these systems. Normann (1971: 214-215) concluded the report of his research as follows:

> The conceptual scheme and the propositions developed from the data suggest that innovation is a very complex process which should be considered in the large context of the organization-environment relationship. Furthermore, a recurrent theme has been that innovation can be understood only in the context of the very complex interaction patterns between cognitive and political processes in organizations. These interaction patterns are an important field for further research.

While Normann's conclusion may not necessarily have directly or substantially informed subsequent research in the field, this early inductive study has been followed up by more extensive attempts to understand the complexity of the innovation process. These attempts have been part of a rising wave of interest in process research which started in the 1980s and has carried through into the 1990s. This interest has produced some outstanding work including several large scale projects which have not only sought to clarify connections between levels of analysis but have also examined these relationships over time. As a result, these studies are characterised by longitudinal research methodologies.

A pre-eminent example of this large scale research mentioned is the work which has been undertaken as part of the Minnesota Innovation Research Program (see Schroeder *et al.*, 1986; Van de Ven *et al.*, 1989). This particular programme examined fourteen innovations in terms of four central concepts - new ideas, people, transactions and contexts. As part of the larger study, Schroeder *et al.* (1989) described seven innovations (four new product technologies and three new administrative arrangements), and identified several key observations as to how these developed over time. They found that most innovation processes 'can be traced to some kind of shock that stimulated peoples' action thresholds to pay attention and initiate novel action' (Schroeder *et al.*, 1989: 123). This notion, Schroeder *et al.* (1989) argue, is closely related to March and Simon's (1958) hypothesis that dissatisfaction with performance stimulates search for improved conditions, whereas satisfaction suppresses search. However, while shocks such as new leadership or impending loss of market share may stimulate the innovation process, Schroeder *et al.* (1989) also suggest that the initial idea will tend to proliferate into several new ideas as the process ensues. Unpredictable setbacks may also be experienced. At the same time, the organisation may be restructured in order to better handle the innovation process. Throughout the

innovation process, the role of managers positioned between one to four levels above the project team was found to be critical (Schroeder *et al.*, 1989: 132):

> Top management controls proliferations, deals with setbacks, helps to link the old and the new, and restructures the organization as needed, in addition to providing general goals and resources to support the innovation.

While Van de Ven *et al.* (1989) focused on innovations from various industrial sectors ranging from agriculture to military equipment, Walton (1987) developed a comprehensive framework for understanding and managing innovative change on the basis of a detailed study of a single industry - international shipping. Walton's intention was to provide answers to fundamental questions about innovative change: why does innovation take place, what is the nature of the change, and how is the innovation developed, implemented and diffused. According to Walton (1987: 28-29), the capacity for innovative change in a social system is

> strengthened to the extent that innovative change is (1) guided by models that are sound; (2) motivated by economic incentives that are strong and that align the interests of all groups with a stake in the change; (3) supported by values and other social factors sympathetic to the innovation; (4) facilitated by institutions with a structure and climate that make it easier to sponsor, reach consensus, and process information about innovations; and (5) managed by individuals with the relevant competencies.

While Walton proposes that the five components each directly influence the degree of innovative change, he also stresses that innovative capacity is also determined by the interaction between the factors over time. For example, the model or 'vision' that guides the innovation process may be shaped by the particular combination of motivational forces and the competence of individuals who manage the innovation process. Similarly, exposure to the innovation process may add to the level of competence of participants and influence their attitudes and beliefs towards the innovation.

Besides emphasising the interaction of influence factors, Walton's framework also acknowledges factors at the level of the individual, the organisation and the environment (Walton, 1987: 25):

> Regardless of the level of one's primary interest, however, one must also take into account conditions at the other levels. An innovation may simultaneously be influenced by conditions and policies at the national level, at the industry level, and so forth.

In addition to the five interacting components described above, Walton (1987) suggests that the capacity to innovate is modified by external forces of two types. Firstly, broad technological, market and political trends in the environment may impact on the innovative capacity of the social system in question. Secondly, innovation may be influenced by a factor called 'metacompetence', which is represented by the actions of decision-makers to modify the social system or environmental factors in order to make then more favourable to innovative change.

Walton (1987: 326) explicitly indicates that he has attempted to integrate variance and process theory. Moreover, he notes that his theoretical framework has marked similarities with the content/context/process framework used by Pettigrew (1985) for the analysis of strategic change at ICI. Pettigrew (1987a: 657-658) defines the core concepts in his framework as follows:

> Outer context refers to the social, economic, political, and competitive environment in which the firm operates. Inner context refers to the structure, corporate culture, and political context within the firm through which ideas for change have to proceed. Content refers to the particular areas of transformation under examination. Thus the firm may be seeking to change technology, manpower, products, geographical positioning, or indeed corporate culture. The process of change refers to the actions, reactions, and interactions from the various interested parties as they seek to move the firm from its present to its future state.

Pettigrew (1985; 1987a; 1987b) has expressed a dissatisfaction with much of the theory and research on change. Some of the main faults with this body of knowledge, according to Pettigrew, include a lack of emphasis on the effect of

the outer context on change, a lack of any historical analysis and a tendency to develop highly linear and rational models of process. In response to this, Pettigrew argues that change should be analysed in terms of the continuous interplay between the context (outer and inner), the content, and the process, of change. Besides this 'processual' and 'contextualist' approach, Pettigrew also argues for a historical method based on longitudinal case studies.

Although Pettigrew tends to write about strategic change and not about innovation, processual and contextualist approaches similar to his own have informed research projects undertaken by the Work Organisation Research Centre (WORC) on 'strategic innovation'. This research includes a detailed analysis of the SD1 project within the Rover Company during the period 1968-1982 (Whipp and Clark, 1986). This particular study of 'design and innovation' extended on Abernathy's categories of 'product innovation' and 'process innovation' by focusing on the three-way combination of the product, its process of manufacture, and the form of work organisation involved. The latter combination is fundamental to the definition of 'strategic innovation' provided in another WORC study by Child and Smith (1987: 566):

> For firms, strategic innovation refers to major systemic decisions and their implementation concerning the choice of products and markets, of production processes and technologies, and of work organization. It therefore involves a significant transformation for the organizations concerned.

In Whipp and Clark's (1986) study, the analysis of the three interrelated areas of design and innovation was guided by a framework which consisted of four elements: a historical dimension, societal comparisons, enterprise structures and processes, and the sector. The emphasis on 'the sector' in this study is common to other major WORC research projects including Child and Smith's (1987) research on Cadbury Ltd, and Starkey and McKinlay's (1988) comparative study of innovations in work organisation in four major organisations.

Besides attempting to account for the role of both action and structure in the innovation process, an analysis of the studies described above reveals at least three other important aspects of the interactive process perspective in use. Firstly, there is a widespread rejection of the rational economic model of decision-making (Starkey and McKinlay, 1988: 115). Instead, the non-rational

aspects of organisational behaviour are deemed to be important and significant. Consistent with this view is the attention which tends to be given to the political context in which innovations are introduced (see Normann, 1971; Child and Smith, 1987). Secondly, an emphasis is placed on trying to understand the dynamic nature of the innovation process and the changes that occur to the innovation of interest. In particular, it is now widely accepted that innovations do not remain static during the innovation process, rather, they may be transformed by it (see Walton, 1987: 319; Rice and Rogers, 1980: 500-501). Thirdly, the interactive process perspective has major methodological implications. The use of longitudinal case studies is prevalent, as is a focus on induction. For example, Van de Ven *et al.* (1989: 108) explicitly state that they used a 'grounded theory approach'. A small number of cases usually provides the focus for research, although some researchers (e.g. Bessant and Grunt, 1985) have opted to study relatively large numbers of cases following a sampling logic.

Summary

Several perspectives have informed the development of theories which specifically focus on innovation in organisations. Each of these perspectives offers a different way of looking at the objects or processes of interest. The differences in approach stem from the underlying assumptions which are set in relation to considerations such as the ontological status of organisations and the nature of human behaviour.

This chapter has delineated three 'perspectives on action' germane to innovation in organisations. These were respectively referred to as the individualist perspective, the structuralist perspective and the interactive process perspective. The individualist perspective seeks to explain innovative behaviour in terms of the characteristics and actions of individual participants, whereas the structuralist perspective assumes that innovation is determined by the structural properties of organisations and environmental components. By contrast, the interactive process perspective adopts a mid-position in which action is seen to be neither determined solely by individual action nor by structural properties. This perspective argues that the interconnection of both structure and action must be taken into account.

Of the three perspectives, the structuralist view has tended to predominate in innovation research. In recent years, however, some innovation researchers have become dissatisfied with the assumptions, methodologies and research orientations which are associated with this particular perspective. Not only has the emphasis on structural determinism been considered to be too limited, there has also been a concern as to whether the appropriate research questions have been addressed. In particular, Van de Ven *et al.* (1989: 3) found that the process of innovation and its complexities were still poorly understood in spite of the large research output focusing on the structural determinants of innovation. This, in conjunction with other concerns, has encouraged a new generation of innovation research which has been informed by an interactive process perspective. The longitudinal case study has been the most commonly adopted research strategy in this recent body of work on innovation.

These theoretical and methodological considerations provide an important background to the empirical study that will be outlined in the next chapter. The main focus of this study is on the processes associated with the utilisation of ergonomics knowledge in organisational settings. The analysis of the empirical data presented in Chapters 4 to 7 will focus on several levels and attempts will be made to link these. Thus, the role of particular individuals in the innovation process will be examined and their involvement will be related to wider organisational and environmental contexts. Given this emphasis on processes in context, the orientation adopted in this study will be more closely aligned to that of the interactive process perspective than to those of the individualist and structuralist perspectives.

Chapter Three

Research Design and Methods

Introduction

This chapter starts with the central research problem and describes how this was translated eventually into three research questions. These questions broadly relate to how and why ergonomics capability emerges and develops in organisational settings. Having discussed the formulation of the research questions, the chapter proceeds to identify the research strategy and methods used. Given the focus of the research questions on processes and contexts, the comparative case study method was considered to be an appropriate strategy and ultimately a case study design of six cases was constructed and employed. The remaining sections of the chapter address methodological considerations such as gaining access and data collection techniques. The chapter concludes by outlining how the data collected in the field were analysed.

Research questions

The design of the empirical study introduced in this chapter was consistently guided by an interest in the relationship between the propensity of an organisation to make use of ergonomics expertise and organisation-level factors. This interest can be traced back to a combination of influences. Firstly, the author had been following a rising interest within the ergonomics field in relation to organisation design and management issues (see Hendrick and Brown, 1984; Brown and Hendrick, 1986). In monitoring this trend, a number of publications had been identified which linked the use of ergonomics

knowledge to organisational factors (e.g. Liker *et al.*, 1984). This literature is described in Chapter 1. Secondly, around this time the author was involved in a consulting project which revealed, amongst other things, that particular organisational structures impacted negatively on the implementation of ergonomic programmes. The interest created at the time by these (and other) events was subsequently translated into a broad research objective which focused in particular in the identification of organisational factors that influence the use of ergonomics knowledge.

Further literature search and analysis subsequently revealed that the general problem surrounding the use of new ideas, knowledge and practices in organisational settings had also been addressed in a relatively large group of studies from the innovation literature. However, as this latter body of literature was examined in more depth, a number of significant theoretical and methodological problems came to the foreground. For example, those innovation studies which have set out to determine the structural characteristics (such as organisation size, complexity, and differentiation) that facilitate and inhibit some aspect of organisational innovativeness have been plagued, amongst other things, by operationalisation and measurement difficulties (Downs and Mohr, 1976; Van de Ven and Rogers, 1988). However, as the research of the past was being criticised, ways forward for future efforts were also being suggested (see Mohr, 1982). On this basis, it was considered desirable to substantially adjust the initial research objective described above. Rather than seek to identify the key determinants of ergonomics knowledge use, it was decided to examine the *processes* by which ergonomics knowledge comes to be adopted and implemented within organisations. Furthermore, it seemed appropriate to locate these processes not only within the *context* of organisation-level influences but also in relation to the wider economic and socio-political environment (see Pettigrew, 1985; and Chapter 2). Given the comparative 'paucity' of descriptive research focusing on innovation and change processes (Schroeder *et al.*, 1986: 502), it was considered that the latter approach would be able to provide a more substantive contribution to current understandings in respect of ergonomics knowledge use.

While the focus on processes which unfold over time continued to guide the research, the central research questions were refined as the data collection and analysis got underway. A significant aspect of this further refinement was a change in the terminology and concepts employed. Firstly, the concepts

'adoption' and 'implementation' were replaced by more dynamic terms such as 'emerge' and 'develop'. Secondly, in preference to 'ergonomics knowledge', the concept of 'ergonomics capability' was formulated and subsequently employed. The latter concept was introduced to acknowledge that in the process of using knowledge, organisations may also at the same time create knowledge. The precise rationale for this will be discussed in Chapter 5. The central three research questions which eventually guided the data collection and analysis were: (1) What changes in ergonomics capability take place in organisations? (2) How does ergonomics capability emerge and develop within organisations? and (3) What are the contextual factors facilitating or impeding the emergence and development of ergonomics capability in organisations?

Research strategy

Given that the research questions outlined above are largely directed towards understanding *processes in context*, the most appropriate research strategy is the case study method. As was discussed in Chapter 2, innovation and change researchers (Van de Ven and Rogers, 1988; Pettigrew, 1985) have recognised the suitability of the case study method for studying continuous processes within their various contexts. They argue that researchers may come to a better understanding of the events that unfold over relatively long periods of time by focusing their attention on a limited number of cases. This opportunity to study processes over time does not present itself to the same extent in survey research. A second reason for using case studies is that this method allows the wider context in which innovation and change occurs to be fully examined (Pettigrew, 1990). As Yin (1989: 23) has noted, it is this aspect of the case study method - its ability to focus an investigation onto 'a contemporary phenomenon within its real-life context', when 'the boundaries between phenomenon and context are not clearly evident' - that sets it apart from other methods such as histories and surveys.

The approach adopted in this research was to use case studies to come to an improved theoretical understanding of the emergence and development of ergonomics capability. In other words, the case study technique will be used as a means of building theory rather than testing hypotheses and propositions (Glaser and Strauss, 1967; Smith, 1989). The decision to pursue the former

direction was influenced by the following considerations. Firstly, as relatively little had previously been documented about the phenomena of interest and the particular settings which were to be eventually chosen for further study (*cf.* Whipp and Clark, 1986: 212), there seemed to be a need for descriptive research. Secondly, given the author's lack of familiarity with the research setting, there was a real danger of unsuitable concepts being selected and imposed on participants. Instead, the approach favoured was to try to understand the emergence and development of ergonomics capability from the point of view of those who were directly involved. Such an interpretive approach may lead to the generation of new concepts and categories (Patton, 1990).

At an early stage it was decided to focus on a small number of cases, rather than on a single case. The use of multiple cases was considered to be a superior option as comparisons and contrasts between the cases can be made. Miles and Huberman (1984: 151) have observed that

> by comparing sites or cases one can establish the range of generality of a finding or explanation and at the same time pin down the conditions under which that finding will occur. There is much potential for both greater explanatory power and greater generalizability than a single case study can deliver.

Having settled on the comparative case study method, some decisions also had to be made regarding the exact nature of the setting to be examined. This is because ergonomics knowledge may be used in at least two different parts of an organisation. On the one hand, ergonomics knowledge may be used as an input to the design of products, while, on the other hand, it may be used to inform the assessment and modification of production machines and processes. Singleton (1982: 13) refers to these two orientations respectively as *product ergonomics* and *production ergonomics*, and notes, furthermore, that they differ in several important respects. First, in production ergonomics the key operator is the production worker; whereas product ergonomics is concerned primarily with the product user. Second, production ergonomics is related to the disciplines of industrial engineering, work study, occupational health, and safety engineering. Product ergonomics, on the other hand, is more closely linked to the disciplines of industrial design, design engineering and marketing. These differences have significant implications for the study of ergonomics capability in organisations as it is possible, and indeed likely, that capabilities in product ergonomics and

production ergonomics will evolve at different rates and in differing circumstances. It was decided to focus on product design and development although the transference of knowledge between this, and other, functional areas of an organisation was also a topic of considerable interest.

Taking an organisational site as the unit of analysis, it was decided to select pairs of organisations from a population of those firms (referred to here as a 'sub-sector') which have overlapping interests in at least one product-market. In all, three pairs of organisations were selected for further research and the 'multiple-case design' (Yin, 1989: 52) produced, allowed for comparisons to be drawn not only between organisations within the same sub-sector, but also between organisations in different sub-sectors.

While the 'representativeness' of the six cases was not a consideration in their selection (for reasons outlined in Mitchell, 1983), several other criteria did play a role. In selecting appropriate sub-sectors for study, an overriding consideration was that the products of interest should have a significant user-product interface. In other words, there had to exist a reasonable potential to apply ergonomics knowledge to the product. In this respect it is apparent that ergonomics is a more important consideration in some product-markets than in others. For example, ergonomics is less likely to be considered to be an important feature in the design of an electric fence generator than in the design of a car. The product-markets chosen - fuel pumps, electric ranges, and office seating - are all based on products with a non-trivial user-product interface.

A second factor that determined the choice of product-market, was the requirement that its associated sub-sector should consist of at least two organisations operating from a manufacturing site within New Zealand. This criterion imposed some limitations on the choice of cases as some product-markets in New Zealand are only served by a single organisation. For example, there is only one New Zealand-based manufacturer of refrigerators. A further consideration was that each pair should, where possible, consist of an organisation that had acquired a reputation as being a 'design leader' in its respective sub-sector. This, it was hoped, would maximise the insights obtained as comparisons could be drawn between leaders and non-leaders in the same sub-sector as well as between leaders (and non-leaders) across the three sub-sectors.

A third criterion was that the organisations selected would be 'product developer/manufacturers' rather than mere manufacturers. This excluded from selection any organisations which were merely involved in the manufacture of products under license to overseas companies. New Zealand manufacturing has historically been highly dependent on imported technology, components, and product designs (Golledge, 1964; Cullwick and Kan, 1983).

The selection of sub-sectors was also substantially influenced by opportunity and ease of access. As is common in case study research (see Buchanan *et al.*, 1988), the selection of organisational sites was, to some extent, 'opportunistic' in that use was made of professional contacts in gaining access. In this respect, the author made use of her contacts through the member network of the New Zealand Ergonomics Society.

Finally, the selection of cases was influenced to some extent by location. Initially, for reasons of practicality, the researcher wished to limit the choice of research sites to the immediate geographical region. However, given the spread of industrial centres in New Zealand, this criteria had to be relaxed. As a consequence, the distance between the two most remote research sites was about 800 kilometres.

Given these criteria, the three pairs of organisations listed in Table 3.1 were studied.

Table 3.1
Case names of six organisations from three product-markets

Product-market	Case name	Name of organisation (early 1991)
Petrol pumps	PEC	PEC Ltd
	Fuelquip	Fuelquip Services Ltd
Electric ranges	RDD	Range and Dishwasher Division - a division of Fisher and Paykel Industries Ltd
	Atlas	Manufacturing Division - a division of the Email Ltd subsidiary Simpson Appliances (NZ) Ltd
Office seating	Formway	Formway Furniture Ltd
	Feltex Furniture	CoDesign (NZ) Ltd - a division of the BTR Nylex Ltd subsidiary CoDesign Ltd

Negotiating access

The fieldwork commenced in October 1989 following the negotiation of access to Formway. Gaining entry to this organisation did not present any difficulties mainly because the author had known several individuals in the organisation including senior managers since the mid-1980s. The issue of the organisation's participation in the research was first broached quite informally with the managing director during a telephone conversation. The initial response was favourable, although it was qualified by a comment from the managing director that the other partners in the business would need to be consulted. It was then suggested that the matter be pursued further through the research director, who also was a partner in the business. This suggestion was taken up and, following an on-site meeting with the research director at which issues of confidentiality and access were discussed, the go-ahead to proceed was given.

The level of access granted by Formway's management was substantial. The owner-managers were forthcoming with information and the author was given unrestricted access to all areas of the plant. This included open access to the design and development work area in which commercially sensitive product development work was being carried out. This openness meant that the process of familiarisation with the company's manufacturing activities and product development processes was easy and relatively quick. In addition, the owner-managers assisted in making a range of documents freely available. Being able to oversee the various types of documents that are produced and stored within relatively small organisations enabled the author to ascertain the range of documents that might be available at other sites and their potential significance to the research. This meant that the author was able to weigh up the risks associated with asking for sensitive information of potentially limited value in less receptive research sites where trust relationships were more tenuous.

Personal contacts with manufacturing managers at the other sites were instrumental in the researcher gaining access to Feltex Furniture (latterly CoDesign-NZ) and RDD. Access to Fuelquip was negotiated at a formal meeting in March 1990 with the general manager and the manufacturing manager, while access to RDD was in fact 'offered' to the researcher. During 1990, the researcher had conducted two training seminars at RDD on aspects of occupational ergonomics. At an informal meeting following the first seminar (conducted in June 1990), the manufacturing manager suggested rather casually

that the researcher might wish to use RDD as a case in her research. After considering the potential suitability of the case, the researcher sought formal approval from the division manager during her next visit in September 1990 and arranged for further fieldwork to be conducted during January 1991.

In contrast to the research sites just mentioned, where access was gained through professional contacts, the researcher had had no prior link with either PEC or Fuelquip. In early 1990, the organisations were approached initially through a telephone call to the general manager. After a brief introduction, an appointment was requested so that the nature of research could be explained more fully. The responses to these telephone requests were mixed. The general manager at Fuelquip responded positively, but the reaction of the general manager of PEC was initially unfavourable. In the latter instance, the researcher was informed that PEC was a 'lean and mean' operation and the general manager could not, given the harsh business environment, afford to have his staff spend valuable time being researched. Nevertheless, after some persuasion, the general manager stated that the organisation would co-operate given that the author was based at a university with which PEC had developed a fruitful relationship.

While initial and ongoing access to PEC was problematic, access to the Atlas site was denied. The first approach to the latter organisation was by way of a telephone conversation with the most senior manager, who turned out to have the title of plant manager. This initial contact was followed up by an on-site meeting at which the issue of access was discussed more fully. While the plant manager indicated some interest in participating in the research, the matter was referred to the organisation's Head Office for approval. However, the researcher was subsequently informed by a letter from the plant manager that access would not be granted. No reason was stated. The lack of access to this organisation was particularly unfortunate in light of the particular multiple-case design chosen: the site could not be replaced with another as there were no other electric range manufacturers based in New Zealand. Consequently, despite the lack of access to organisation members, a decision was made to use the background information collected during the initial meeting with the plant manager and to supplement this with secondary data and material provided by external informants.

At initial meetings such as those described above, the research project would be outlined and its exploratory character would be emphasised. Some managers had obvious difficulty with this aspect of the research, while others were more appreciative: one took the view that his organisation was 'learning all the time too'. At these initial meetings, the researcher was conscious of the need to establish a relationship of trust while not making any promises that could not be fulfilled. For example, the author was careful not to commit herself when a manager at one research site expressed the hope that his company and its products would be portrayed in a favourable light in the final thesis. Similarly, at another site, the author was asked if she would consider writing an article about industrial design and in this mention the organisation's commitment to it.

At these meetings, confidentiality in relation of commercially sensitive information was also discussed. In this context, the author pointed out that the organisation would not need to modify existing policies relating to the disclosure of new product information and restrictions on access to design and development areas to outsiders. It was explained that the focus of the research was on the past and present (or, at least, relatively recent) use of ergonomic inputs in the design and development process, rather than on the detail design of products yet to be released. In one organisation, information about the nature of new products was consciously withheld from the researcher. This was indicated by the very general and 'coy' comments made by informants from this organisation. In other organisations, however, top managers and design team members specifically asked the researcher for her views on the ergonomic aspects of product prototypes under development. In the latter instances, the researcher was relatively well-known to the people concerned, whereas in the former case, the researcher was not previously known. It is reasonable to argue that relationships of trust mediated the level of access granted to commercially sensitive information.

Data collection methods

Interviews, documents, and direct observation were used as a set of complementary techniques to generate a database of information about circumstances and events in relation to each case. Data collection commenced in October 1989 and continued until late 1991. During this period, each of the

sites was visited on a number of occasions with each visit lasting anywhere from between a few hours to four days. The number, frequency and interval between visits were not tied to any predetermined pattern.

Interviews

Interview data were obtained from two groups of informants. The primary group of informants consisted of those organisational members who were (or had been) directly involved in the product development process. These informants included owner-managers, senior managers, design managers, design engineers, in-house industrial designers, industrial design consultants, as well as former managers and employees. Some of these key informants were interviewed on more than one occasion. In addition, interviews were conducted with a secondary group of informants which included industrial designers not directly associated with the six research sites, ergonomists, individuals associated with government agencies and professional design associations, and industry representatives. This latter group of informants helped clarify aspects of the contexts in which the various organisations operated.

Interviews with informants were arranged as follows. Firstly, information was provided verbally (and in some instances in written form) about the general nature of the research as well as about the background of the researcher. In particular, potential participants were informed that the researcher was a member of the academic staff at Massey University and that the research was being conducted towards the completion of a doctoral thesis. Potential participants were then asked if they would consent to an in-depth interview. At the commencement of these interviews, informants were asked if they would approve of the interview being tape recorded. The tape recording of interviews was considered to be an important means of fully capturing the comments made by informants while preventing the distortions and distractions which may be associated with a reliance on note-taking (Patton, 1990; Smith, 1989). There was a high acceptance of this practice among informants as on no occasion was a negative preference indicated when approval to tape record interviews was sought. In all, 38 in-depth interviews were conducted in this manner and these varied in length from 3/4 of an hour to 1.5 hours. In addition to these in-depth interviews, many less formal interviews, discussions and telephone conversations took place. Although notes were made of the information passed

on during these encounters, some informal interviews were also tape recorded. Given obvious pressures on the time of many key informants, some of whom were struggling to manage their business through a major recessionary period, lengthy in-depth interviews and prolonged informal encounters were considered inappropriate. In some instances, a series of interviews was arranged instead. These repeated contacts also allowed more time for a relationship of trust to develop between the informant and the researcher.

The in-depth interviews were guided by a prepared list of questions. These questions were used mainly to start off and direct the discussion in each interview. The question list was also used at the end of the interview as a form of checklist to ensure that the various points of interest had been covered. During the interview, however, the lack of a fixed structure allowed the researcher to respond to the individuality of each case and each encounter. In particular, as informants often generated new and surprising information, this lack of predetermined structure meant that they could be asked to elaborate on points. In some instances, as fieldwork progressed, informants would also be asked to comment on the researcher's own observations and interpretations. This semi-structured approach had not initially been the intended interview technique. Instead, it had been hoped that on the basis of the author's experience at Formway (which was regarded as a pilot case), a structured interview schedule could be developed. This, in the end, did not appear to be a feasible or appropriate option. Here the author's experiences mirror those of Bresnen (1988: 38) who eventually 'ditched' his initial attempts to devise detailed interview schedules, and opted instead for a more 'responsive' method involving semi-structured interviews and unstructured conversations.

In formulating questions during, and prior to, interviews and conversations, the author was most concerned not to impose key theoretical concepts onto the discussion. Instead, participants were allowed to respond to questions using their own frames of reference and terminology. In particular, the author tried to avoid using the terms 'innovation' and 'knowledge', particularly during the initial contacts at each research site. The use of these terms, it was felt, might direct informants' responses unduly. As happened, midway through the fieldwork, the New Zealand Ministry of Commerce introduced 'The Innovation Programme' consisting of a video, guide and series of workshops. Formway's top managers were involved in this programme and featured in the video. Had these top managers been able to link the innovation theme of this Programme

with that of the present research, it is possible that their responses might have been unduly shaped by the common emphasis.

All tape recorded material was transcribed. The transcription process was facilitated by the employment of a secretarial assistant who transcribed tapes of relatively good sound quality. Only about three-quarters of the tapes fell into this category, as interviews often had to be conducted against a background of factory noise or in offices and meeting rooms with poor acoustics. Tapes of poor sound quality were transcribed by the author, who also personally checked all tapes transcribed by the secretarial assistant for errors and omissions.

While interviews and conversations provided a primary source of data they do have certain limitations. Interviews may be subject to bias, inaccurate articulation and more importantly, in the context of retrospective case studies, they may be subject to poor recall. For this reason, it was considered very important to cross-check interview data with the information obtained using other data collection methods such as document analysis and direct observation.

Direct observation

During visits to each research site a range of situations, objects, and environments could be observed on an informal basis. This observational evidence not only provided a valuable additional source of data, it also 'fed back' into other techniques in that on occasions the observations triggered further questioning and clarification. As a result, direct observation assisted the researcher in coming to a broader understanding of ergonomics capability within the various research sites. Nevertheless it must be recognised, as Yin (1989: 91) has inferred, that observation is limited in its ability to uncover information relating to the historical aspects of a case.

Ongoing observation during in-depth interviews can provide significant insights that may otherwise not be borne out effectively by interview transcripts. For example, the demeanour of an informant during an interview may suggest something about their level of interest in the topic being discussed. Similarly, through observation, the researcher may be able to assess the informant's confidence in answering questions relating to a specialist knowledge domain (such as ergonomics). In addition to directly observing the behaviour of

informants, valuable information may also be gleaned from observations of the built environment. Thus, depending on where the interviews take place, some information can be gained from the interview setting itself. Moreover, in walking around the research site an overall impression of the organisation's facilities may be gained. This, in turn, may suggest to the researcher something about status relationships, the prevailing organisational climate, and the organisation's level of prosperity (Yin, 1989: 91).

While the above considerations were all relevant to the present study, observational activity was also directed towards assessing the level of ergonomic detail evident in the design of products and workplaces. While the researcher had an obvious interest in becoming familiar with an organisation's products, the researcher was also interested in workplace design as this provided some insight into the application of ergonomics in other functional areas. Finally, direct observation can also provide some indication of an organisation's degree of 'design consciousness' and investment in design-related facilities. Both these factors are reflected in the appearance and condition of buildings, and in the extent and location of dedicated design and development work areas.

Documents and archival data

To supplement the information provided by the interviews, a variety of documentary and archival sources were consulted. This material proved to be a particularly valuable means of cross-checking the sequencing of events referred to by respondents in the interviews.

A certain amount of documentary evidence was referred to by informants in the course of the interviews. Where appropriate, access to copies of this material was requested. The material collected on this basis included in-house newsletters, company brochures, product brochures, product briefs, design reports, minutes of meetings and student reports. However, in some instances, where materials were requested and the informant was willing to supply these, they could no longer be found. Generally, the organisations in this study did not store or archive historical material in a systematic way. Some records were kept, including 'history files' of press clippings, but major gaps and inconsistencies in these files were evident.

In addition, a variety of secondary information sources were used. The Index to New Zealand Periodicals (latterly NEWZINDEX), was systematically scanned to identify articles published in New Zealand business magazines or newspapers in relation to any of the six research sites. Information about the wider industrial and economic environment over the period of interest was also collected in the form of magazine articles, journal articles, historical accounts, and reports. Finally, searches were made of public documentation centres including the Patents Office, the Registrar of Companies Offices and the National Archives.

Data analysis and presentation

The formal analysis of the research data commenced with the preparation of a written 'case record' (Patton, 1990: 386) for each research site. As the researcher was interested in how events were related in a temporal sequence, each case record followed a chronological format and integrated the raw data of the interview transcripts, documents, and field notes into a single document. At this stage the data were sequenced, cross-checked and validated against other evidential material, while decisions were continually made as to what information would be included and what should be left out. The sorting process was assisted by several techniques which worked with varying degrees of success. For instance, the use of a 'document summary form' (Miles and Huberman, 1984: 51) helped enormously in the sorting and retrieval of documents. A summary sheet was appended to each document. The date of origin of the document was then indicated on the summary sheet along with a brief description of the document's content and the reasons for its significance.

While more manageable than the documents, transcripts and notes on which they were based, the case records were nevertheless detailed and lengthy, ranging from between 10 to 20 pages. Although not written as a readable narrative, the case records did allow the researcher to highlight inconsistencies and gaps in the data. Where significant gaps were evident at this stage, attempts were made to seek more information from informants either by way of another visit to the research site or through telephone contact. Once the case records were completed they were then recast into shorter, more readable, case study narratives following the procedure outlined in Patton (1990: 388). These narratives are included in Chapter 4 as a means of introducing the six cases.

Following the preparation of the case narratives, the within-case analysis was extended in several ways through the use of display techniques advocated by Miles and Huberman (1984). These assisted in the identification of processes, patterns and themes. For example, a flowchart was constructed for each case which linked events and states over time. In addition, matrices were constructed on a chronological and thematic basis. While these techniques assisted the researcher to come to grips with the complexity of the data, the use of codes was found to be more problematic. Although attempts were made to explicitly code the data, some difficulties were encountered in specifying a full range of codes beforehand. Indeed, as coding was underway, new themes and patterns would still emerge. Consequently, any explicit coding tended to be ongoing and iterative.

Throughout the analysis phase, concepts from the innovation literature (including those introduced in Chapters 1 and 2) were used to 'sensitise' (Patton, 1990: 216) the data contained in the case records. At the same time, the author was open to patterns, themes and categories that emerged from the data. Of particular interest was the language used by informants and the meanings that they gave to terms (such as ergonomics) that were specifically dealt with in the research.

Although the narratives (and the analysis in subsequent chapters) use the proper names of the six companies, all names of individuals are pseudonyms. The only exceptions to this are the names of prominent individuals external to the six organisations such as J.B. Coe (former Head of the Wellington Polytechnic School of Design), and L.B. Yap (an ergonomics lecturer at the Wellington Polytechnic School of Design), and public figures of national standing such as Dr W.B. Sutch.

The decision to use the proper names of companies was based on several considerations. Firstly, in order to completely conceal the identity of the various organisations the case studies would have had to be stripped of much meaningful detail. For example, product brand names would have to be changed and yet in research which focuses on the area of product design and development these names convey important information. The problem that anonymity can present for the description of rich data has been noted by Pettigrew (1990: 286). A second consideration relates to the lack of anonymity actually provided by

pseudonyms when dealing with small economies such as that of New Zealand, where the number of players in a particular sub-sector can often be counted on one hand. Under these conditions, anonymity can only hope to provide a relatively thin disguise.

The use of pseudonyms for most individuals was implemented to protect their privacy. Given this paramount concern, the researcher also has either placed any controversial or sensitive comments in a broader interpretive context or has made such comments non-attributable. By employing these measures, it is considered that adequate protection has been put in place so as to avoid potential harm to informants.

Summary

This chapter commenced with a discussion of the research questions which were to influence the selection of a research strategy and guide the analysis of data collected from fieldwork. From this initial discussion, the emergent nature of the research questions is evident (see Pettigrew, 1990: 279). Over a period of time, the research questions were amended and sharpened to reflect the insights obtained from further literature analysis and the initial phases of data collection. As a result, the attention shifted from a focus on the use of ergonomics knowledge to an emphasis on understanding the processes by which capability in relation to ergonomics develops. The impact of contextual factors on these processes would also be examined.

Having established the research questions, the chapter then proceeded to outline the research strategy employed. This is based on the comparative case study method. This research strategy was selected because it is suited to the examination of both processes and contexts. Once it was established that the research would focus on product development settings, the selection of cases was directed by a number of considerations such as location, ease of access, nature of product, and the potential for inter-sector comparisons.

In all, six research sites were studied. These sites were drawn from those sub-sectors of New Zealand manufacturing activity which service the following product-markets: petrol pumps, electric ranges and office seating. Data were collected in relation to each of the sites using multiple sources including in-

depth interviews, direct observation, documents and archives. The raw data were subsequently brought together into a chronological case record for each site. These case records provided a starting point for the analysis which follows in Chapters 4 through to 7.

Chapter Four

Ergonomics Capability In Six Manufacturing Organisations

Introduction

In this chapter, six organisations are profiled in separate narratives which map out changes in ergonomics capability over time and surrounding events. These narratives will be elaborated upon and analysed in subsequent chapters. This chapter commences with the petrol pump manufacturers (PEC and Fuelquip), followed by the electric range manufacturers (RDD and Atlas) and the office seating manufacturers (Formway and Feltex Furniture). The narratives conclude with events in 1990 or 1991.

PEC

PEC designs and manufactures petrol pumps, access control equipment and point of sale terminal products. Widely recognised as a 'jewel in the crown' of the New Zealand electronics industry, PEC employs about 95 staff and in 1990 had total sales in excess of $NZ 15 million, 60 percent of which was generated by exports.

PEC was established in 1939 in the same rural town where it is based today. The company initially made smoke bombs for the war effort, then ploughs, and during the 1950s it specialised in making mechanical and hydraulic products for the local oil industry. In 1955, the company commenced partial manufacture of petrol pumps under license to a UK firm. Following this, PEC quickly became the leading supplier of petrol pumps in New Zealand.

In 1965, Bill Howard handed the management of the company over to his son Keith, who had joined the company several years previously having graduated with a degree in chemical engineering. From the 1960s, under this new leadership, the company pursued a policy of integrating solid state electronics into its products wherever possible. The required expertise in electronics was obtained by employing two specialists who had been released on a part-time basis with the approval of their respective government department employers - the Post Office and the DSIR. These specialists were eventually to join PEC full-time.

After some initial project work, this collaboration led to the development of a first generation post-payment self-service petrol dispensing system, called the M-system. During the development of this product, officers from the newly established New Zealand Industrial Design Council approached Keith Howard and encouraged him to attend the 'Design for the Seventies' seminar held in Wellington in December 1969. Howard went to the seminar and as a direct consequence of this he approached the Council's Designer Service which subsequently provided the names of several industrial designers. Of these designers, the candidate to be eventually selected was Paul Costello. Although Costello was based some distance away in Auckland, his engineering experience and background in naval architecture appealed to the engineers in PEC who themselves formed a dominant group.

Managers and employees at PEC (which by this stage employed a total of around 50 people) had had no prior experience in working with an industrial designer and there were expectations that Costello would merely be there to pretty things up or give a 'space age' look to equipment housings. As a result, people were surprised with the detail that Costello went into, both in his analysis of the design problem and in the drawings that he produced. His early impact on the company is reflected in the clean lines of the M-system console with its simplified and functionally grouped controls which could be operated comfortably from a seated position.

It was through becoming familiar with Costello's approach to the design process that Howard and others at PEC were also to come to appreciate the role and significance of ergonomics. Whereas ergonomics was a subject that PEC's engineers generally had limited knowledge of, Costello placed strong emphasis

on ergonomic design. Costello himself had come to appreciate the significance of ergonomics as a result of working for several leading industrial design offices in the USA between 1950 and 1965. One of these offices, the Van Doren agency, routinely used human factors analyses in the design process.

In emphasising the need to consider ergonomics during the design process, Costello turned the orientation of the engineers from engineering expediency to a focus on the requirements of the user. Previously, the engineers had merely placed equipment parts where they thought they ought to go from an engineering point of view. Costello, however, argued for a different approach and showed the engineers how the user's interactions with the product could be studied by employing techniques such as observation, photography, mockups and testing.

Costello's association with the company continued through the 1970s. He assisted with the design of electric fences when the company in 1972 diversified into products for the agricultural sector, and he was involved in the design of PEC's first microprocessor-based petrol dispensing systems which emerged in the late 1970s. The latter systems consisted of an electronic computer head with LCD display (Retron 80) which could be inserted into existing pumps and a Micro-M console (a smaller, microprocessor based version of the M-system). In addition, Costello worked on the design of the M-PEC 80, one of the first electronic petrol pumps in the world. However, as his suggestions were not always carried out fully, Costello was less satisfied with the outcome of some of this later work.

The company, during this period, was assisted by grants, incentives and advances from government agencies keen on promoting export development. By the late 1970s, PEC was also starting to see some gains for its efforts both financially and in terms of reputation. Around this time the company also won a top export award for its Retron 80 and Micro-M system, which eventually became the industry standard in New Zealand.

During the late 1970s the company grew in size as more electronics engineers were appointed to support the shift into micro-processors. This group of engineers knew very little about ergonomics and industrial design and displayed relatively little interest in these aspects of development work. At the same time, the company was becoming more marketing-oriented. Consequently the marketing function, which had a substantial interest in matters of product design, increased in strength.

In 1981, the company diversified into personnel access control (with the introduction of the Cardax range) and set up a subsidiary in Australia. Around this time, Costello ceased to have contact with PEC. Instead, the company decided to employ Richard Walker, an industrial designer who tutored at the Wellington Polytechnic and also had consultancies with other manufacturing companies including Formway. Like Costello before him, Walker considered ergonomics as a matter of course during the design process.

Walker continued to work with PEC until he went on an overseas study tour in 1985. Prior to leaving, Walker developed a concept for a multi-product pump which featured a novel display/nozzle arrangement. This arrangement was arrived at directly from Walker's attempt to improve the relative positioning of multiple displays and nozzles. Although the design concept had been approved, and this subsequently formed the basis for a successful patent application, the design team subsequently decided to shift to something more along the lines of a C-shaped pump which in Walker's absence from the country had been released by competitor Fuelquip. The company was under pressure to get something onto the market quickly. At this stage, PEC involved Mark Ryan, an industrial designer and graduate of the Wellington Polytechnic School of Design, who had been working with the company on the latest version of Cardax. PEC did not renew its association with Walker when he returned to New Zealand, choosing instead to further its relationship with Ryan.

By this stage, senior members of PEC's design and development function considered ergonomics to be a fundamental part of the design process. Where appropriate, the need to consider ergonomic factors was specified in the design brief for each new development. However, in doing so, it was more or less expected that the industrial designer involved in the design project would be the main source of this input. For instance, as part of the development work on the Cardax range, Ryan researched such detail design considerations as the keypad angle, desirable mounting heights, card-swiping actions, location and size of visual instructions. While much of the required information was available in literature sources, little was found in relation to card-swiping actions so Ryan constructed a mockup and tested this out with a range of subjects. This information was collated and presented to PEC in report format. While Ryan had an understanding of the principles of ergonomics, he would tend to consult an acquaintance who worked as a tutor in ergonomics at the Wellington Polytechnic if he required more expert advice.

Around the time Ryan joined the company, 23 staff (including 12 software engineers) were directly involved in design and development. The salaries of these staff made up a substantial part of the 13.5 percent of total sales that PEC invested in research and development in 1989. In maintaining this level of expenditure, the company now operated with limited government support for its R&D and exporting activity. After 1984, in particular, the New Zealand Government had substantially changed the form, and lowered the level, of its assistance structures for industry.

This unfavourable background continued through the 1980s and into early 1990. During this period, Keith Howard and his stable, experienced team of senior executives retained a tight control over resource allocation and, in particular, adopted a policy of not capitalising in manufacturing facilities. According to this policy, products with sales potential which were beyond the capacity of PEC's manufacturing plant would be subcontracted or licensed out to specialist manufacturers. On the design and development side, the company had, as a result of experience built up during the 1970s and 1980s, become very good at managing the design process, and picking successful projects for development. PEC's management was also careful to contain the costs associated with employing an industrial design consultant, a factor which may at times have led to a degree of restraint in product design. Nevertheless, during 1991, Ryan was still employed by PEC.

Fuelquip

As at 1990, Fuelquip employed 160 people in the design, manufacture, installation and servicing of liquid fuel handling and associated equipment. Based in Wellington, the company was formed in April 1984 as a result of a management buyout of Gilbarco Industries New Zealand Ltd which, along with its U.S. parent of similar name, was a subsidiary of Exxon Enterprises.

Gilbarco Industries' presence in New Zealand dates back to 1967 and in the early years, the company focused primarily on equipment servicing and installation although, as an ancillary operation, petrol pumps were manufactured according to the specifications provided by Gilbarco Australia. With the robust

and well-engineered pumps that were produced following these designs, Gilbarco was able to command a sizable share of the New Zealand petrol pump market.

During the early 1980s however, as a result of the competitive tactics employed by competitor PEC, Gilbarco's share of the total New Zealand petrol pump market eroded from about 50 percent to virtually nil. By lowering the price of its electronic pump heads, PEC had succeeded in establishing its Micro-M system as the New Zealand standard for pump controllers. As Gilbarco pump heads were incompatible with the Micro-M system, the demand for this Gilbarco product fell dramatically.

Rather than compete by allowing Gilbarco pump heads to communicate with PEC's Micro-M system, the management of Gilbarco New Zealand (who received their direction from the Board of Gilbarco Australia) considered dropping the manufacturing side of the business altogether. Such a move would, however, result in a proportion of the company's 90 employees being made redundant. Recognising that these redundancies would also extend to the middle management ranks, four managers subsequently made a successful bid for the business. They jointly acquired a 89 percent shareholding with the remainder being held by the Development Finance Corporation. Under this new arrangement, Gilbarco's chief accountant Rod Jones was appointed general manager of the renamed company while the three remaining director-managers took over the management of the manufacturing, operations, and marketing functions respectively.

Almost immediately, efforts were made to design a new range of pumps, with the intention of achieving compatibility with PEC's Micro-M system. Furthermore, the pumps had to be different: the directors wanted to convince their oil company customers that the restructured organisation would be more responsive to their needs than Gilbarco had been.

Kevin Bradshaw, the manufacturing manager in the new Fuelquip organisation, and the only director with an engineering qualification, assumed responsibility for product design and development. As the company had not designed petrol pumps from scratch before there were few design resources. There was only one drawing board and there was limited information in the form of standards and drawings. Bradshaw also recognised that he required additional expertise in

specific areas and so appointed a full-time electronics engineer. Furthermore, in July 1984, John Crozier was retained as an industrial design consultant. Crozier had studied industrial design during the mid-1960s at the Wellington Polytechnic School of Design.

As a first priority, Crozier was asked to come up with a number of concept sketches. Some of these sketches were then shown to personnel in the oil companies. This tactic provided Fuelquip managers with a general indication of customer interest in the concepts as well as additional feedback about specific customer requirements. In addition, the technique of customer involvement in the design process allowed Fuelquip to demonstrate their new customer-orientation.

One of the concepts that was developed to the prototype stage was a rounded, futuristic looking pump that would be fabricated in fibreglass. In performing the detail design for this pump (the FQ21), Crozier analysed a variety of problems and observed existing pumps in use at service stations. Attention was given to ease of operation in terms of the positioning of the nozzle, the design of the display, and the wording of the instructions for the data entry keyboard. As the prototype neared completion Crozier consulted with a colleague on some of the ergonomic aspects. This colleague, who worked as a tutor in ergonomics at the Wellington Polytechnic School of Design, visited Fuelquip on two occasions and made some suggestions.

Throughout this process, Bradshaw was closely involved and progressed from merely knowing about ergonomics as a buzz-word, to understanding a little more of its scope. In particular, the 'zone of vision' concept which Crozier used, as well as the insight that instructions need to cater for a low reading age, brought ergonomics to the forefront for Bradshaw. Apart from that, however, Bradshaw took the view that the rest was common-sense, that is, what others might call ergonomic problems were to him obvious practical situations that could be improved. Bradshaw was generally receptive to the idea that the pumps had to be both easy to operate and easy to service. The latter, in particular, was considered to be important as pumps that allowed for quick and easy access had a direct impact on the cost-effectiveness of Fuelquip's servicing operations.

Prototypes of the pump were constructed and placed on trial towards the end of 1985 but shortly afterwards, when Fuelquip was informed that the design did not

fit in with BP's world-wide corporate identity programme, the prototypes and the design concept were scrapped. As substantial funds had been sunk in the development of the pump, Fuelquip's directors wanted to have a product on the market quickly. A design brief was drawn up in early 1986 for a series of hard-edge, non-controversial pumps that used traditional materials, with a time constraint of June 1986. This short development time was achievable as the design team could draw heavily on what had been learnt up until then. Thus the same electronics and hydraulics were used as well as the position and detail design of the nozzle boot, displays and data entry keyboard. The basic design concept for the new pumps, although unique to New Zealand, was a formula that had been used in Europe and for this reason there was some confidence that it would find favour.

Following the release of these new products (called the FQ23 and FQ24) Fuelquip started to regain a share of the New Zealand pump market. In addition, Fuelquip successfully applied for a Designmark for the pumps, and these eventually reached a finalist position in the 1988 Prince Philip Award for New Zealand Industrial Design. These awards helped Fuelquip to establish itself as a company that could design products to a high standard.

The FQ23 and FQ24 pumps were promoted as being cost-effective, safe, compatible, serviceable and of 'ergonomic design'. Although the latter attribute was used as a promotional tool in the marketing of the new pump series, the directors of Fuelquip were to conclude that provided there were no obviously adverse ergonomic features, the oil companies were mainly interested in price.

Fuelquip proceeded to extend the FQ20 series with the release of other models. Following this, there was a break in the product development programme until March 1988 when work commenced on a new series of multi-product pumps (the FQ30 series) for Mobil Oil. Having learnt from the 'FQ21 disaster', the new series of pumps was designed to be compatible with Mobil Oil's specifications, and at a distance they looked similar to models available from other New Zealand and overseas manufacturers. Although others in the company were still sceptical of the value of ergonomics and the benefits derived from the company's expenditure on industrial design, Bradshaw continued to involve Crozier in new development work.

The oil industry in New Zealand was deregulated in 1988 and Fuelquip was reasonably well prepared for the surge in business that resulted. The company

continued to expand its staff numbers and company profits increased. By 1989, the three remaining partners - Jones, Bradshaw, and Hudson (the company's national operations manager) - had not only bought out their fourth partner, they had also acquired the equity that the Development Finance Company had held since the management buyout. By mid-1990, although Fuelquip had taken a 50-60 percent share of the New Zealand petrol pump market, it had yet to consider exporting. Work had also commenced on a new range of pumps and in line with Bradshaw's preference for a degree of continuity in the recruitment of external consultants, Crozier was to be involved once again.

RDD

RDD is a division of Fisher & Paykel (F&P), a New Zealand-based concern with a turnover of $NZ 512 million generated primarily by its interests in whitegoods manufacture, the marketing of Panasonic products, and electronics development. Established in 1871 as an iron foundry in the centre of Dunedin city, RDD has in recent times moved to another facility several kilometres away. This facility had been purpose-built for the manufacture of two main product lines - electric ranges and dishwashers. Unlike other divisions in the F&P whitegoods group, RDD mainly serves the New Zealand market. Thus, in 1991, exports made up only 5 percent of the annual turnover of $NZ 60 million generated by RDD's 330 employees.

F&P began business in 1934 by importing and distributing whitegoods but, following the imposition of import controls in 1938, the company moved into the assembly of products under license. In the decades that followed, the Paykel and Fisher families allowed their business to expand. More depth in manufacturing was acquired through the development of flexible production technology and there was a gradual shift towards in-house product development. Despite a broadening of ownership in 1979 when F&P was listed on the New Zealand stock exchange, the two founding families have continued to be a dominant force in the management of the company. This ongoing family influence has supported the preservation of a distinctive culture and philosophy characterised by people involvement, continuous improvement, self-reliance in design and development, customer orientation, and loyalty to its New Zealand origins.

RDD has its origins in a private family business called H.E. Shacklock (or 'Shacklocks') which, as a result of its poor financial performance, sought assistance from F&P in the 1950s. The boards of the two companies subsequently formed an association which provided H.E. Shacklock with management expertise as well as access to F&P's dealer network. Although the initial nature of the association was not of a legal character, this was to change in 1962 when F&P purchased 50 percent of the shareholding in H.E. Shacklock, and again in 1981 when the remaining shares were acquired.

As a fully-owned subsidiary, H.E. Shacklock continued to operate relatively autonomously until the end of 1983 when it was redesignated as Range and Dishwasher Division and restructured. At this stage, Ken Adams (formerly a marketing manager in another F&P whitegoods division) was appointed as general manager to oversee far-reaching changes in the division including a reduction in staffing levels, redundancies of long-serving staff, rationalisation of the product range, investment in new machinery, changes to work practices, and a greater emphasis on continuous improvement and marketing.

RDD's functions were also extended to include the new product development work which had previously been conducted by designers based at F&P in Auckland. While this arrangement had, during the 1960s, helped H.E. Shacklock reposition itself as New Zealand's leading designer of electric ranges and helped strengthen the Shacklock brand name, it was now considered that if the required design changes to RDD's products were to be made this could only occur by bringing product design closer physically to the division's manufacturing and marketing functions.

As part of the shift toward on-site product design and development, John Dillon and Noel Anderson (two Shacklock engineers who had been working together at F&P in Auckland on the design of RDD's products) were asked to return to Dunedin. In April 1984, they were followed by an industrial designer, Jason Lewis, with whom they had worked in Auckland. Together these designers and Ken Adams (RDD's general manager) formed a close team who worked urgently to face-lift the division's products.

While the on-site presence of an industrial designer was a new development within RDD, it was not the first time that an industrial designer had contributed

to the design of the division's products. Since 1962 at least, the division's design work had been supervised by F&P's design department which itself had a tradition of employing in-house and consultant industrial designers going back to 1945. Consequently, when Lewis first started working with the F&P design department he entered an environment where the role of the industrial designer was understood and ergonomics was a routine consideration.

Despite this, some industrial designers were inclined to give more priority to ergonomic factors than others. Thus prior to working with Lewis, both Dillon and Anderson had worked with industrial designers who were more inclined to compromise ergonomic relationships for visual appeal. On occasions this situation had led to conflict. Dillon and Anderson, however, were on common ground with Lewis, who was inclined to favour designing products that were simple and easy to use. Furthermore, once these designers were together in Dunedin, their stance was reinforced by Adams' intolerance of any design that was frivolous or quirky.

Scott Delany, a recent graduate from the Wellington Polytechnic School of Design, was employed as RDD's second industrial designer in early 1986. In November of the same year, Lewis transferred back to Auckland. He was replaced and since then RDD has usually had at least two industrial designers in employment at the same time. Significantly, all industrial designers employed at RDD have been graduates of the same programme which has had ergonomics as a core subject since the early 1960s. However, while they all will consider ergonomics to be a part of their design work, they have neither as individuals, nor collectively, been widely recognised in RDD as strong proponents of ergonomic design.

Despite this, by 1990, there was a widespread awareness of ergonomics among RDD employees both in relation to workplace and product design. This was brought about initially through the injury prevention activities of Karen Fraser who was appointed to the position of full-time occupational health nurse in 1987 (by which time the design engineer John Dillon had been promoted to the position of division manager). Although qualified as a registered nurse, Fraser had no prior experience in occupational health nursing. She was, nevertheless, attracted to the injury prevention aspect of the work and, having identified poor workplace design as a cause of injuries, she approached the production manager for technical assistance. As this direct approach for resources was unsuccessful,

Fraser pursued other avenues including the systematic collection of accident statistics and the formation of a Health and Safety Committee and an Ergonomics Group. At this early stage, the Ergonomics Group was convened by Fraser and its membership consisted of an occupational physician, the production manager, the personnel manager and a maintenance engineer. The first issues to be dealt with by the Group included seating in assembly areas, lighting and office workstation design.

On the basis of the injury statistics she had collected, Fraser was able to justify the employment of a person to work specifically on workplace design problems alongside Peter Knight, the division's industrial engineer. Thus, in July 1987, Angela Roberts was appointed as RDD's second industrial engineer and until Fraser left the division in 1989, the two women worked together closely. Fraser was able to identify high-risk workplaces, while Roberts had access to the technical resources that Fraser lacked.

Although Roberts had never heard of ergonomics prior to joining RDD, she was attracted to the subject's emphasis on designing for people. With the assistance of Fraser and F&P's information service, Roberts acquired articles and books on ergonomics and also started attending meetings of the Ergonomics Group. Around this time, Roberts also had contact with an Auckland-based consulting ergonomist who had been employed by other F&P divisions. This consultant visited RDD and suggested improvements to workplace design which Roberts followed up afterwards. While contacts with this ergonomist were not taken much further than this, Roberts did meet other people interested in ergonomics through attending meetings of the local branch of the New Zealand Ergonomics Society.

Fraser had recognised that her ability to identify high risk workplaces depended on her getting signals from employees. She believed that this communication would only occur in an environment where employees had a basic knowledge of the workplace risks, and a level of trust, that would gave substance to RDD's espoused commitment to continuous improvement and people involvement. A basic knowledge of risks was communicated to staff as part of an 'awareness training programme' which all RDD employees were required to attend during the second half of 1988. As part of a health and safety section in the programme, Roberts presented an hour long session on ergonomics and this helped raise the profile of ergonomics substantially.

The problems that the Ergonomics Group tackled initially were obvious design faults. Consequently, despite a lack of in-depth knowledge of ergonomics among individual Group members, dramatic improvements were made. This was in turn reflected in a reduction in days lost due to accidents and injuries, an outcome that caused senior management to look upon the work of the Ergonomics Group more favourably. However, as the obvious faults were removed, this only served to highlight the more difficult problems relating to work organisation and the design of products that the Group had yet to address.

At an early stage, the repetitive nature of assembly work had been identified as a risk factor and efforts were made to introduce job rotation in some work areas. While this generated considerable resistance among production supervisors, Roberts continued to experiment with job redesign and in doing so she had the support of RDD's manufacturing engineering manager who was particularly interested in the 'one worker - one product' concept. This manager considered that this 'flexible' approach to assembly work, in addition to giving workers a greater variety of movement, would also enable workers to assemble products of consistent quality without the pressures of assembly line pacing.

While changes were being made to job design, Roberts and Fraser also recognised that a proportion of ergonomic problems in assembly operations could be attributed to the actual design of the product, which was being modified on a more or less continuous basis. With respect to electric ranges, design changes that would achieve cost reductions were imperative given the price war initiated in 1987 by another electric range manufacturer. At the same time, products had to be upgraded to stave off competition from the imported products that had entered the market as a result of the relaxation of import controls in the mid-1980s. As these changes in product design usually necessitated alterations to the assembly operations, Roberts realised that it was important to ensure that assembly workplaces continued to be adequate from an ergonomic point of view. Consequently, Roberts sought a greater degree of co-ordination between herself and product designers and invited Noel Anderson, who was now RDD's product engineering manager, to attend meetings of the Ergonomics Group. Anderson was to become an important ally for Roberts and Fraser. He had been interested in ergonomics for some time, but was also compelled by a need to know more. Consequently, he pursued a part-time university courses in ergonomics during 1989 and 1990.

During 1989, the Ergonomics Group decided that all members of RDD's design team (which by now had increased in size to 20) should be given training to make them more aware of ergonomic problems in product assembly. Roberts subsequently arranged for two university-based ergonomists to co-ordinate a two-day seminar. This seminar was held in May 1990 and was attended by product engineers, industrial designers, plant engineers and tool engineers. Several months later the seminar was repeated to a group of production supervisors.

The seminars were successful in establishing 'ergonomics' both as a unexceptional word and as something that should be routinely considered in the design process. In addition, the designers and engineers were showing more sensitivity to the requirements of users and had started to ask Roberts for advice and information. Despite this, Roberts still experienced some resistance with production supervisors particularly in those areas where she had introduced the one person - one product approach to the organisation of assembly work.

Following the seminars, the Ergonomics Group only met infrequently. On the one hand, the occupational health nurse who had replaced Fraser was less inclined to use the Ergonomics Group as a means of communicating information that linked injuries with particular workplaces. Roberts was now the main person pushing ergonomics. On the other hand, Roberts no longer required the support of the Group; now she felt she could implement changes with relative ease and tended to use more direct channels. Wishing to learn more about the subject Roberts also attended a post-graduate course in ergonomics at the local university during 1991.

Although RDD was now more profitable than it had been for many years, the product development programme was expanded with a new sense of urgency and more design engineers were employed. RDD had underestimated the impact that top-market imported brands such as AEG and Blanco had had on their share of the range and dishwasher markets. While ground-up work on a new 'internationally marketable' dishwasher had been underway for some time, a second design team was set up to work on the ground-up design of an electric range. Roberts was confident that ergonomic considerations would inform the design process, particularly from the point of view of ease of manufacture.

Atlas

The organisation that will be referred to here as Atlas, was acquired by Simpson Appliances (NZ) Ltd in December 1988 and at the time redesignated a Manufacturing Division. As part of this new structural arrangement, Atlas continued to design and assemble electric ranges for the New Zealand market. The change in ownership was the last in a series of transactions which had seen Atlas pass into the subsidiary portfolios of several large diversified companies having initially commenced operations as a family-controlled foundry business.

By the mid-1970s - a decade after the foundry business was first established - Atlas was trading as Atlas Appliances Ltd and formed part of the Atlas Majestic Ltd group of companies. This group, which manufactured consumer products such as electric ranges, refrigerators, stereo equipment and televisions, was directed and coordinated from head offices in Auckland. At this central level, some initiatives were taken in relation to involving industrial designers in the development of Atlas' products. This use of expertise was necessary as, during the 1960s and early 1970s, Atlas' electric ranges had not fared particularly well in comparative consumer tests conducted by the Consumers' Institute. Atlas' products were, for example, consistently ranked lower than Shacklock and Frigidaire brands. Some design inadequacies had been singled out for attention: the reports of trials conducted in 1973 and 1974 indicated that 'Atlas trailed the field' in the area of control markings.

Against this background, head office management commissioned Paul Costello (who at the time was also working for PEC) to do some design work for Atlas in the late 1970s. Costello's involvement with Atlas was to be limited in scope and personal contact, however. He only worked on a single series of electric ranges and focused, in particular, on the design of the control panel. Costello worked from his own office in Auckland which was located at a distance of 800 kilometres from the Atlas plant and he only visited the Christchurch plant on two occasions. Having completed this project, Costello was not called upon again.

Nevertheless, in subsequent years Atlas did employ other design consultants in an attempt to meet the design requirements in an increasingly competitive market for whitegoods. Furthermore, in 1985, Atlas was to experience a

significant change in ownership which resulted in heightened financial performance expectations. At this time, Atlas was absorbed into Ceramco Ltd, an investment company with a portfolio generating revenues totalling $NZ 280 million. Typical of the type of investment company that sprung up in New Zealand during the mid-1980s, Ceramco was primarily interested in maximising returns on shareholder's funds by acquiring and retaining businesses that would promise above-average returns in the short-term. This organisation expected Atlas, which had held the New Zealand agency for the Simpson brand (of Australian origin) for some time, to aggressively develop the market for these products.

Although, by 1988, Atlas had lifted its design performance to the extent that the company was awarded a Designmark for a new series of upright electronic cookers, Atlas continued to underperform financially. The company was experiencing considerable difficulty in breaking the Simpson brand into the New Zealand whitegoods market. As a result, Ceramco's top management willingly sold Atlas to Simpson Appliances (NZ) Ltd, a subsidiary of the Australian company Simpson Holdings Ltd.

In acquiring Atlas in December 1988, Simpson Holdings Ltd was not merely gaining an electric range manufacturer, it was also taking control of its own New Zealand agency. However, rather than compete on the basis of product quality or price, Simpson's Auckland-based subsidiary (of which Atlas was now part) proceeded to engage in aggressive tactics that would attack a major distribution barrier - the retail franchise arrangements of its competitor Fisher & Paykel. Thus, during 1989, Simpson Appliances (NZ) Ltd contested the exclusive dealing clause of this arrangement in a series of Commerce Commission hearings. This tactic was followed by an attempt to buy a controlling interest in Fisher & Paykel in a further effort to force the company to drop the clause.

As these unsuccessful competitive battles were being fought, Atlas continued to design and manufacture products under the direction of a plant manager. Around 110 staff were employed in these activities, including 5 engineers who were specifically involved in product development work. However, while Atlas had survived its latest ownership change and yet another shakeout among electric range manufacturers, these forces had left their mark. In particular, as a result of continued low margins, there had been minimal investment in plant and buildings. Nevertheless, when two other New Zealand electric range

manufacturers ceased operation in 1990, the outlook for Atlas looked much brighter. The demise of these competitors brought the most recent price war to a (temporary) end, and when the market shares were redistributed between Atlas and the only other remaining New Zealand electric range manufacturer, Atlas settled down with a comfortable 30 percent share.

Formway

From its base in Petone (near Wellington), Formway designs and manufactures commercial furniture for the New Zealand and Australian markets. Highly acclaimed in both countries for its office seating products, the company has never employed more than 95 employees. By mid-1991, Formway had annual sales of around $NZ 9 million and plans were underway to expand into the South-East Asian market.

Formway developed from a light engineering and toolmaking business established in 1955 by toolmaker Bill Mackie. Five years later, Mackie was introduced for the first time to the science of ergonomics through contact with a interior design consultant from a local architectural firm. This same consultant encouraged Mackie, who had just started to produce steel frames for office desks and chairs, to obtain a copy of a recently published British Standard (BS 3044) which dealt specifically with the ergonomic design of these products.

In the years that followed, Mackie continued to design and manufacture office chairs and related products and, in this, he was influenced by the principles outlined in BS 3044. Furthermore, Mackie started to take an interest in developing and applying novel height-adjustment mechanisms. Thus, in 1963 and 1966 he lodged two (successful) patent applications for mechanisms of his own design and in 1969 his business became the first New Zealand manufacturer to import gas-spring components into the country. While Mackie continued to gain experience in the use of gas-springs other New Zealand manufacturers showed a reluctance to adopt this technology.

Although Mackie had always designed his own products, this was to change somewhat in the late 1970s as a result of an involvement with students and tutors from the Wellington Polytechnic. Mackie had been approached by an industrial

design student who was looking for some assistance with her final-year seating design project. As a direct result of this encounter, Mackie was eventually to select a secretarial chair designed by another Polytechnic student for further development by his company. This chair, called Cambio, was released in late 1980 as part of a new range of seating products.

This range, and in particular the strengths of the Cambio, were to attract two potential buyers (Mark Carter and Peter Stevens) who were looking for a business to own and operate. Mackie, who was then 67 years old, agreed to sell Formway on the condition that his eight employees and his son (a minority shareholder) would be retained. Despite Mackie's own initial intention to retire, he was still being employed part-time by the company in 1990.

Following the sale of the business in October 1981, the new owners initially set about correcting some weaknesses in marketing and financial control and focused the business by rationalising the product range. Thereafter, having resolved that the business would continue to design its own products, Carter and Stevens started to involve themselves directly in the design of an adjustable computer workstation to complement the Cambio chair and meet the ergonomic requirements of a 'VDU agreement' which had been struck between the Public Service Association and the State Services Commission (PSA, 1982).

While neither Carter, who had an accountancy background, nor Stevens, who was an industrial chemist, had any prior experience in the furniture industry they recognised that if they were to achieve the quality of design that they wanted, they would need the assistance of an industrial designer. Hence, in November 1982, from a selection of four industrial designers suggested by the New Zealand Industrial Design Council, Richard Walker was retained as a consultant.

It was mainly through working with Walker, that Carter and Stevens discovered that ergonomics was an integral part of the design process. They had been vaguely aware of the term 'ergonomics' as it was starting to come into more general use in the commercial furniture industry, but it was only through working directly on detail design problems, such as keyboard heights and copy holder positions, that Carter and Stevens developed a more detailed understanding of the subject and its application. This was further extended through contacts with an emerging external network of specialists (including an optometrist, physiotherapists and industrial designers) which was supportive of the design initiatives underway at Formway.

Following a series of field evaluations, Formway moved into the full production of the new computer workstation (called the Ergostation) in early 1984. As the product met the PSA/SSC Agreement requirements it was readily accepted. Furthermore, even more interest in the product was generated when the New Zealand news media started to highlight the RSI problem. The success of the Ergostation was such that Formway's turnover quadrupled over the two-year period that followed its release. At the same time, the company's profile in the industry soared.

In response to customer queries about RSI, Carter and Stevens had to learn more about this occupational disorder and how it could be prevented. At the same time, Ian Chalmers, an industrial design graduate of Wellington Polytechnic who had joined the company in late 1983 to assist with the Ergostation development, was to become an important resource. Chalmers had an interest in ergonomics, and was encouraged to learn more about it.

From 1984, the ergonomics knowledge acquired by the directors and employees of Formway was used directly as a promotional tactic. Recognising that people initially had to be informed of what constituted well-designed office furniture before they could make considered purchase decisions, the company started offering seminars to potential clients. In these seminars the basic ergonomic principles were communicated first, followed by an explanation of how these principles had been incorporated into Formway's products. In addition to these promotional seminars, Chalmers and Mark Carter also presented seminars that focused exclusively on ergonomics.

During this time, Formway had begun to develop a reputation for having staff who knew more about ergonomics than other people in the commercial furniture industry. As a result, the company was approached by end-users and professionals who were seeking assistance with specific workplace design problems. Although Formway was unable to satisfy all requests, these contacts were generally welcomed and regarded as a form of investment. At the same time though, the company's 'ergonomics credibility' was also under constant scrutiny from ergonomists. Thus, when Formway applied for a Designmark for the Ergostation, the application was rejected as a result of the concerns expressed by an ergonomist on the evaluation panel in relation to the validity of some of the ergonomic conclusions embodied in the design. This experience

was similar to Mackie's unsuccessful attempt in 1980 to obtain a Designmark for the Cambio.

The rejected Designmark application for the Ergostation caused Chalmers and others in the company to seek out more information and establish with even greater certainty their position in respect of the various ergonomic theories of seating. As part of that process, Chalmers read widely in international journals and books and, consequently, broadened the company's sources of ergonomics information which, up until then, had derived largely from contacts with local specialists. The knowledge that was amassed by Chalmers was also used directly to inform the design of the Cambiare, the successor to the Cambio chair. While the Cambiare was relatively successful, it was not of a standard that could compete with the rising flow of imported products stimulated by concerns about RSI and the distribution of guideline documents by government agencies which advocated 'ergonomically designed' seating. The imported products were often of superior visual appearance and this had helped to heighten local expectations in the area of office furniture. At the same time, a demand for visually appealing furniture was being generated by massive restructuring of the New Zealand private and state sectors, which from 1985 had resulted in many corporations seeking to shake off their old image. An increasing emphasis on visual appeal was also stimulated by the increasing use of architects and interior designers, rather than purchasing officers, in the specification of furniture requirements for commercial developments.

It was recognised that to be competitive in the domestic market Formway would have to manufacture products that would stand up against overseas products. Given this aim, overseas developments were monitored more closely. During 1985 and 1986, Formway managers attended furniture trade fairs in Europe and attended the 'Ergodesign 86' conference in Switzerland. At the same time, a design team was created within Formway to develop an internationally competitive office chair. The team was headed by Brian Carter - a younger brother of Mark - who had worked as the company's factory manager and had acquired a financial stake in the company. In addition to Brian Carter, who was mainly responsible for the engineering aspects, the team consisted of Walker, who was to focus particularly on the aesthetic detailing, while Chalmers acted as the ergonomics advocate. The design team wanted to minimise the amount of compromise between engineering, ergonomics and aesthetics. In doing so they believed that they could make a good chair - one that would be as good as

anything else in the world. At the same time, higher performance criteria were set through the adoption of the exacting German seating standard DIN 4551: 1987.

In addition to seeking expert advice and consulting appropriate standards, further information was obtained by scanning the ergonomics literature, evaluating competitors' products and performing tests with end-users. These investigations, which directly informed the design of the new chair, were written up in the form of an in-house 'seating standard' by Chalmers shortly before he resigned and went to England in July 1987.

After a longer than anticipated development period, the new chair, named Zaf, was finally released in 1988. It was well received in the marketplace, particularly after it was awarded the prestigious 1988 Prince Philip Award for New Zealand Industrial Design. Once the Zaf went into production, however, the company was restructured largely in an attempt to separate longer-term research activity from routine development work, and elevate Brian Carter and Craig Stevens (a younger brother of Peter, and the fourth partner in the business) to the same director status as their older brothers. As a result of the restructuring, Brian Carter was appointed research director. Rather than being required to manage a department and an associated group of employees, this arrangement gave Brian Carter considerable freedom to pursue research activities and work on special projects including a seating range to succeed the Zaf. The ongoing development work would be managed by Craig Stevens who, as design director, worked together with a small team of internal staff and consultants including Walker. The latter design function focused primarily on introducing new products to fill gaps in the company's product range (e.g. desks, partitions and storage walls) and on extending the Zaf range with an executive model.

Despite the substantial amount of development work underway, the full-time position vacated by Chalmers was not filled. Instead, Walker's involvement with the company was increased to one and a half days per week. This arrangement was considered to be more cost-effective than training up a new designer. Nevertheless, development costs were of increasing concern as by 1988 Formway's growth rate had fallen to a level less than that forecasted. This poor performance could be attributed largely to a much weakened domestic demand following the 1987 share market crash, which in turn had put pressure

on margins in the commercial furniture industry. Despite these difficult economic conditions, when it was known that Ian Chalmers was to return to New Zealand, he was offered employment, albeit on a part-time contract basis.

During his absence, Chalmers' 'seating standard' had been used to guide the development process. Upon his return in early 1990, Chalmers was asked to upgrade the company's ergonomics knowledge in light of any significant developments during the past two or so years. This information was required as an input into the design brief for Formway's next seating range. Intensive work on this range was scheduled to take place in 1992. Chalmers was also asked to prepare support material for the company's agents in Australia which would explain the ergonomics rationale behind the Zaf range.

In early 1991, when Formway cut its staff by a third in response to a further fall-off in sales, the company still continued to employ Chalmers and Walker as part-time consultants.

Feltex Furniture

In early 1990, Feltex Furniture combined with CoDesign-NZ to create an integrated commercial furniture marketing and manufacturing operation employing just over 100 people. Although this new organisation structure was referred to as CoDesign-NZ following the merger, it continued to develop and market 'New Zealand-made' products under the Feltex Furniture brand name.

A familiar participant in the local commercial furniture industry, Feltex Furniture had operated since the 1960s as a subsidiary of Feltex New Zealand Ltd from its manufacturing base in a provincial town in the lower North Island. The company served the markets for educational furniture and office seating and in doing so it adopted a high volume, low cost, position. Low costs were achieved in part by sticking with the same product designs throughout the 1960s and 1970s. Not only did this minimise the expense associated with new product design and retooling, the lack of change meant that Feltex Furniture was able to focus on achieving efficiencies by refining its manufacturing processes. At the same time, however, the gap between the design of Feltex Furniture products and those design concepts becoming widespread overseas continued to increase.

In spite of this widening gap, Feltex Furniture's Harter secretarial chair (which was based on a design acquired from a North American company in the 1960s) continued to be a top-selling item in New Zealand. This situation was to change in 1981, however, when Formway released the Cambio secretarial chair. This product, despite its higher price, started to make substantial inroads into sales of the Harter. Sensing that a competitive product was needed quickly, the management of Feltex Furniture responded by introducing a secretarial chair which had been designed by a student of the Wellington Polytechnic as part of a final-year project in industrial design. This chair design was similar to the Cambio in that it had a height-adjustable backrest and a gas-spring adjustment mechanism for the seat height. Although Feltex Furniture's production engineers had had some initial concerns about using a gas-spring mechanism, this feature was incorporated into the chair (called Le Chair). After its release, the Le Chair was further modified to conform to the ergonomic requirements of the PSA/SSC VDU agreement. This agreement had started to influence the purchasing decisions being made by government departments.

Aside from increasing competition from local companies, other changes in the market for office seating were evident. By 1983, imported office seating products were starting to appear on the market in a flow which further increased during the mid to late 1980s when large New Zealand organisations started to seek a more up-market image in a climate of economic liberalisation. The Le Chair was too basic for these new requirements and Feltex Furniture, now under the direction of a new manager, started to look for new designs via agency relationships with overseas companies. As part of this reaction, Feltex Furniture considered importing a contemporary, very 'up-market', chair from the Harter company. This initiative did not proceed.

In light of attention that was given to repetitive strain injury (RSI) by the New Zealand media from April through to June 1985 the level of interest in ergonomics among purchasers of office furniture continued to increase. Responding to a heightened demand for 'ergonomically designed' products, Feltex Furniture introduced a secretarial chair, called the Ergotec, which featured a seat with an optional forward-tilt position. Released in early 1986, the design concept for the Ergotec was not developed internally, instead the concept

was obtained, royalty free, through Feltex Furniture's links with an Australian supplier of seat adjustment mechanisms. The Ergotec and other special projects were co-ordinated by project engineer James Gardiner, who first joined the company in 1984.

In January 1986, Feltex Furniture's parent company Feltex New Zealand Ltd acquired the Australian-based commercial furniture manufacturer CoDesign. This subsidiary was placed, together with Feltex Furniture, under the direction of a Commercial Interiors Group. The management of this Auckland-based Group then proceeded to establish the structures and facilities necessary for the manufacture and marketing of CoDesign products in New Zealand. This eventually led to the acquisition of a wall partition and steel desk manufacturing plant near Wellington and the decision to have all local manufacture of CoDesign chairs take place at the Feltex Furniture site. However, as CoDesign seating products were relatively sophisticated in their design, this decision meant that in several areas, including upholstery, the skills and techniques employed within Feltex Furniture had to be upgraded. However, while some investment and learning occurred in relation to manufacturing processes, there was no need to invest in the product development function as all design specifications were provided.

Although the designs of CoDesign seating products originated from various sources, two major providers included CoDesign's own research and development section in Sydney, and a German manufacturer which had licensed CoDesign to manufacture according to its specifications. As a result, a proportion of the CoDesign range had been developed by professional designers some of whom appear to have been cognizant of ergonomic considerations. The research and development section of CoDesign, in particular, has since the early 1980s maintained an informal mutual relationship with an ergonomist. Furthermore, a designer within this section, who subsequently became its manager in 1986, was strongly interested in ergonomics and pursued advanced studies in the subject at university level. Although the section was small - in 1986 it consisted of only 5 staff - it was efficient in that a high proportion of the projects undertaken came to fruition and the section regularly lodged successful patent applications.

In August 1986, shortly after Feltex Furniture started to make CoDesign chairs, Barry Johnston took over as manager and proceeded to drop several product

lines including the Harter range. Johnston also negotiated an association with an Auckland-based developer and manufacturer of computer furniture, an arrangement which enabled Feltex Furniture to broaden its product range quickly without engaging in any in-house development. A broad product range in computer furniture was required as Feltex Furniture, in following the direction taken by other manufacturers in the industry, was increasingly dealing directly with the end-user rather than with retailers.

Johnston, a former furniture buyer for Feltex New Zealand, was keen to see the company adopt a customer orientation and become more flexible in terms of modifying standard products to suit the varying requirements of customers. In line with this, Gardiner was promoted to the position of national contracts manager. In this new role, Gardiner was given responsibility for working with major customers while meeting their specific needs with existing or slightly modified products. While the shift in orientation and attitude that Johnston was seeking took some time to occur, it was facilitated by turnover among some of the 65 staff working in the factory.

During this period, a modest level of product development was budgeted for and these activities generally took one of two paths. At one level, sales personnel would identify specific customer needs and then approach the factory with ideas and requests relating to minor product modification. These ideas included 'cost versus feature' exercises on products including the Ergotec. At another level, both Gardiner and Johnston were involved in the more structured process of introducing 'new' products marketed under the Feltex Furniture brand name. The latter were often a collection of ideas and features borrowed from other products including the CoDesign range. For instance, Feltex Furniture would produce down-market versions of CoDesign products which were substantially cheaper to produce because their designs had been modified to better suit the operating characteristics of available manufacturing plant.

When Johnston joined Feltex Furniture he found that there existed a degree of confusion regarding the ergonomics of seating within the company. This situation had in part arisen as a result of the company's use of Mandal's research to promote sales of the Ergotec. However, as the company was to learn, Mandal's ideas are controversial and are not widely backed by ergonomists. Gardiner's response to this controversy was to become cynical of the role of ergonomics and ergonomists, whereas Johnston took the view that the company

should adopt a low-key position with respect to ergonomics. Consequently, the company ceased to cite Mandal's research in its sales promotions and, unlike its competitor Formway, it did not attempt to teach ergonomic principles to the consumer.

Rather than have Feltex Furniture assume the role of expert in the area of seating ergonomics, Johnston took the view that the customer ought to determine what was important. Consequently, Feltex Furniture focused on providing a flexible range of products with a wide range of ergonomic features, while letting the customer decide which were most appropriate to their needs. This idea was reflected in the design of the Ergotec which was promoted as a 'chair that does almost everything'.

Nevertheless, Johnston and Gardiner were still driven to incorporate ergonomic features such as waterfall fronts and lumbar supports in some Feltex Furniture products. At the same time, the company continued to use the term ergonomics as a 'promotional tool' in its own sales literature. Thus, in 1989, the company advertised Feltex Furniture's entire range of office furniture as the 'Ergosystem business furniture range'. However, rather than researching the ergonomics of seating, the company obtained ergonomic inputs for the development process by following the (predominantly dimensional) requirements set out in locally developed guidelines and standards.

Up until this point, Feltex Furniture had been owned and supported by its parent Feltex Furniture which, in more recent times, had operated respectively as Feltex International Ltd and Feltrax International Ltd. In January 1989 however, Feltrax International (and Feltex Furniture along with it) was bought out by the Australian giant BTR Nylex. Under this new ownership arrangement, attempts were made to restructure Feltex Furniture and CoDesign-NZ with the result that in early 1990 the two organisations were formally merged.

Both Gardiner and Johnston assumed key positions in the new structure. Johnston was promoted to operations manager while Gardiner took on the role of national manufacturing manager. Together, they were to continue to be directly involved in the development of Feltex Furniture products although after the merger they found themselves with less time to devote to these activities. This was despite the fact that in the new integrated organisation about 40 percent of total turnover was generated by products with the Feltex Furniture brand name.

While Johnston and Gardiner were finding that they were spending more time on the 'high profile' CoDesign range, this was not accompanied by any change in their attitudes to product development and ergonomics. For instance, Gardiner and Johnston continued to have limited contact with CoDesign's research and development section in Australia. Any exchange of information that did take place was usually restricted to technical issues of manufacturability rather than matters relating to ergonomics and product design. Furthermore, Gardiner continued to take the view that the company should not present itself as an expert in ergonomics. In this, he was supported by CoDesign-NZ's national marketing manager who also took the view that to speak out about ergonomics in any detail was a risky business. Accordingly, CoDesign-NZ's sales representatives were not given any formal instruction in relation to ergonomics. Rather, it was assumed that they would be able to pick up an adequate understanding of ergonomics through becoming familiar with the company's products and their ergonomic features.

Chapter Five

The Emergence And Development Of Ergonomics Capability: Innovation and Learning

Introduction

The profiles of the six organisations in the previous chapter provide insights into the processes by which ergonomics knowledge may be introduced into, and subsequently used in, product development settings. By comparing and interpreting these profiles (and the data from which these were developed) certain patterns start to emerge. These patterns provide the focus for this chapter. As will become evident, the analysis and interpretation of the phenomena of interest have been guided by concepts that have their origin in the literature dealing with organisational innovation and organisational learning. Furthermore, it should be noted that while this chapter will touch on contextual factors, these aspects will be dealt with more extensively and systematically in Chapters 6 and 7.

Initially, this chapter establishes the need for a more dynamic conception of ergonomics knowledge use and to this end introduces the concept of ergonomics capability. Following this, the chapter then proceeds to focus respectively on the *emergence* and *development* of ergonomics capability. Common themes to emerge in relation to these two processes include the recruitment and routinised involvement of industrial designers in product design and development activities. The chapter concludes with a section which specifically focuses on the transference of ergonomics capability between functional areas of an organisation.

Ergonomics capability

Each of the profiles in the previous chapter describes the events that surrounded the introduction of ergonomics knowledge into the product development function of an organisation. The profiles also provide some insights into the circumstances under which these organisations were to continue to apply ergonomics knowledge in subsequent years. When the profiles are compared, several patterns readily emerge from the data. In addition, it is also possible to discern more subtle processes that link events over time. While these patterns will be examined in later sections of this chapter, a major finding to be considered initially is the need for a more dynamic conception of knowledge use in organisational settings.

From the data collected in this study, it would appear that phrases such as 'the utilisation of ergonomics knowledge' and 'the adoption and implementation of ergonomics knowledge' fail to capture the dynamic nature of the processes of interest. In particular, the operationalisation of the key concepts in these phrases (i.e. utilisation, adoption and implementation) usually proceeds on the basis of an assumption that the processes of knowledge creation and knowledge use are separate in time and space (see DeMartini and Whitbeck, 1986). According to this view, knowledge creation occurs 'out there', where 'there' may refer to a centre of expertise or some other repository or source of knowledge. From 'out there', knowledge is then transferred through various mechanisms to organisational sites of relative ignorance, where the knowledge is consumed. However, this *consumptive view* of knowledge innovation is problematic in that it fundamentally ignores the ability of a recipient organisation to itself create new knowledge. By contrast, not only did the organisations in this study create new knowledge as a 'by-product' when they used knowledge, they also generated knowledge as a result of their own in-house research activities.

This chapter and those that follow will use a different terminology in order to emphasise the dynamics of knowledge creation and use. Firstly, ergonomics knowledge will be assumed to *emerge* and *develop* within organisations rather than follow the mechanistic pattern of an 'adoption' phase followed by 'implementation' or 'utilisation'. Secondly, the concept of 'ergonomics capability' will be employed as a means of capturing those forms of knowledge that are not usually implied in references to the term 'ergonomics knowledge'. In particular, ergonomics capability includes the firm-specific, practical

knowledge which may have been generated by the organisation's own research and development activities. Moreover, the competence emphasis implicit in 'ergonomics capability' adds another important dimension in that it suggests that past learning holds within it the potential for future activity.

Although Burgess (1986: 411) has referred briefly to 'human factors in-house capability', he did not define this term. The following working definition of ergonomics capability will guide the present research: ergonomics capability is a condition or state of an organisation which is represented at any given point in time by (1) the extent to which the actions and thought of organisation members are informed by ergonomics knowledge; (2) the extent to which organisation members are familiar with ergonomics methodologies; and (3) the collective experience of organisation members in the practical application of ergonomics.

Having signalled this important shift in emphasis and terminology, this chapter will now proceed to examine the changes in ergonomics capability that took place in the six organisations studied. In doing so, these changes will be interpreted as processes of innovation in which 'routines' play a major part. In particular, it will be argued that ergonomics capability emerged in the organisations in this study largely through the addition of a new *recruitment routine* (Mohr, 1987: 24). Subsequently, as learning within this particular routine took place over time ergonomics capability continued to develop.

Although this line of argument was informed by the 'routines as genes' metaphor upon which Nelson and Winter's (1982: 134) evolutionary theory of change is in part based, Levitt and March's (1988) discussion of routines within an organisational learning framework was also influential. Using a perspective on organisational learning that is narrower than that used by others (Starbuck, 1976; Hedberg, 1981; Fiol and Lyles, 1985), Levitt and March make the assumption that organisational action is guided by 'routines' rather than anticipatory choice or intention. The term 'routine' is used as a generic term to embrace rules, procedures, conventions, strategies, belief systems, and cultures around which organisations are constructed and through which they operate. Levitt and March (1988) also posit that organisational learning processes are 'history-dependent', in that routines which guide action are based on interpretations of the past more so than on anticipations of the future. As such, the lessons of history are 'captured' in a variety of routines which are independent of the actors who execute them. While organisational routines are

capable of surviving considerable turnover in personnel, they are however also subject to change. For example, as organisation members come to learn what routines they should use, new routines may be selected or old ones may be discarded. In particular, those allocations, strategies and technologies that previously have led to success will tend to be pursued while those which have led to failure will be avoided (Cyert and March, 1963: 123). At the same time, learning may occur along a second dimension (March, 1988: 9) in that, through their repeated use, routines may also be refined. As a result, organisations may become better at the things they do often and, conversely, less capable at things they do infrequently.

Capability emergence: A new recruitment routine

The present study reveals that the emergence of ergonomics capability may coincide with an organisation's *first* use of an industrial designer. In the cases of PEC and Fuelquip, the first industrial designers employed by these companies worked with ergonomic inputs and passed on some of their prior knowledge of ergonomics to others in the organisation. Variations in this pattern can be seen in Formway, RDD and Atlas, while Feltex Furniture provides the only contrary evidence for the involvement of industrial designers. In none of the six cases was the emergence of ergonomics capability *directly* linked to contacts with a professional ergonomist or human factors engineer.

Except at Feltex Furniture, ergonomics capability did not emerge in the organisations in this study as a result of a conscious attempt to improve performance in ergonomics *per se*. Instead, top management were generally motivated to narrow 'performance gaps' in relation to their organisation's overall standard of product design and by using a new recruitment routine involving an industrial designer some level of ergonomics capability was introduced into the organisation. This introduction usually occurred *unwittingly* as many organisation members were, at the time, unaware that the use of ergonomics knowledge is a routine that may be *embedded* within the recruitment routine of employing an industrial designer. The view that organisational routines may be embedded within one another, or may be related in some other way, is also supported by Levitt and March (1988: 322) who observed that 'each routine is itself a collection of routines, and learning can take place at several

nested levels'. The discussion will now turn to consider the circumstances surrounding the employment of industrial designers.

At Fuelquip, the decision to employ an industrial designer followed as a direct result of a management buyout of the company in 1984. The events surrounding this recruitment decision support Nutt's (1984: 446) observation that innovative activity is associated with the arrival of new leaders who wish to demonstrate that an organisation has been revitalised. In the case of Fuelquip, the new owners wished to demonstrate to prospective clients that the company was 'back in business'.

Prior to the management buyout, Fuelquip's share of the petrol pump market in New Zealand had fallen to virtually nil. However, rather than cease manufacturing and marketing pumps altogether, the new management wished to claim back a substantial part of this market. To be successful in this, however, it was recognised that they would have to demonstrate to their customers - the oil companies - that Fuelquip had broken with the old ways of Gilbarco. In particular, the new management was keen to demonstrate that Fuelquip would be more responsive to the needs of its customers. Fuelquip's manufacturing manager had this to say:

> It was part of our new image if you like. We had broken away from Gilbarco. If we had carried on doing the same old thing as Gilbarco then Fuelquip would just get labelled with the same thing when we wanted to tell everyone we were different: local control now, we've got new ideas, we can make decisions.

In addition to demonstrating that the company's new culture was now to be characterised by a customer orientation, the management wished to establish Fuelquip's new image and competence by developing a petrol pump that was 'different'. As a result, when a team was formed in the company to work on this project, a conscious effort was made 'not to copy what everybody else had done'. However, given the project team's lack of prior experience in designing new products, there were some doubts whether any of its members had the required competence to design some aspects of the pump, particularly its exterior. Thus, at an early stage in the design process, a decision was made to seek professional design assistance. Fuelquip's manufacturing manager explained how the company's first industrial designer (John Crozier) came to be

employed following a limited degree of search activity which involved the New Zealand Industrial Design Council (NZIDC):

> We [the manufacturing manager and marketing manager] had some ideas on what shape and things we wanted but there was an influence that maybe we should - most probably we were talking among ourselves - maybe we should get some professional help with the design ... we initially approached the Design Council and they gave us two names. The first one - the guy was engaged, so then we rang the second one whose name was John Crozier.

In establishing contact with an industrial designer via the Designer Service of the NZIDC, Fuelquip was following the same path as its competitor PEC. However, the initial decision at PEC to employ an industrial designer occurred fifteen years earlier and was motivated by a different set of factors. When asked about this period in the organisation's history, PEC's managing director Keith Howard directly and emphatically attributed his initial decision to employ an industrial designer to his attendance at a seminar organised by the NZIDC in late 1969. At the time, Howard believed that the company's electronic designs were very good but he left the seminar with the feeling that the standard of the equipment housings could be significantly improved. Moreover, as PEC was in the process of looking for new areas for market development, NZIDC's 'design for export argument' struck a chord with the management. PEC's technical director, who in 1969 was employed as an senior electronics engineer in the company, recalled that officers from the NZIDC had said something along the lines of: "Look, you guys are doing some wonderful jobs, but you could do a world class job by packaging your products correctly". According to this top manager, this line of reasoning had considerable impact:

> We considered ourselves pretty reasonable at engineering, but like most New Zealand companies at that stage, we didn't understand the concept of ergonomics, or packaging for international markets. We had our obviously very protected local market at that stage that used to purchase what we made. It was really the whole trigger for us, I think, to get out and look at the possibility of selling our products through the world.

Unlike at PEC and Fuelquip, the employment of Formway's first industrial designer towards the end of 1979 occurred without any involvement of the

NZIDC. Instead, it was a direct outcome of an association that formed between Formway and an educational institution with an interest in industrial design: the Wellington Polytechnic. In early 1979, two industrial design students from this polytechnic's School of Design approached the owner-manager of Formway, Bill Mackie, and asked him for assistance with their final-year seating design project. Mackie agreed to this request and at the end of the year he offered a full-time position to one of the students.

Mackie's decision to offer this graduate a position in the firm, which at the time employed less than ten people, was linked to signs of 'de-maturity' (Abernathy *et al.*, 1983) in the domestic product-market for office seating. Mackie had noted that, amongst other things, there was a rising interest among local competitors in the gas-spring technology which had been a feature of Formway's seating products for about a decade. In his own words, the 'renewal of effective competition generated the motive to stay ahead in chair design'. Consequently, Mackie employed the graduate industrial designer to assist him with the development and marketing of his new 'Forma' range of high quality office seating.

Quite a different pattern was evident at Feltex Furniture. In the years leading up to this company's integration into CoDesign-NZ, Feltex Furniture never employed an industrial designer, although in the early 1980s the company did have a brief association with industrial design students and tutors at the Wellington Polytechnic School of Design. In this respect, Feltex Furniture also differs from the other organisations in the study, in that the contact with the School was an *intentional* effort to tap into some ergonomic design capability. At the time, Feltex Furniture was under pressure to develop a 'more ergonomic chair with waterfall front and some of the other features'. The subsequent decision by the management of Feltex Furniture 'to give a project to Wellington Polytechnic to do' was a form of distress innovation (Knight, 1967).

When compared to the four organisations considered thus far, the involvement of industrial designers at RDD is more complex. As a result of the division's association with Fisher & Paykel, industrial designers have contributed to the design of the division's products at least since 1962. However, these designers were not employed directly by RDD and they generally had very little contact with the division. In 1984, however, this situation changed when RDD employed its first in-house industrial designer.

This move to employ an industrial designer on-site was but one aspect of the internal restructuring that transformed RDD in 1984. The top management of F&P initiated this restructuring in an attempt to prepare RDD for the new trade environment being created as a result of the Closer Economic Relations Trade Agreement that had been struck between Australia and New Zealand in January 1983. In particular, it was recognised that RDD would have to start to lift its standards in production and product development at least up to those of other F&P whitegoods divisions. The required changes were spearheaded by a new managing director who had previously worked in the marketing function in another F&P division. This managing director was described by RDD's first industrial designer as a 'real product man' who

> could see that the product in Dunedin hadn't changed for years and years and if it didn't change it was going to die. And so he basically went in there and turned everything upside down to ensure that the product was designed correctly.

The managing director believed that the product development function would have to be brought on-site so as to ensure greater co-ordination with production and marketing functions. This was achieved by transferring product engineering and industrial design expertise from the wider F&P organisation to the division. These changes coincided with other initiatives and emphases, all of which helped to bring RDD's organisational culture more into line with the 'Fisher & Paykel way'. Thus, there was an increased emphasis on marketing and quality. Practices widely adopted within the wider F&P organisation, such as open-plan office layouts, were also imported into RDD.

Due to the difficulties in gaining access to Atlas, the circumstances surrounding this company's first employment of an industrial designer remain unclear. Although it has been established that Paul Costello worked for Atlas while he was still working for PEC, it is not known whether there had been other industrial designers involved before him. Due to the limited nature of his association with the company, Costello was unable to comment with certainty on this matter.

From the above discussion we see that the innovative decision to employ an industrial designer was 'initiated' (March and Simon, 1958: 173) by

dissatisfaction with the company's present course of action. Furthermore, consistent with the observation of Schroeder *et al.* (1986: 513), dissatisfaction may be stimulated by some kind of 'shock' or major change in the organisation or environment. This is most evident in RDD, Fuelquip, and Feltex Furniture where shocks included new ownership and leadership, and impending loss of market share. By comparison, at Formway and PEC the employment of an industrial designer was stimulated by a more or less accidental encounter which presented an 'opportunity' (March and Simon, 1958: 183; Nutt, 1984: 442) for more satisfactory performance.

So far, this chapter has described some important patterns in the emergence of ergonomics capability. Industrial designers or industrial design students were crucial to this stage. These designers usually brought to the organisation some level of ergonomics capability which subsequently increased over time in all six organisations, although this general trend was often punctuated by periods of stability and decline. The next section will examine this capability development in terms of the practice of employing an industrial designer on successive design projects.

Capability development: The continued employment of industrial designers

Although this section will deal mainly with the continued employment of industrial designers, the role of other important participants must be acknowledged before proceeding. As Van de Ven *et al.* (1989: 17) have noted, 'innovation is not the enterprise of a single entrepreneur'. Instead, it usually involves a group of people who engage and disengage in the innovation process over time. In the present study, industrial designers (and industrial design students in the cases of Formway and Feltex Furniture) usually worked closely with several members of the organisation who were directly involved in, or responsible for, product design. Together, these individuals and the industrial designer constituted an 'innovating unit' which worked together on the development of a particular product or product range. Beyond this 'design team', there were usually other organisation members who had varying degrees of association with design team members.

Generally, the design team for a particular project was small, and ranged in size from three to about six members. The teams usually included at least one

engineer and, in several organisations, individuals with marketing responsibilities were also represented. Of greater significance, however, was the presence of owner-managers in the design teams at Formway, Fuelquip and PEC. Although the role of owners and top management will be discussed more fully in Chapter 6, the direct involvement of owners and top managers is not only due to the relatively small size of the organisations in the study, but also to the fact that new products were recognised to be the 'lifeblood' of their companies.

The design team is a temporary structure which is created around a particular project which has a beginning and an end. Team members will have varying involvements between these end-points but generally as the project nears completion the team will tend to disband. When the organisation's next project is initiated, however, the same team may regroup with no, or only little, change in composition. Alternately, as a result of turnover or altered responsibilities, the change in composition from project to project may be more substantial.

The design teams in the organisations studied exhibited varying degrees of consistency in composition over time. At Fuelquip, for example, there has been only a small amount of change in the teams which worked intermittently on projects since 1984. Thus two of the same three individuals who worked together on the initial FQ20 series of pumps in 1984 were in 1990 still working together on the company's latest development project. Moreover, throughout this period, the same owner-manager had continued to act as leader of the design team.

By contrast, the leadership of Formway's design teams has changed on several occasions since 1981. These changes can be linked to a new ownership structure (in 1981), the initiation of a major new development project - the Zaf - (in 1986), and major restructuring of the company's research and development activities (in 1988). At the same time, design team composition shifted as a result of turnover among the company's in-house industrial designers. Despite these changes, the presence of the same consulting industrial designer on successive design teams since 1982 has provided a degree of stability.

The involvement of the same industrial designer over a relatively long period of time is also characteristic of two other organisations. Since 1970, PEC has employed three designers for periods of about ten, five and six years

respectively, always on a consulting basis. Fuelquip has repeatedly employed the same consulting industrial designer since 1984. Atlas, on the other hand, has had associations with several design consultants but on occasions their involvement has been very brief. Costello was only employed for a single project and another industrial designer recalled that while he had done 'a bit of work' for the company in the mid-1980s, he had not been invited back.

While 'long service' appears to apply for consulting industrial designers in this study, turnover among the in-house full-time designers employed by Formway and RDD has been much higher. Since 1984, RDD had relied exclusively on in-house designers and in the period to 1991 at least five different designers were employed. The division's first industrial designer stayed only for two and a half years before being transferred. Similarly, at Formway, three in-house designers have been employed since 1978 for periods ranging from one to four years. The relatively high turnover among these designers may be attributable to young age and professional inexperience. At least three of these designers resigned from their position in order to travel and work overseas.

Although length of service may be related to an industrial designer's willingness to work with a particular organisation, the continued presence of industrial designers also depends on the organisation's inclination to continue to re-employ consultants and replace those in-house designers who leave. The latter practice of continued and ongoing recruitment can be explained in terms of organisational learning: organisations will continue to use routines which are successful (March, 1981: 567). Consequently, if the routine of employing an industrial designer on a project is judged to be successful it is likely to be repeated. Alternately, this practice may be discontinued if it is linked to failure. Although in practice, success is often ambiguous (Levitt and March, 1988: 325), it may generally be defined in terms of targets and performance outcomes. The targets are not merely financial, they may also relate to prestige, status or recognition. Furthermore, the level and nature of targets may also change over time.

The early success of industrial designers in meeting targets may explain why Formway and PEC continued to employ these professionals. At PEC, the M-system which Costello initially worked on was reasonably successful in New Zealand. More significantly, sales of the M-system to Australia demonstrated that the company had the potential to move into export markets. Costello's role

in this was recognised: feedback from export markets indicated that his console design was on par with similar systems developed in other countries. Costello was asked to work on subsequent major projects during the 1970s. Since then, PEC has continued to employ industrial designers.

By 1990, 60% of PEC's sales derived from exports and the company's ability to sustain this performance was linked directly to the employment of consulting industrial designers. As PEC's technical director explained:

> We are very pleased with the feedback that we do get out of international markets, and we all truly believe that without industrial design, including the ergonomics, we would not be in international markets. And I think that goes without saying.

While the continued employment of designers at PEC occurred against a background of relative stability in senior management, organisational 'memories' (Hedberg, 1981: 6) ensured that the practice of employing industrial designers at Formway was resumed in spite of a major break in design team composition caused by a change in company ownership. Following this change, the new owner-managers (Mark Carter and Peter Stevens) formed the core of a design team which commenced work on the design of an adjustable computer workstation. However, as development work progressed, the owners conceded that they lacked the expertise necessary to develop a product to the standard that they considered appropriate. Carter and Stevens were aware that the Cambio chair, the company's most successful product at the time, had been designed by an industrial design student. Furthermore, knowing that the company had also, in the recent past, employed an industrial designer, the new owners decided to repeat this practice. Years later, the company's early experiences with industrial designers were looked upon as a 'fortunate' element underlying the company's dramatic growth in the mid-1980s. As Brian Carter recalled:

> There was a certain amount of luck in that when we purchased the company, the previous owner, Jim Mackie, had already had contact with the Design School. So there had been one designer already at work with Formway and there was a recognition that we didn't know what all the answers were and we needed some professional help.

Whereas Mackie had employed a young industrial design graduate in a full-time position, the new owners of Formway initially employed an experienced industrial design consultant on a part-time basis. However, during 1983, as well as retaining Richard Walker, the company proceeded to employ an industrial design graduate full-time. Although this young designer stayed with the company only briefly he was replaced immediately by another graduate (Ian Chalmers) who, during the mid-1980s, became Formway's 'ergonomics advocate'.

The adjustable workstation which Walker and both full-time designers helped design was an 'enormous success'. For a considerable time, the product generated more than half of the company's sales while, at the same time, annual turnover continued to double: the company's annual turnover increased by 85 percent in the 1984/85 financial year and 106 percent in 1985/86. For the owner-managers, this success (which was also in part attributable to mounting public concern about RSI) confirmed the value of employing industrial designers. High profits also provided slack resources which could sustain the ongoing full-time employment of Chalmers.

When Chalmers left Formway in mid-1987 for overseas, the practice of employing in-house designers was discontinued. Management believed that a young inexperienced designer would not be able to provide the advanced level of design expertise that the company now needed. Instead, the necessary input was obtained through increasing Walker's part-time involvement with the company. As Mark Carter explained:

> We still see a place for that [hiring young designers], but in part we spend a year lifting, training them and then we see a small amount of results in the second year, not a lot, and of course, naturally, they want to expand their knowledge, so it's only a limited time frame you can expect them for because they will want to go and do other things which is fair enough. So, we felt that because we were raising our expectations all the time, that if we were going to get the results for the sort of investment we are making here, then we needed a higher level of input.

When Ian Chalmers returned to New Zealand in 1990 after an absence of two and a half years, Formway's management was keen to have access to his skills.

However, as a result of the company's low growth rate, and prior commitments to employing Walker, the management was faced with something of a dilemma. As Brian Carter indicated: 'We couldn't afford to employ Ian, but we also couldn't afford not to employ him'. In the end, Chalmers was offered work but only on a short-term, part-time, basis.

In contrast to Formway and PEC, the initial involvement of an industrial designer (John Crozier) at Fuelquip was, to a degree, associated with failure. Although the company has continued to employ the same industrial designer since 1984, the first petrol pump design this designer contributed to (the FQ21) was scrapped at the prototype stage after a considerable amount of time and money had been spent on its development. This negative outcome, however, was attributed more to the inadequate specification practices of a client, than to any incompetence on the part of the designer.

In understanding the events that followed it must be noted that Fuelquip had used a scale model to test out the response of the oil companies to their proposed design concept for the FQ21. The response was generally positive, and one oil company proceeded to sign up an order. Crozier recalls the events that followed:

> We got as far as a prototype run of ten and it went out, and apparently it was quite, it was reasonably, successful I believe. Then the chap who was really our target client left to go overseas. [Then] the design went to a guy in head office in London who just scrubbed it because it didn't fit within the corporate identity programme. So the whole thing was just packed up and sent to the tip ... we really didn't know or understand that there were other regulations or requirements at an international level that they had to conform to.

Although the outcome was 'demoralising', the company's design team regrouped immediately and started working on the design of another series of pumps. Crozier was involved once again. This time, however, the design was guided by a written design specification which called for a non-controversial 'industry pump' with a traditional 'hard-edged appearance'. The team worked quickly, using much of what had been learned from the FQ21 development. The main change involved the overall shape and this, according to a Fuelquip design engineer, was essentially derived from a concept used overseas.

> Although the design concept, that particular shape of pump, was unique to New Zealand it was a formula that has been used in Europe anyway, so we were pretty sure that something along those lines would find favour.

Upon their release, these 'hard-edged' pumps were a commercial success. They not only provided the company with a substantial share of the local pump market; they also helped the company receive recognition for design excellence in a national design competition.

While Crozier's association with this initial development work had been relatively intensive, his involvement with Fuelquip's more recent projects has been less substantial. Consequently, when Crozier was brought 'back into the picture' in 1990 after a gap in the company's development programme it was mainly to 'do a little bit of sketch work'. To some extent this reduced involvement reflects a shift in the company's product strategy. Whereas in 1984, the company's directors had initially aspired to produce a 'different' product that would capture the market and demonstrate that the company was 'back in the business', aspiration levels were to adapt to experience. Firstly, the company's directors had learned that market share could still be effectively captured by 'borrowing' design ideas and introducing relatively conventional pump designs. Secondly, this conventional pump design was sufficient to enable the company to establish its credibility as a competent producer of fuel dispensing equipment. As a result of these experiences, there was diminished support for major expenditure on product design activities.

Against this background, Fuelquip's design team leader (Bradshaw) was obviously concerned about the costs associated with employing experienced consultants:

> It is pretty expensive. Initially, the more you use them and the better they get, the better you get, the more expensive they become. Because they have learnt off your product. Using a lot of consultancy is all very well but if they make a mistake and have to redesign something and have to go through it all again it's all still charged on you.

While Bradshaw was conscious of the costs associated with employing consultants, he was nevertheless anxious not to lose expertise from the design team. Bradshaw had already suffered a substantial loss in the late 1980s when Fuelquip's electronics consultant left to work overseas. As a result of this experience in particular, Bradshaw was determined to only work with consultants who would 'stay in business for a while'. For this reason, he was probably reluctant to employ an industrial designer other than Crozier.

RDD has continued to employ industrial designers since 1984. Moreover, since 1986, there have been at least two in-house designers in full-time employment at any one time, a pattern that repeats itself in Fisher and Paykel's other whitegoods divisions. By 1990, these 'industrial design units' were linked together through a senior industrial designer who worked from a centralised position essentially as an internal consultant to the various divisions.

The continued employment of industrial designers at RDD can be linked to the division's relationship with its parent. From 1984 onwards this became increasingly close. Moreover, over this same time period, the presence of one or two in-house industrial designers became accepted practice within all of F&P's whitegoods divisions. This situation is reflected in the increasing number of in-house designers employed by F&P: from 2 in 1983 to 6 in 1990. This growth is a reflection of F&P's more recent confidence in its ability to successfully develop products from the 'ground up'. A senior industrial designer had this to say:

> I think in a lot of ways it started with the Gentle Annie [electronic auto washing machine] seriously in that we proved we could develop new products from the ground-up successfully and it's now become iterative in this division.

The employment of in-house industrial designers is associated with an overall improvement in RDD's product design, even though some 'fundamental errors' have still occurred from time to time. According to RDD's product engineering manager:

> Since the early eighties when we have been getting the sort of fresh graduates from the design school there has been a marked improvement in the product design. There is certainly more focus

> on the customer interface with the product than there ever has been in the past.

While RDD has relied on in-house industrial designers, its competitor Atlas appears to have continued to employ design consultants. Although little is known about this organisation's recent experience with industrial designers, several informants were certain that design expertise had been applied to the company's latest range of products.

The main exception to the continued use of industrial designers in this study is Feltex Furniture. This organisation continued to conduct its in-house development work without the assistance of an industrial designer, even though it did have a brief association with industrial design students from the Wellington Polytechnic in the early 1980s. Although this association was relatively successful, in that it provided Feltex Furniture with a chair design which subsequently was commercialised, the practice of using design consultants was not repeated in any form. Thus the company continued, as before, to pursue a product strategy which was characterised by manufacturing under license and imitation. This situation may be explained by a number of factors. Firstly, soon after the encounter with the Design School, the senior manager who had initiated contact with the School left the company. Not only may this have resulted in a loss of experience, this turnover also introduced a new senior manager who favoured a strategy of manufacturing under license. Furthermore, in 1984, a project manager was appointed who considered himself to be sufficiently competent to undertake the design modification and imitation work that was being conducted. This project manager continued to work for Feltex Furniture during the remainder of the 1980s.

While the foregoing discussion has attempted to relate the continued employment of industrial designers to factors of success or failure, the relationship is not a simple one. Generally, in this study, the employment of industrial designers enabled the organisations concerned to develop product designs of a high standard. Despite this, these products did not lead automatically and directly to commercial success for the organisation. Other influences, particularly consumer demand and the actions of competitors, may preclude this. However, where management perceives these influences to be beyond the control of industrial designers, these latter will continue to be employed in spite of a degree of commercial failure. Furthermore, where the

fault does lie clearly with the design and not with external factors, it may be difficult to blame only one member of a multi-member design team. Other team members are often directly implicated by not having challenged the design direction taken at an earlier stage.

Despite the difficulties in attributing the continued employment of industrial designers to organisational success, this staffing routine does appear to be strongly linked to an organisation's overall product strategy. This study indicates that where (as at PEC and Formway) an organisation's product strategy continues to be characterised by a high degree of emphasis on in-house development then it is likely that industrial designers will continue to be employed. Consequently, if organisations (as is demonstrated in the cases of Fuelquip and Feltex Furniture) move away from in-house development and rely more heavily on routines of imitation or acquisition, the skills of industrial designers will be involved to a lesser extent.

In the context of this study, product strategies are taken to be a particular form of organisational routine. This position will be discussed in more detail in Chapter 6. Here, however, it is argued that product strategy is part of an interrelated collection of routines which together support the development and continuance of ergonomics capability. This relationship is illustrated in Figure 5.1 below.

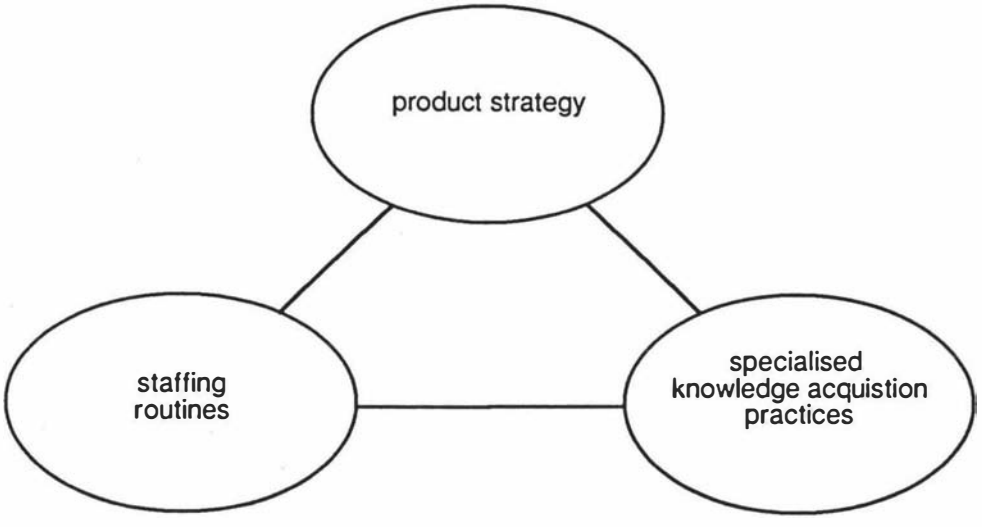

Figure 5.1 The collection of interrelated routines which support the development of ergonomics capability.

Figure 5.1 introduces 'specialised knowledge acquisition practices' as a new element. This term is used here to refer to routines associated specifically with the development of an organisation's capability in specialist knowledge domains such as ergonomics. Examples of these practices include search activities, training, experimentation, networking, and applying theoretical and practical ergonomics knowledge. These practices will be referred to in the following discussion which starts by looking at learning within design teams.

Learning about the ergonomics domain

Industrial designers usually brought to the organisations in this study a level of ergonomics capability in relation to product design that did not previously exist. In doing so, they also set the scene for further learning in that they provided the 'prior related knowledge' that an organisation needs as a base for the assimilation and use of new knowledge (Cohen and Levinthal, 1990). At the same time, by working with and through other people, the industrial designers usually passed on some of this knowledge. This section describes the learning in relation to the ergonomic domain that occurred within design teams.

Prior to working with an industrial designer for the first time, most design team members had already heard of ergonomics as a result of various diffusion channels. Some team members could attribute their initial exposure to the discipline of ergonomics to contact with a particular individual or 'source' (Rogers and Shoemaker, 1971: 20). Thus an engineer who worked with RDD's first in-house industrial designer claimed that he had first heard of ergonomics at a seminar in 1977 which had been organised by an ergonomist employed by Fisher & Paykel; and Mackie of Formway first heard of ergonomics in 1960 through his contact with an interior designer. By contrast, other design team members were unable to link their first exposure to ergonomics to any individual or event.

Those design team members who worked with an organisation's first industrial designer usually had a knowledge of ergonomics that was limited to a mere knowledge of the existence of the word - a form of knowledge that Rogers and Shoemaker (1971: 277) call 'awareness-knowledge'. An exception to this pattern is RDD: the division's first industrial designer worked with design team

members who had attended seminars on the subject and had previously worked with industrial designers who applied ergonomics.

While working with the design teams in this study, industrial designers would normally make use of ergonomics concepts and data where the nature of the product demanded this. In this, they were influenced by their professional training in industrial design (see Chapter 7). However, individual designers did vary in the extent to which they *explicitly* worked with ergonomics concepts and data. Some designers used ergonomics terminology openly in their verbal and graphic communication, while other designers appear to have adopted a more tacit approach. This factor can impact on the degree of learning that takes place in a design team in that learning processes are unlikely to be triggered in those situations where ergonomics is applied covertly. On the other hand, if ergonomics is used openly in the course of team interaction, other design team members will be able to link new knowledge with the label 'ergonomics'. As a result of this associative learning, team members may be able to enhance their understanding of the discipline. For instance, when Fuelquip's manufacturing manager was asked to describe what he associated with 'ergonomics', he was able to respond immediately:

> Basically I associate the interaction of people with machines. How comfortable people feel operating a piece of equipment or how comfortable you feel sitting in your chair I suppose. Interaction between people and machines.

Opportunities for learning may be reduced where the industrial designer works in relative isolation from the design team. For instance, when Costello worked for Atlas in the late 1970s, he did the necessary work in his own design office and had limited interaction with Atlas staff. On neither of his two visits to the company did Costello 'make a big deal about ergonomics'. By contrast, industrial designers at Fuelquip, PEC and RDD were required to work more intensively with other design team members while trying to resolve detail design problems. In the course of group interaction, the designers would present their ideas, using ergonomics to rationalise their position. These arguments would be weighed up by other design team members who would tend to look for evidence or lines of argument that were 'convincing'. These exchanges were described as follows:

> I remember we had long discussions ... we had great arguments about - I felt that there should be front controls ... we talked a lot about the shape of the controls. (Design team member, RDD)

> We used to have these sessions with him [Costello] and he would come down and talk us through his ideas. And we would try to make compromises for engineering reasons ... just because of the way we used to do things, and Paul would get very, very, strong and say: "No, you can't do that. That is ergonomically unacceptable" and things like that. (Design team member, PEC)

> The thing that led us to understand more about ergonomics was in having to get into the details of designing an adjustable workstation ... getting into understanding about copy holders and keyboard heights and all those things. So in doing that the design people we were working with - we really had to be quite open to the different arguments that support different views and different ways of doing it. (Design team member, Formway)

These and other responses from design team members also indicate that ergonomics knowledge use and learning occurred at two levels. Firstly, ergonomic data were used in the context of solving highly specific design problems. Although some of this data was derived from publications, product-specific information was also generated as a result of observational studies and experimentation. Although the industrial designer often played a central role in these activities, other design team members would become familiar with the nature of the ergonomic information that was being used and the methods employed in the process. Secondly, through their experiences of working with an industrial designer, design team members could acquire an understanding of the 'ergonomic approach'. As the following comment by a top manager of PEC indicates, design team members may obtain a broad understanding of the importance of designing with users in mind.

> [Prior to Costello's appointment] our awareness of ergonomics was terrible. We by and large are engineers in this organisation ... when we would design the product we would get an engineer to design the product and, of course, the parts went where they were logically

> placed from an engineering point of view. There was no consideration of how easy it was to use, how well it interfaced with the person that was supposed to be using it ... And suddenly people like Paul really just introduced the whole concept of ergonomics to us and the way machines interfaced with man and told us how to study how customers used our products ... it was a complete turnaround really.

Although this manager was not personally involved in the use and generation of data, it is evident that ergonomics did influence his thinking. This broad and general impact of a knowledge domain has been referred to as 'conceptual utilisation' (Rich, 1991: 332) or 'enlightenment' (Weiss, 1978 cited in Larsen, 1980: 425). The recent recognition that has been given to this less visible type of knowledge use has major implications for knowledge utilisation researchers who have traditionally relied on observational techniques such as counting the number of reports and handbooks consulted during a project (Larsen, 1980: 425).

This 'conceptual' impact of ergonomics at PEC contrasts with the experience of Bradshaw, the owner-manager on Fuelquip's design team. Bradshaw recalled that ergonomics only came to the forefront of discussion when the design team was trying to resolve problems relating to the pump exterior. In this process, ergonomics was associated mainly with a new concept (zone of vision) and new insights into the design of instructions.

> I don't think we consciously thought 'ergonomics' until we thought of this 'zone of vision' thing, and the wording on the pre-set. That was the only time ergonomics was really brought to the forefront.

Interestingly, the user-centred approach adopted by Crozier (Fuelquip's first industrial designer) was not considered to be novel or particularly insightful. Rather, given that key members of Fuelquip's design team had for some time been aware that pumps could be redesigned to make servicing operations easier, this overall approach was considered largely to be 'common sense'. As Crozier explained:

> They probably don't even see it as ergonomics, I think, but things like straightforward layouts of equipment, based on experience

> where the hydraulic unit has been ... jammed in. [It is] like working inside of the bonnet of a Jaguar, you need a triple-jointed arm to get up inside of it. But they would see that very much as a practical situation, they wouldn't see that as ergonomics.

As a result of repeated learning cycles, a degree of knowledge overlap in relation to ergonomics will develop within the design team. At its most elemental level this shared knowledge is characterised by a shared language and basic skills; at a more advanced level it may include recent scientific or technological developments in the knowledge domain (Cohen and Levinthal, 1990).

The level of shared knowledge varied between the design teams. At PEC, for example, it was acknowledged that, while team members did acquire an understanding of ergonomics, no-one had intentionally raised their understanding to a more substantial level. PEC's technical director described this situation:

> I suppose many of us, by working closely with designers have got an understanding of ergonomics, but none of us have taken it up as a particular crusade, and none of us have any experience in ergonomics as a discipline.

This distribution of expertise compares with Formway where the overall level of shared knowledge was lifted and sustained at a relatively high level. According to Ian Chalmers, the collective knowledge of Formway's top management and other design team members had, by the mid-1980s

> developed to a point where we could communicate the first principles. We could communicate the principles about seating, about support, about anatomy, anthropometrics.

Another factor which influences shared knowledge is the intensity of experience in a particular knowledge domain (Cohen and Levinthal, 1990). This, in turn, will depend on the degree to which design team members specialise in their respective roles. Thus, while Chalmers continued to be the main 'boundary spanner' (Tushman, 1977; Tushman and Scanlan, 1977a; 1977b) in terms of ergonomic information at Formway, other design team members also participated in this activity by, for example, attending ergonomics conferences.

The resulting high degree of knowledge overlap in Formway's design team, meant that during the development of the Zaf chair, specialisation had to be enhanced by clearly assigning different 'advocacy' roles to design team members. Thus Chalmers became the ergonomics advocate for the project, while Richard Walker and Brian Carter were, respectively, to look after the aesthetics and engineering aspects. As Brian Carter explained:

> It requires each of these aspects, I think, to be independently championed and the chance to make a good product requires strong champions in those major identified areas, even if individually they are capable of doing more than one of those roles: that's helpful if they are, because they are able to reason more in the discussions and fights that follow. 'Fights' is not really the right word but it has got to be that strong almost. [It is significant that Carter used the terms 'advocate' and 'champion' spontaneously, that is, with no prior prompting during interviews].

By contrast, PEC's recent design teams have been characterised by a higher degree of specialisation in relation to ergonomics knowledge. In these teams, the industrial designer is recognised to be the main source of ergonomics expertise. This specialisation was described by a senior member of PEC's management team. He indicated that while others in the design team may have an interest in ergonomic considerations

> you don't have a lot of argument. For instance, when an industrial designer presents an ergonomic model and says "That is really the way it's got to be", probably the most vociferous might be the marketing people, or product manager. He brings up, perhaps, issues that have not been considered in the ergonomics study, but pretty much the industrial designer is considered to be the expert on ergonomics.

These patterns of knowledge specialisation and overlap within the design teams at Formway and PEC may have an impact on each organisation's innovative performance. As Cohen and Levinthal (1990) have argued, prior-related knowledge confers upon an organisation the ability to evaluate and utilise new, external knowledge. This ability or 'absorptive capacity', will be enhanced where there is an appropriate distribution of expertise within the organisation's innovating units.

Although the knowledge of the ergonomics domain acquired by design team members reflected its various elements (of perspective, theory and practice), one can suspect that the learning that took place may have at times been superficial and imperfect. This in itself would not be an extraordinary situation, if we accept the position that much of the learning that takes place in organisational settings is incomplete (March and Olsen, 1976). Incomplete learning can be attributed to many factors including the cognitive limitations of information receivers which result in filtering, distorted interpretation and biases in the allocation of attention. These factors, in part, explain why organisational units frequently know less than their individual members (Hedberg, 1981).

Aside from the effect of the attitudes and cognitive limitations of individual design team members on their own understanding of the ergonomics domain, the quality of knowledge passed on was itself limited by the sender's knowledge, attitudes and skills. With the exception of those design team members at RDD who went on to study ergonomics at university level, or attended in-house seminars on ergonomics, most design team members in this study acquired their knowledge of ergonomic principles in a less structured way, primarily through the direct experience of working with an industrial designer. In these circumstances, incomplete learning may also result where the knowledge transferred by the designer is itself imperfect.

Flaws in the industrial designer's own understanding of ergonomics may stem from their design training. Wasserman (1989), in writing about his experience in the USA, considers that the ergonomics training undergone by industrial designers is no substitute for a background in experimental psychology, systems engineering, cognitive psychology and an ability to perform empirical tests and interpret data. These criticisms would also apply to the designers in this study, even though their training in ergonomics was not insubstantial. This training did, for example, tend to place relatively more emphasis on physical ergonomics than on psychological ergonomics. Furthermore, as the emphasis was placed on the integration of ergonomics in design, the scientific research skills of the designer were usually developed only to a limited degree.

Although the inclusion of ergonomics in their design training may give industrial designers reasons to believe that they are competent practitioners of ergonomics in the context of product design (Ward, 1990), design school training is only one

potential source of a designer's ergonomics expertise. Learning will result from the practical experience of designing, and learning may be further enhanced through the use of information search routines and experimentation. In this study, the extent to which industrial designers relied on these additional modes of learning varied considerably. Some designers, for example, relied mainly on the basic understanding of ergonomics provided by their training, and subsequent experience. In doing so, they appeared to rely on an overall ergonomic orientation, basic ergonomic principles, and a limited amount of ergonomic data that they had collected as a background resource. These designers tended to see their approach to ergonomics as being largely 'instinctive' or 'intuitive'. By contrast, other designers would use a variety of problemistic search routines. When confronted with a new problem they would search the literature and/or consult with ergonomists they 'trusted'. Those designers that had searched for data, indicated that they often couldn't find the specific information that they were seeking. While it is possible that they weren't looking in the right places, a problem also exists in that much ergonomic data has not been translated into a form that is usable by designers (McClelland, 1990). The designers responded to unsuccessful search in different ways. Most would fall back on the basic understanding of ergonomics that they had acquired as a result of their training while some would seek out further information through other channels such as experimentation.

Aside from search that was directed at solving particular problems, the industrial designers did not appear to learn about ergonomics through searches motivated by curiosity, interest, or a search for understanding (see Cyert and March, 1963: 121). This may help explain why, with the exception of Chalmers at Formway, who was recognised as that company's 'ergonomics champion', none of the industrial designers in this study had attended ergonomics conferences, participated in ergonomics societies, or had undertaken further formal study in ergonomics.

While a full examination of the reasons why industrial designers come to take this approach is beyond the scope of this section, it is important to note that the learning, or lack of it, does not occur in isolation. The actions or inaction of industrial designers are constrained by the structures through which they have to operate. For example, industrial designers who are cast as 'cosmetic consultants' will be only be involved towards the end of a design project when time constraints are substantial. Furthermore, the funds made available for

employing an industrial designer will tend to be limited to a level that is commensurate with this 'superficial' role. On the other hand, industrial designers are not merely constrained by their context, they also help to reinforce and shape it. For example, designers will merely reinforce narrow role definitions if they continue to rely mainly on creativity and intuition as opposed to analytical techniques.

Learning about ergonomic design

In working alongside an industrial designer for the first time, design team members in this study often encountered a professional who considered ergonomics to be a *routine* aspect of their work. As noted in the previous section, most of the industrial designers in this study had been taught ergonomics as part of their design training, and had come to accept that ergonomic inputs formed an integral part of the design process. As a result of their first experiences of working with an industrial designer, some design team members also came to share this view of ergonomics. Mark Carter at Formway explained:

> I don't think that we understood there was a thing called ergonomics when we first realised we needed design, although we would have, I guess, heard of it. But I don't think we understood what it really meant until we saw a designer applying what it was. So I suppose the first step was in terms of recognising we needed to hire design expertise and then *discovering that ergonomics was an integral part of that process*. [emphasis added]

Similarly, PEC's technical director recalled:

> He [Costello] really did believe very strongly in designing products with ergonomics in mind and he really got that across to us. He really made us appreciate that that was a very important *part of design*. [emphasis added]

While the relevance of ergonomics to the design process was recognised by design team members, ergonomics also generally came to be recognised as a

discipline in its own right. Design team members at Formway, Fuelquip, Feltex Furniture and RDD were also aware from an early stage of the existence of 'ergonomists' as a distinct professional group. However, while some organisations did obtain advice from ergonomists in relation to specific problems, the organisations continued to rely primarily on industrial designers to actually *apply* ergonomic inputs during the product design process. This is particularly evident at PEC, where consulting industrial designers were expected to be sufficiently competent to act as the organisation's primary source of ergonomics expertise. Having experienced a succession of designers who had been trained in the subject, this expectation had proven itself to be reasonable. According to Mark Ryan, PEC's current industrial design consultant:

> Being a New Zealand company and having been serviced by graduates from the Polytechnic - they are very used to having product designers having a high appreciation and working knowledge of ergonomics. So I think that they just expected that I would have that.

Unlike the ergonomist, whose knowledge is often specialised and academic in nature, the industrial designer is concerned with a wider range of design inputs including ergonomics, aesthetics and engineering considerations. Indeed, industrial designers are valued for their ability to synthesise these various inputs (Bishop and Guinness, 1966). Thus, while at PEC, the industrial designer was recognised as the 'ergonomics expert' in the company, this was considered to be but one aspect of the designer's bundle of skills. As a senior manager explained:

> Our requirements for a designer span a whole variety of things. Ergonomics is really only one of the things that we would look for. Because all our products are products that interface with a human being, we would always look for somebody that was sympathetic to the ergonomic requirements, but we have come across designers that we felt didn't have a strong balance of, for instance, cost-effectiveness, fitness for purpose ... so we had a whole variety of requirements of a designer, in addition to ergonomics. I think ergonomics was just one of five reasonably high priority requirements we saw the designer to have.

The comment that a designer must be able to 'balance' different criteria reflects, to some extent, those prescriptive accounts of the design process in which

ergonomics is viewed as one of several inputs that must be used in a design process which proceeds ideally through the *optimisation* of fitness for purpose, based on market considerations and the criteria of quality, performance and cost effectiveness (Flurscheim, 1983: 1). Significantly, this study revealed that the design process was rarely seen as a positive process of optimisation, instead, it was widely seen to involve 'compromise'.

Compromise may result from a conscious attempt to find some midway position between conflicting opinions; it may also mean knowingly not taking an action because of shortage of time or financial resources. Thus at Fuelquip, Bradshaw considered that the design team had had to compromise on the angle of the petrol pump nozzle boot, a factor which had implications for the ease of handling. The team had incorporated vertical nozzle boots in the design of the FQ23 despite their awareness that the trend was moving away from this overseas. At the time, however, a change would have involved discarding components which had already been purchased; there also wasn't enough time to make the necessary modifications. Time pressure was also mentioned by RDD's marketing manager:

> The industrial designers have done some training [in ergonomics] as I understand and they are applying it to certain areas of the product, but probably one of the biggest things is that a lot of our product designers are constrained either by time or by where the product is now ... ergonomics is taken into account but it doesn't always come out a winner. Perhaps I should say that it doesn't come out often enough as a winner. We probably haven't got the right balance yet.

Besides time and financial constraints, other factors may contribute to compromises of an ergonomic nature. These factors include the distribution of power in the design team and the strength of conviction and purpose of individual team members when they have to defend their point of view. For example, in spite of the increasing influence of industrial designers within RDD's design teams, the product engineering manager was of the opinion that in relation to ergonomics, none of the industrial designers 'had been very strong on it'. By contrast, at PEC, Paul Costello is remembered as having been very 'strong' in relation to ergonomics and being somewhat intolerant of 'compromises for engineering reasons', while PEC's second and third designers were 'probably more inclined to change the design for appeal a little more than

Paul would have been'. Indeed, Costello may not have achieved the 'balance' that PEC has looked for in its more recent designers. Visual appeal is likely to have been of growing importance in the company as it had become increasingly marketing-oriented during the 1970s.

Finally, compromises may occur because a design team member is not able to, or is not expected to, participate in design decisions on a day-to-day basis. This may be a problem with the use of external consultants. Chalmers, on the other hand, considered that the presence of a full-time designer, particularly one who was prepared to 'push' ergonomics (and act as a watch-dog), had set Formway apart from its competitors.

> I think that one of the differences that Formway has had is having somebody on the staff on a full-time basis who is pushing, pushing that barrow, and saying this is where we are heading for, and always pushing, pushing for that rather than somebody coming in from the outside giving a once-off package of recommendations and then leaving them to their own devices as to what they do with them.

As a result of feedback from customers and competitors, an organisation may come to 'know' the extent to which ergonomics can be compromised *vis-à-vis* other factors and yet still be acceptable to its target customers. While some organisations will be satisfied with this level of performance, others may, however, continue to experiment with the level of design compromise. For instance, the development of the Zaf chair at Formway was guided by an aim of minimising the degree of compromise between ergonomic, aesthetic and engineering aspects. Although the design team members considered that they had gone a long way towards achieving this aim, and the Zaf was promoted as 'the chair without compromise', the development was at considerable cost to the organisation. The development took longer than anticipated and this caused some friction in the management team. Not wishing to repeat these negative outcomes, the management restructured the organisation so that routine product development work became separated from longer-term research activity. This is similar to RDD's separation of its product engineering function into two areas which focus respectively on 'ground-up' work and 'continuous improvement' activities. This two-pronged approach can provide a shielding mechanism which protects the organisation's core activities while still allowing for a degree of experimentation and an element of 'foolishness' (March, 1976; 1981).

The Zaf development illustrates that while a striving for minimal compromise may be an experiment that is advantageous from the point of view of an industry or a society, it may not be entirely sensible from the point of view of a single organisation (March, 1981). Attempts to minimise the degree of compromise will tend to take up more time and other resources and this ultimately may prove not to be an experiment worth the risk. As has been noted by others, if the (uncompromised) design is relatively easy to copy, imitators may easily learn and profit from the design produced by the innovator. In situations like this, 'the innovator may well end up positioned disadvantageously relative to a follower' (Teece, 1987: 190).

The Zaf development was initiated at a time when Formway was enjoying enormous success both financially and in terms of reputation. On the basis of their experience, the company's top management concluded that customers would value design solutions that addressed their needs well. This, in turn, confirmed the importance of using ergonomic inputs. Formway's research director had this to say:

> Along with those sales [from the adjustable workstation], there was the demand for seats that would adjust. And in that area we made seats that go lower than our competitors and because we discovered in the market that we had an advantage, it really reinforced the position of people making ergonomic inputs from within the company, and advisers and independent people outside who were in some cases providing us with feedback or working with us on particular contracts.

This success provided management with the self-confidence necessary to initiate design work on a chair that would be of an 'internationally competitive' standard. In working towards this aim, the 'ergonomic routines' that had been pursued so far were repeated. Industrial designers were involved, the company continued to invest in a network of external contacts who were interested in ergonomics, and the design team once again engaged in design research. However, the additional learning that occurred within these routines was over and above that which would occur through their mere repetition. The level of design research was elevated and systematised during the initial stages of the new chair project. In particular, rather than relying solely on local standards and

expertise, attention shifted towards international sources: trade fairs were visited in Europe, imported products were evaluated using a checklist, the international ergonomics literature was consulted, and the advice of overseas ergonomists was sought out. This information was then fed into a set of performance requirements which later guided the detail design process.

Throughout the early stages of the design process, the design team and the company's owners wished to confirm that they were on the 'right track' with their emerging design concept. The design team had noted, in particular, that Mandal's work (which promulgated the use of a forward-sloping seat angle) was becoming influential in Australasia. This approach varied from the more 'conventional' seating approach that had characterised Formway's seating design since the 1960s. A large degree of the uncertainty was removed, however, when Brian Carter and another director attended the 'Ergodesign 86' Conference in Switzerland. As Brian Carter recalled:

> At that stage, we had been unable to weight effectively the often conflicting theories put forward both for forward seating angles versus rear-sloping seats. We came away from there [the conference] with a much clearer idea on what was appropriate at the time ... we discovered at that conference that in the ergonomics field at large his [Mandal's] work was not held in the same regard that some people in our industry, in Australia in particular, held.

Further confirmation of the validity of the evolving performance requirements developed by the design team was found by consulting international standards on seating. The company had since the 1960s referred to British standards, but during the project a decision was made to translate and adopt the German seating standard DIN 4551 (then in its draft form) because it was perceived to be 'the most relevant and demanding'.

> The ergonomic work and investigation which Ian [Chalmers] carried out and which our travels and discussions overseas very much confirmed, led to a lot of parameters ... when we came to evaluate that brief against the DIN standard, we found it fell very well within their requirement.

This proactive approach contrasts strongly with that taken by Formway's competitor, Feltex Furniture. This company, despite the absence of an industrial

designer, acquired and sustained a level of ergonomics capability, albeit relatively low. Although this company incorporated ergonomic inputs into the products it developed in-house, it did so almost reluctantly. Gardiner who, as project manager, was involved initially in updating and modifying the Le Chair, considered that these changes had been 'forced' upon the company by government departments, who as large customers 'were becoming very aware of ergonomics at that stage'. The modifications involved changes to the shape of the chair backrest and its height. Looking back, Gardiner noted that:

> RSI wasn't around then. It was all to do with the lumbar area of the back and the ability to adjust the back. We ran a roll around the back of the chair - and we were forced into that.

Following Le Chair, the seating products developed under the Feltex Furniture brand name were largely designed by imitation. As a result, the company's design team was able to produce reasonably successful 'ergonomic' designs while its collective understanding of the ergonomics of seating remained limited to that information which was available through minimal search or study. Hence, when the company's sales representatives attempted to legitimate the Ergotec's distinctive forward-tilting seat feature by referring to research by Mandal, they were relatively unaware of the highly controversial nature of this work.

Feltex Furniture eventually found that it was having to defend its use of Mandal's theories to customers and other interested parties. In response to this situation, the company's marketing and design functions both took as much distance from ergonomics and ergonomists as was practicable in a marketplace that was still demanding 'ergonomically designed products'. Thus, while the company continued to use inexpensive routines that would provide the necessary ergonomic inputs, it looked for ones that were relatively 'safe'. In particular, the company followed those trends which had achieved a degree of acceptance within 'the chair industry' and obtained detailed ergonomic inputs mainly from the guidelines contained in locally developed standards, particularly *Seating for Office Workers* published by the New Zealand Department of Health (1989). As Gardiner explained, the standards were followed closely:

> If your data says that your chair has to go say about 370mm up to 420, you have just got to design a chair to do that. So all our chairs fall in that range.

At the same time, Gardiner responded to his prior experiences by becoming openly bitter about ergonomists and the scientific status of ergonomic theory. Whereas he had expected there to be a 'correct answer', he had found instead that ergonomists only offered more uncertainty.

> There is no correct information. What one ergonomist says is correct, another will dispute and say "Well, that is not correct". There is no set theory. Like Mandal with his forward-tilting seat. That was one theory. Some of the guys say "No, that is a load of rubbish and we can't do it like that" ... I think that the biggest problem is that you don't know what is ergonomically correct.

While Gardiner considered that there was little that he could learn from ergonomists, he also indicated that he was not personally interested in the biological content of ergonomics. Instead, he was drawn more to problems of an engineering nature.

> I am more interested in the engineering side of it, the actual mechanisms, the hard engineering side, rather than the aesthetic side. Personally I am not interested in how the body flows and forms and all that. Even though it is important to my job, the biology of its doesn't enthuse me as much as how the gas-lift works and how the chair rocks back and forth.

Although individuals will undoubtedly differ in terms of their interest and their curiosity for a subject such as ergonomics, interest in a subject will probably be heightened where it is linked to success and dampened when it is linked with failure. This is reflected on the one hand in Gardiner's negative attitude towards ergonomics and on the other by frequent references to an 'interest' in the subject of ergonomics at Formway.

While design team members at Formway have continued to learn more about ergonomics and become more skilled at its application, once a satisfactory level of ergonomics performance was achieved by Fuelquip, no real attempt was made to further increase this organisation's level of ergonomics capability. While 'basic' ergonomic inputs were applied to the design of the company's first pumps by an industrial designer, and the advice of an ergonomist was sought out

during the design process, the response of the oil companies to the company's claim that their pumps were the result of ergonomic design had been more lukewarm than expected. It seemed that as long as nothing was obviously wrong with the pumps from an ergonomic point of view, and the oil companies' own standards had not been infringed, then the main consideration was cost. As Bradshaw, Fuelquip's manufacturing manager, recalled:

> I think at the start we were a bit nervous that people wouldn't take us seriously. And we were always trying to do things to make sure that we had done them right when really all the oil companies wanted was to buy a product that worked and it was a reasonable cost. And I think cost played a much bigger part in it that we originally thought. We thought that [the emphasis] would be on ergonomic design and all this sort of thing, and using those words would make a difference but basically it hasn't.

This experience demonstrated to Bradshaw that provided no *obvious* ergonomic faults were evident, Fuelquip's customers appeared to place little value on this aspect of design. As a result, further investment in ergonomics capability did not appear to be warranted. Bradshaw also justifies this decision in terms of the nature of the product:

> We applied as much ergonomics as we needed to, to this piece of equipment, considering that no one actually sits on it, no one actually moves it around.

Aside from learning how much ergonomics to apply, organisations can learn when to apply it in the design process. Both at Formway and PEC, ergonomic issues are considered at an early stage. Since the restructuring of Formway in 1988, a design brief is created for each major new project which must be signed by all four directors before detailed design work commences. This brief will normally contain a section outlining the 'ergonomics rationale' behind the new development. PEC, on the other hand, initially gives the industrial designer a very 'loose' brief. Nevertheless, ergonomic studies are usually associated with the second in a series of six steps in the design process.

The foregoing discussion has argued that in the organisations in this study the application of ergonomics is an organisational routine within which learning

occurs over time. Organisations learn how much ergonomics to apply to their products, who should apply it and when it should be applied. Furthermore, it appears that these experiences are retained to varying degrees in an organisational 'memory' which is supported not only by stories but also by a variety of physical records such as working drawings, scale models, photographs, product briefs, and other written documents. This accumulation of experience in routines and memories means that in spite of changes in the composition of their design teams over time, organisations will be buffered from major shifts in the use of ergonomics in product design.

The transference of ergonomics capability

Although this chapter has focused on the application of ergonomics in product design and development, ergonomics can also be applied to other areas within an organisation. Ergonomics can be applied in production settings; it can also be used to enhance marketing techniques (Vink, 1990). This section will examine whether the ergonomics capability that developed in relation to the product design and development function was transferred and 'absorbed' into other areas.

In the organisations in this study, some degree of ergonomics capability did develop over time within the marketing function. This occurred through a number of mechanisms including the direct involvement of marketing personnel in design teams, and the involvement of industrial designers in marketing activities such as market research and the design of sales literature and support material. Despite this, ergonomics capability in the marketing function developed mainly in relation to the marketing function's use of ergonomics as a 'selling tool'. In four of the six organisations in this study, explicit claims were made in promotional materials that the design of the company's products had been informed by ergonomics. Formway, Feltex Furniture and Fuelquip first used claims such as 'ergonomically designed' in the early to mid-1980s, while PEC first described the M-system as having a console with controls which were 'ergonomically within reach' in the early 1970s. In using these claims, the organisations received feedback from the external environment and this, in at least two cases, caused them to substantially modify their approach. In recent years, Formway and Fuelquip have both played down their use of terms such as ergonomics or ergonomic design as a marketing tool.

Both PEC and Formway started to refer to 'ergonomics' before the term was brought to wider public attention in the mid-1980s through the RSI debate. Although this debate impacted directly on the supply of, and demand for, 'ergonomically designed' office products, wider public awareness of ergonomics also influenced marketing practices in other industry segments. Thus, during the mid to late 1980s, advertisements for automobiles appeared in New Zealand newspapers and magazines that also referred to ergonomics.

This spread of the use of ergonomics as a 'marketing tool' during the 1980s was interpreted by industrial designers in this study as a response to 'fashion'. Thus, Crozier suspected that Fuelquip had developed its ergonomics capability (and, in 1987, promoted its new series of pumps accordingly) largely 'because it was a fashionable situation to be in' - a situation that was expected to lead to an increase in product sales. Nevertheless, further examination would suggest that because 'ergonomic design' was perceived to be 'fashionable' and 'up-to-date' it was used by Fuelquip to affirm, symbolically, that the company was open to new ideas and approaches. As indicated elsewhere in this chapter, following the management buyout in 1984, Fuelquip's new management was highly conscious of the need to present the organisation as being customer-oriented and capable of designing good equipment. As March (1981) has noted, new managers will often express their competence through the use of symbols. Furthermore, the symbols used often relate to some aspect of innovation as the ideology of good management tends to associate managers with the introduction of new ideas, new organisational forms, new technologies or new moods (March, 1981: 573).

At the same time, Fuelquip may also have used references to ergonomic design as a means of differentiating its practices not so much from those of its competitors and from those of its predecessor - Gilbarco. It may be, as Bourdieu (1986) has pointed out with respect to the cultural consumption of individuals, that decision-makers in organisations may seek to differentiate their products and services by incorporating features or practices that either have the appearance of being new or rare, or are associated with a group of organisations to which they aspire to belong. However, as references to ergonomic design became commonplace in an industry, the phrase also loses its distinctive value. For this reason, managers who wish to position their organisations as being 'better than the rest' may eventually cease to use the term 'ergonomic design'. Instead, they will look for other symbols and concepts that will demonstrate their difference.

While Fuelquip's use of the term 'ergonomic design' met with an indifferent and largely uncritical customer response, companies such as Formway and Feltex Furniture had to cope with closer scrutiny from a wide range of potential clients and professional groups. These organisations know from experience that if they make claims about ergonomics they may be challenged. However, the two organisations responded in different ways. Thus, since the 'arguments' that followed Feltex Furniture's use of Mandal's theory, the company's policy was to avoid getting mixed up in the 'can of worms' that ergonomics had come to represent. Consequently, the company took a 'safe', 'less dogmatic' approach to marketing its products. Rather than appear to support one seating approach, the management favoured buffering particular products from shifts in consumer demand by loading them with a range of features. Thus, according to a senior manager:

> A manufacturer has got to be fairly careful you don't get too rigid in the way you promote your furniture and ergonomics. You have got to promote a flexible range of furniture with adjustability and then allow the customer to decide what features are appropriate to whatever they want to do or whatever they believe in.

By contrast with Feltex Furniture (and latterly CoDesign-NZ), the top management of Formway were prepared to participate at an expert level in the industry and beyond. The high level of ergonomics capability that had accumulated in this organisation had given the managing director and others in the company sufficient knowledge and confidence to present seminars on office ergonomics to groups including the New Zealand Department of Labour factory inspectors whose role included the implementation of the *Code of practice for visual display units*. As Formway's managing director explained:

> We ended up providing quite a lot of education opportunities to people in those organisations, because of our interest in the area and because in many ways I think we knew more about it than any of them did.

Besides some absorption of design-related ergonomics capability into the marketing function, there is also evidence that, under certain conditions (which will be discussed further in Chapter 6), this capability may be used to inform the

design of an organisation's workplaces. Thus, in the early 1970s, when Costello first introduced PEC's engineers to ergonomics they started to look more closely at the design of their own workplaces. As a senior manager recalled:

> We started to think in terms of the ergonomics of virtually everything we did. And it went far beyond the sort of products we were designing. We started to think about the ergonomics of our own workstations, the ergonomics of where we were placing our own computer terminals and the height of our desks.

At Formway, there has also been a direct and substantial transfer of product-related ergonomics knowledge to other areas of application. For instance, as a result of their professional interest in the ergonomics of computerised office environments and their working relationship with a local optometrist, owner-managers became sensitive to the issue of lighting in factory workplaces. As a result, when the company moved into new factory premises in 1985, a decision was made to invest money in painting the walls. While other people who ran manufacturing plants in the area were somewhat puzzled by this action, Formway's owner-managers argued that the workplaces would not only be 'lighter, brighter and safer' it also improved performance: 'the lighting is better, so you've got better visual acuity, so you are more likely to get an accurate job'. Similarly, Formway's owner-managers have applied their understanding of postural principles to the design of Kanban trolleys in an attempt to reduce manual handling in the company's manufacturing operations.

At RDD a reverse transfer of capability from the production function to product design is more dominant. In this organisation, ergonomics capability emerged independently in the production function and developed to a considerable degree through the championing activities of an industrial engineer (Roberts) and an occupational health nurse (Fraser). Through a company-wide training scheme, these individuals were able to generate a basic but widespread level of understanding of ergonomics among RDD employees. Furthermore, Roberts was also able to create an awareness among senior management and product design personnel of the benefits that could accrue if RDD's products were designed so that they would be easy and safe to manufacture. As a result, it was Roberts, rather than any of the industrial designers, who was recognised as the person 'pushing' ergonomics. According to Roberts, although the industrial designers had been around before she joined the company in 1987, they had never impacted on the application of ergonomics in production applications.

> They [the industrial designers] never mattered, and [never] passed on their knowledge. They were only used for design and so they didn't really, they had an input, and yet they, I don't know why, they didn't use the word 'ergonomics' in their applications, they didn't say this is why they were doing it.

By 1991, Roberts' continual 'pushing' was starting to impact on the design practices of RDD's industrial designers. Not only did they claim that they were more conscious of the need to design for 'manufacturability', they were also planning to consult a psychologist from the local university (who specialised in human factors) in relation to the evaluation of their design concepts.

Summary

This chapter has focused on the processes by which ergonomics capability emerged and developed in six manufacturing organisations. It has shown that in four of the organisations a level of ergonomics capability was first introduced through the adoption of a new routine which involved the recruitment of an industrial designer. Ergonomics was introduced in this way, because almost all of the industrial designers associated with these organisations included the use and generation of ergonomics knowledge among their own professional routines. In the course of their work, some of this knowledge would be transferred to other people in the organisation. Thus, particularly where other members of the design team worked intensively with an industrial designer who explicitly used ergonomics, they might come to learn about the ergonomics perspective, the ergonomics domain, and how to apply ergonomics to product design. Increasingly, these organisation members would come to recognise that ergonomics was something which could be put to use in product design and development. Thus, as opposed to earlier stage-wise models of the innovation process which imply that at some point in time a decision is made to adopt a new idea or technology, it is not possible to say exactly *when* ergonomics knowledge was 'adopted' in that no exact moment of decision can be identified. Instead in this study, the adoption of ergonomics knowledge appears to be a state or 'outcome' of certain organisational processes (see Mohr 1987: 26) involving new routines and learning.

After ergonomics capability was introduced into an organisation, this was maintained through the continued presence of an industrial designer. This was evident particularly in the cases of Fuelquip, PEC, and Formway where industrial designers were employed for relatively long periods of time on successive design projects. As a result of their involvement with an organisation and its products, the ergonomics capability that individual industrial designers bring to an organisation will develop. At the same time, ergonomics capability will expand as more organisation members gain an improved understanding of ergonomics either from working with the industrial designer or engaging in their own learning activities.

While the patterns that were evident in the emergence and development of ergonomics capability have been interpreted in this chapter, there are clear differences in the extent to which ergonomics developed in each of the organisations. In this chapter it was suggested that this may be because staffing practices (including recruitment) are linked to other routines including, in particular, an organisation's product strategy. The impact that product strategy has on the development of ergonomics capability will be examined, along with other organisational factors, in the next chapter.

Chapter Six

The Organisational Context of Ergonomics Capability

Introduction

In the previous chapter, the initial emergence of and subsequent changes in an organisation's ergonomics capability were interpreted as processes of organisational innovation and learning. These processes centre mainly around the presence of industrial designers who, as active members of design teams, are themselves in a position to learn and also pass on their knowledge to other organisational members. Although the latter indicates that learning does not take place in a vacuum, an aspect not yet adequately addressed is the impact of the wider organisation on the design team.

This 'inner context' (Pettigrew, 1985) or 'organisational context' (Perrow, 1983) provides the focus for this chapter. Attention will be given to those aspects of organisational behaviour and structure which serve to constrain or encourage the emergence and development of ergonomics capability. The factors to be considered include control and support mechanisms, aspects of organisation structure, attention and financial resources, the goals pursued by top management, and an organisation's realised product strategy. The discussion commences with an examination of control and support mechanisms.

Social control and managerial support

The ability of consultants and in-house industrial designers to introduce new ideas and practices will depend to some extent on the actions of other organisation members. Such actions may be interpreted as support for the new practices. Alternately, resistance may be expressed through social control tactics. The latter may include tangible practices such as recruitment strategies and the withholding of resources as well as more subtle processes of labelling and role definition. This section will consider these processes specifically in relation to the development of ergonomics capability.

Given that the practice of employing an industrial designer for the first time is itself an indication that the top decision-makers of the organisation are willing to try something new, the industrial designers in this study usually entered an organisation and then introduced ergonomics in a context that was already to some degree receptive to their presence. However, as the industrial designer started to work in the organisation, ongoing support would have to be negotiated, particularly given that organisation members were often surprised to learn of the range and nature of the techniques and perspectives used by industrial designers (including their use of ergonomics).

As a result of differences in their cultures, prevailing value systems and structural configurations, some organisations in this study proved to be more open to new ideas and design methods than others. For instance, as was shown in the previous chapter, the first industrial designers employed by PEC and Formway worked in settings that were highly receptive to change and learning. Against this background, these industrial designers were able to demonstrate and convince design team members and managers that ergonomic research was an integral part of the design process. These early patterns eased the way for those industrial designers who were to follow. Thus, when Chalmers joined Formway in 1984, he was given a lot of freedom to undertake design research. As Chalmers explains:

> Being in Formway was an environment where they said "Well, what is good for chairs? What do we need to know?" and so I went out and read books and got articles and built up my own knowledge slowly that way.

Within a setting that was conducive to learning and had the financial slack that was necessary to sustain his ongoing employment, Chalmers emerged as the organisation's ergonomics champion. In this process he was supported by the company's owner-managers who as a group had recognised and fostered what they saw to be Chalmers' 'personal interest' in the subject. However, rather than extend their support merely to verbal encouragement, protection or the provision of resources, Formway's owner-managers supported their in-house industrial designer by becoming directly involved with the subject and its application. They engaged in their own informal study of ergonomics, they talked frequently about the subject and they even named some of the company's products after the discipline. This degree of managerial involvement will have indicated to other people in the organisation that ergonomics was an important and legitimate area of activity.

Although the case of RDD illustrates a more complex situation of champion activity, a similar pattern of active managerial support is also evident. In this organisation, several ergonomic initiatives took place during the late 1980s. These were, however, not directly attributable to an industrial designer, rather they can be traced back to the actions of Karen Fraser, an occupational health nurse who enlisted and received the support of Angela Roberts, an industrial engineer.

While these two individuals were effective because they shared similar values and had complimentary skills, their achievements were also influenced by the support they received from two members of the company's management team. This support, however, did not emerge spontaneously, rather it did have to be elicited. For instance, although one of the two managers admitted that he had had a latent interest in ergonomics, it was only after he was invited to attend meetings of RDD's Ergonomics Group that he did something to further his understanding of the subject. At the urging of the occupational health nurse and the industrial engineer, this manager subsequently studied several units in ergonomics at university level. By contrast, although the second manager was less interested in the detail of ergonomics he was able to see how ergonomics knowledge could contribute to broader organisational competencies such as ease of manufacturability, flexibility, and quality. Furthermore, this manager's interest in the relationship between product design and manufacturability and his own activities in this area provided a background against which Roberts could extend her ergonomic initiatives beyond the boundaries of her normal sphere of

activity (workplace design) into the product development function. Roberts was of the opinion that

> that backing, that support from him has been good, but if I didn't have that support then I might not have gone to product design.

While support was recognised to be an enabling factor, the ergonomic champions in this study were aware that their promotion of ergonomics had the potential to evoke negative responses from other members in the organisation. In the context of a general discussion about the understanding of ergonomics among 'the rest of the staff' (i.e. among non-design team members), Ian Chalmers was prompted to say:

> They know what we are doing, they appreciate why we are doing it, but they don't necessarily or they haven't had the occasion to require the knowledge themselves. So I think the important thing is that they don't sit there and scoff at us when we are trying to do that because there is certainly the potential for whoever is doing the draughting, or whoever is doing the model-making to say: "You pack of twits. What are you doing this for?" But I've never had that. We are very lucky really, very lucky.

Whereas Chalmers' ergonomic activities had not attracted any adverse reaction, this contrasted with the experience of RDD's industrial engineer. In an interview in late 1990, Angela Roberts recalled that when the Ergonomics Group had just been formed:

> To everyone it [ergonomics] was a new concept, a new way of thinking, but now it comes into conversation as an accepted concept, an accepted word. There is nothing new about it, nothing strange about it. But in the beginning it was strange and people were quite cynical, line managers especially, very cynical, and that made it hard, just not to be laughed at.

The laughing or scoffing referred to here allude to those subtle processes of social control which have the effect of trivialising and marginalising the person or activity to which it is directed. According to Pettigrew (1985: 479) these processes are commonly experienced by innovative groups 'whose purpose is to

change some feature of their present or emerging context'. Drawing on his own research on OD specialists, operational research and general management consultants, Pettigrew (1975, 1985) also noted that, when faced with these conditions, innovating groups will have to continually justify their activities and resource needs, and establish their credibility.

To varying degrees, the industrial designers in this study were exposed to these processes. While some industrial designers were well-respected and were included in most, if not all, phases of the development process, in other circumstances, despite their own efforts to change perceptions of the industrial designer's role, they found themselves to be placed on the fringe of product development activities. A general complaint among industrial designers is that they frequently tend to be type-cast by other people, including managers who hold the purse strings, as 'stylists', 'colour consultants', or 'cosmetic consultants'. These terms reflect a tendency to see the designer as a 'superficial' actor who is called in towards the end of the design process to 'tart things up' or 'pretty it up'.

While on some occasions designers may have been seen to be peripheral because they were regarded as mere 'stylists', they were rarely marginalised specifically for their ergonomic stance. This contrasts with the problems that Karen Fraser, the occupational health nurse at RDD, had in legitimising her ergonomic activities. When Fraser decided to focus on plant design as a means of injury prevention, she found it difficult to gain access to expertise. Fraser recalled that when she asked a manager for the assistance of an apprentice to help her 'look at ergonomic things' she was told: "How can you ask for something when you have no facts or figures?"

> I mean that is how against it they were at the beginning, that it was a waste of time, it had to be proven. I didn't have the facts and I didn't have figures to prove it. I didn't actually get anyone allocated, so it was a real slog from then on.

Although in hindsight Fraser recognised that her case was weakened because she had failed to play the 'business game' of facts and figures, an underlying factor is that others perceived her 'place' to be 'in the clinic'. Furthermore, in moving into the factory she was stepping into the legitimate territory of design engineers. This triggered responses including mild scepticism about the value of

ergonomics and direct attempts to undermine the initiatives of the Ergonomics Group in which Fraser took a major role. Fraser recalled that, at the time, some design engineers tried to 'baffle' her with phrases such as ergonomics was 'just common-sense' or 'you will never find the average'. Moreover, when the newly formed Ergonomics Group took upon itself the 'big issue' of seating for the factory and elsewhere, design engineers ignored the Group and went out and bought their own. According to Fraser:

> It was alright for the Ergonomics Group to go out and look at things in the factory but it was a different situation when it came to look at the CAD/CAM System and chairs for the design engineers ... we were saying that the Ergonomics Group will look at chairs ... would you please come through us. We will try and coordinate, but, of course, the engineers went out and got their own chairs, which I think was more a political move.

To some extent these situations were provoked because Fraser intentionally used the term 'ergonomics' as a 'tool for change'. Although later she would confess to having learnt little while at RDD about the detail of ergonomics (as she saw her role to be that of a facilitator and not a technician), her advocacy of ergonomics as a stand-alone issue gave it a high profile in the organisation. This widespread 'pushing' of ergonomics as a 'word', contrasts with its use by industrial designers. This group limited their references to ergonomics and related concepts to their exchanges with the immediate design team and top management. Even then, as applied ergonomics is but part of the industrial designer's repertoire, not his or her prime focus, the subject may not always be discussed openly, at length, or even actively defended. Under these relatively tacit conditions, ergonomics is less likely to emerge as a source of conflict within an organisation.

Perhaps the most significant factor, however, which differentiates the advocacy of ergonomics by an occupational health nurse and by industrial designers, relates to the constituencies served by these two professional groups. Whereas industrial designers will, in approaching their design work from an ergonomic perspective, seek to accommodate the needs and requirements of product end-users or customers, the occupational health nurse's concern is to protect employees from injury and ill-health in the workplace. As such, the health nurse becomes a 'defender' of workers (*cf.* Perrow, 1983: 530) whose efforts to

improve occupational safety and health is often seen as a direct charge against the profitability of the enterprise (Quinlan and Bohle, 1991: 101). The health nurse may thus find herself in the midst of the ongoing fundamental conflict between workers and management and her allegiances in this respect may impact on her ability to apply ergonomics. By contrast, the industrial designer's focus on the customer or end-user is to a large degree consistent with the ideology of good management which has in recent years been communicated to New Zealand business through various avenues including the popular organisational excellence literature. In this literature (Peters and Waterman, 1982; Inkson *et al.*, 1986) being 'close to the customer' is cited as one of several key prerequisites for organisational excellence, while occupational safety and health issues hardly rate a mention.

Although all organisations in the present study have taken on board elements of the discourse of 'customer consciousness', its influence can be seen most clearly in the restructuring of RDD and Fuelquip around 1984. At this time there was a strengthening of the marketing function within RDD, and at Fuelquip major efforts went into making the company more receptive to the requirements of local customers. In both cases, it can be argued that a shift toward a customer orientation helped provide an organisational context that was more conducive than previously to the employment of an industrial designer and the subsequent emergence of ergonomics capability. In such a setting, the user-centred perspective of ergonomics can fit comfortably alongside such customer-oriented practices such as 'listening to customers' or engaging 'customers as designers' (see Inkson *et al.*, 1986: 100) and while this apparent congruence may not necessarily lead to a high investment in ergonomics capability, it is unlikely that such capability once it has emerged will be rejected outright. To do so, it could be argued, would be inconsistent with the organisation's announced objectives and priorities in relation to customers.

Organisation structure and integration

The discussion will now turn from the specific issue of support for individual champions to a broader, more structural, focus on the impact of intra-organisational relationships on the flow of information to and from the design team. The following discussion is based on the widely supported assumption

that the free flow of information in an organisation (and across its boundaries) will assist in the diffusion and emergence of knowledge innovations such as ergonomics.

The ability of patterned relationships, or 'structure', to impact on the emergence and development of ergonomics capability is illustrated clearly by the case of RDD. During the period 1984 to 1986 this organisation restructured; staff numbers were reduced, functions such as product development and marketing were strengthened, and approaches such as 'people involvement' and working in cross-functional teams were promoted. This represented a sharp break from the past as previously, despite the widely accepted view that Shacklocks had had a 'good relationship with its staff', the organisation is also remembered as having been 'very hierarchical'. In illustrating this characteristic, a member of the present management team and a company employee since 1973, recalled that it was ten years before he saw the inside of the managing director's office.

It was against the increasing 'openness' brought about by the restructuring that RDD's occupational health nurse was in 1986 able to set up an Ergonomics Group. Although this group focused initially on workplace design issues and was relatively successful in solving some 'obvious' problems, it became apparent to Group members that some workplace injuries could only be addressed by fundamentally changing the design of the product to make assembly easier and safer. Around this time the occupational health nurse started to confront design engineers with the health and safety consequences of their design decisions. For instance, when it was recognised that the sharp steel edge of a component was causing workers to cut their hands the nurse brought this to the attention of design engineers who she recalled were, with one or two exceptions, genuinely 'interested in this information'. Later, in explaining why they had not been aware of these problems before, design engineers indicated that, in the past, the organisation had been highly 'segmented' (see Kanter, 1985). The divisions that they referred to, however, existed not so much between functional departments as between 'the factory' and other staff. Previously, design engineers would rarely visit the factory floor. As two design engineers at the time were later to recall:

> In the past we just blindly went ahead and designed it and chucked it into the factory and said "Here it is, you make it".

> When I first joined the company there would have been a few [prototypes] put together out the back in secret and then they would have ended up on the line and "Here you go, you have got to make that".

Although the split between 'the office' and 'the factory' has persisted to the present day, various practices have helped to reduce its influence on product development. Design engineers are now required to follow a project right through its various stages which means that during 'proving runs' and 'pilot runs' they are expected to be on the factory floor helping to assemble the products. In addition, the company's induction scheme has required new design engineers to spend some time working in the factory.

As design engineers were coming more into contact with assembly workers (who here may be classified as 'secondary users' of RDD's products), the occupational health nurse (Karen Fraser) was also encouraging the latter group of employees to report their safety and health problems so that these could be fed through to the Ergonomics Group for action. This reporting process was facilitated by a company-wide training initiative which, amongst other things, provided Fraser with the opportunity to talk to all staff on health and safety issues. As part of these sessions, RDD's industrial engineer introduced ergonomics in a one hour session. The effect, as experienced by Fraser, was described as follows:

> The ergonomics thing, the word, it was around everybody, and it was seen that they [the assembly workers] could have a say, it [the word] was over all the company. It fitted in with the overall company structure at the time, which was this openness.

The reference to 'word' in this quote requires further elaboration. It was mentioned in a similar fashion in several other contexts and appears to indicate that, within RDD, ergonomics 'as a word' acquired a significance of its own. On the one hand, the widespread use of the term made it seem more ordinary and this normalcy took some of the pressure off those who were 'pushing' the subject. On the other hand, the word 'ergonomics' could be used by individuals in the company to refer to a class of problems and activities without their having to have the detailed knowledge to be able to articulate the complexities involved. This may have enabled a degree of communication and feedback that otherwise

may not have been possible. Furthermore, widespread knowledge of 'the word' also provided many new starting points for further associative learning.

While the case of RDD shows that basic training in ergonomics may provide a common language with which in-house secondary users can communicate, feedback from these groups may not be forthcoming for various reasons. Secondary users may not wish to create a fuss, they may not recognise the worth of their ideas, or they may be reluctant to assist designers and managers by providing information for which they will probably receive no meaningful reward. In addition, where information has been provided and there has been no subsequent action or feedback, secondary users may be hesitant to repeat this practice. Factors such as these may explain why, at Fuelquip, feedback from secondary users such as servicing and installation personnel was not as forthcoming as members of the design team would have hoped:

> We really don't get enough feedback from installation and servicing personnel. It's something we are saying all the time, tell us your problems, but we are up against Kiwi ingenuity all the time ... they do it and nothing is said. But it is something we are trying to address anyway and improve the general communication between different areas.

The relatively casual elicitation of feedback described here was not the only source of design information used at Fuelquip. The company's consulting industrial designer recalled that during the FQ21 project he conducted observational studies of the problems faced by service personnel while working in the field. In addition, service personnel were asked to give feedback at the prototype stage. In these processes, the owner-manager who led Fuelquip's design team was either directly involved in these exercises, or followed their progress very closely.

Although these techniques were not used by all organisations in this study, the general pattern of direct managerial involvement in design team activities is significant in that it greatly shortens the communication channels between design team members and the dominant coalition. This can be an important factor in ensuring that the information that managers receive about product performance and acceptance can be passed on directly and without delay to the design team. These short feedback pathways between users and designers also

prevented the latter group from becoming completely insulated from the consequences of their decisions. Perrow (1983: 528) suggests that insulation is a reason why ergonomics continues to be ignored in some organisations. In addition, the short vertical communication channels mean that important decisions such as resource allocation can be resolved quickly and with limited distortion. This contrasts with the filtering problems and reporting difficulties faced by human factors groups which are placed 'too low on the totem pole' of companies with tall hierarchies (Meister, 1971).

The relatively flat hierarchies of the organisations in this study were also overlaid by various formal cross-functional structures which promoted lateral communication. This is particularly the case at RDD where, since 1984, a high degree of emphasis has been placed on 'doing things in teams'. It was against this emerging 'team culture' that an Ergonomics Group could be formed along with Continuous Improvement Teams which were used in one section of the company to solve ergonomic problems. However, while the range of team structures used at RDD is not evident to the same extent in the other organisations, all had a design team of some or other form, and the role of this cross-functional structure cannot be overlooked. Indeed, given the small size of the organisations studied, design team structure may tend to bring together and hence promote interaction between a reasonable proportion of those employees who are not directly involved in direct production. This was particularly the case at PEC where research and development personnel represented a quarter of the total employed in 1990. As individuals, these personnel were active in one or more of the organisation's design teams which were structured so as to bring together marketing personnel, industrial designers, engineers and top management.

Besides horizontal communication across functional boundaries, experience in a range of tasks may also promote the flow of new ideas. The impact of this at the managerial level is clearly illustrated by the case of Formway where, by 1990, all four owner-managers had at some stage been a member of a design team. Through working closely with industrial designers the managers learnt about ergonomics so that when they moved on to manage other areas they were able to apply this knowledge in new settings. Thus, when the company introduced a JIT system, the organisation's ergonomics capability was used to inform the design of Kanban trolleys so that the need for excessive manual materials handling could be minimised in the company's manufacturing operations.

At the level of the design engineer, wide experience and lack of specialisation may also promote learning. However, as development sections increase in size, specialisation may creep in. This effect is evident at PEC where design team members now tend to be regarded as experts in their respective areas. Similarly, at RDD, a design engineer recalled that while previously 'everyone did all sorts of jobs', this situation 'started to change' as the development section trebled in size during the late 1980s. The degree of specialisation in these two organisations does, however, need to be put in perspective. An industrial designer at RDD was able to do this when he recalled his experiences of working in a large manufacturing company in Japan. In this organisation each member of the team of 35 industrial designers had a distinct task: one designed the knobs, the other designed the graphics. Against this background, the industrial designer considered that he had enormous flexibility in his work at RDD.

While specialisation can throw up invisible barriers to communication, physical barriers are just as significant. At RDD, for example, top management purposively brought its various functions together at one site in 1984 so as to encourage a higher degree of integration. By contrast, the functional operations of CoDesign-NZ have become increasingly fragmented geographically and this has impacted negatively on the product development work undertaken by the company in New Zealand. As a senior manager explained:

> Before, when we were all on-site, it was easier. There were less hurdles. There wasn't the distance involved. Now, by being remote from the site this has made it more difficult and there is a danger than we don't give it the time and the emphasis.

While the distance factor has of late affected CoDesign-NZ's product development activities, an even greater physical distance separates this company and the Sydney-based R&D section of its parent company. Although the latter section has over the years built up its ergonomics capability, there was little evidence that any of this had diffused to the New Zealand operations.

Aside from the communication barriers which arise where an organisation's functional areas are split over different sites in physically remote locations, the exchange of ergonomics information may be influenced by distances within a

site and the design of workspace. This is illustrated by the case of RDD where, in 1984, new office space was developed according to an open plan arrangement following a practice established by its parent company. This open plan design helped to break down the physical signs which previously bolstered differences in function and status in the division, while the total absence of partitions encouraged interaction between groups including product designers, production engineers and industrial engineers. Interestingly, the division's two industrial designers were not housed in this space; instead they inhabited a separate design laboratory. While this arrangement provided for security and served to highlight the independence of the industrial design function, it did tend to isolate the industrial designers somewhat. Despite physical separation such as this within an organisation's buildings, in-house industrial designers do have greater opportunities for interaction with other members of the organisation than consulting industrial designers who only come on-site for brief periods of time.

The goals and aspirations of top management

When the six cases are compared, there are clear differences in the priority that top management gives to the use of ergonomics knowledge. Furthermore, it appears that these differences can be attributed in part to the goals that top management support and pursue on behalf of themselves and the owners of the organisation. This link has earlier been identified by Perrow (1983), who argued that 'top management goals and perspectives' may impact on the extent to which human factors advice will be heeded or ignored in organisational settings. This section of the chapter will build on this theme. In particular, it will be argued that where top management support a goal of *product quality*, the development of ergonomics capability will tend to be favoured.

Before proceeding, however, the use of the term product quality needs to be clarified. Product quality may be defined as the rated ability of a product to perform its functions (Kotler, 1986: 309) and this may be reflected in different quality levels, for example, low, average, high or superior. Accordingly, while all products will have a level of product quality, some will rank more highly on this dimension than others. On the other hand, an organisation that has 'product quality as a goal' will be aiming to surpass the quality levels specified by minimum standards or those offered by competitors (see Perrow, 1970: 166).

This goal will usually involve the organisation striving to produce products of high or superior quality.

Of the six organisations in the present study, both Formway and PEC stand out as having pursued a goal of product quality over relatively long periods of time. Furthermore, both organisations have been successful in the pursuit of this goal, in that both companies are widely recognised by design professionals, competitors, agents, and customers alike for their high product standards. For Formway, additional 'official' confirmation was also obtained when in 1988 the company received New Zealand's premier award for industrial design. By contrast, PEC has yet to win a major award. As a senior manager explained:

> Our products have not received any tangible recognition for being well-designed products in that we haven't won any awards or anything like that overseas, but we are very pleased with the level of acceptance by the customer of our products and a typical reaction from some customer, or perhaps a distributor that we are trying to get to sell our product, would be that our products are very well designed and stack up with other products they perhaps have in their bag to sell. They stack up extremely well. Much better than the average.

The quality level alluded to in the last sentence of the above quote is also referred to in publicity material produced by the company. For instance, in a booklet titled *PEC: Innovation and Quality* published in 1989 to mark the company's 50th anniversary there are references to 'world class', 'leading edge products' and 'high quality and technical innovation'. Moreover, the frequent mention and prominence given to these phrases is evidence that product development activities and product quality are of considerable importance to this company.

Unlike the buzz-words in their publicity material, PEC's commitment to innovation in product development is not of recent origin. PEC has a record of being relatively early to adopt new technologies and practices. For instance, when PEC invested in a comprehensive development system in 1975, it was 'possibly the first company in New Zealand to move seriously into microprocessor technology' (Cornwall, 1981: 94). Similarly, when the company employed an industrial design consultant (Costello) in 1970 it was the earliest of the six organisations in this study to do so by at least eight years.

Costello's involvement at PEC also shows how exposure to the ergonomics perspective may cause the dominant understanding of what constitutes 'product quality' to change. Prior to Costello's appointment, product excellence at PEC was measured mainly in terms of technical performance. Through his advocacy of the ergonomic approach of designing with users in mind, Costello was able to convince the management of this engineering-dominated firm that their view of 'quality' was too narrow.

Although it would be reasonable to assume that major reinterpretations of product quality will be strongly resisted, at PEC this did not appear to be the case. Senior managers in the company were generally receptive to the new perspective, and were willing to acknowledge the importance of considering the human-machine interface in the design process. In the years that followed, this emphasis on the user was complemented by PEC's adoption of a marketing approach. This sequence is explained by a senior manager:

> We used to make an engineering product and we used to put the human interface where we decided it was best from an engineering point of view. The industrial design side of it, I guess, developed first, but we became a very much more market-oriented or customer-oriented company pretty soon after that.

As at PEC, high quality standards and product innovation have been driving forces at Formway for much of this company's history. Thus in 1960, when the company's founder started to manufacture chairs these were to his own designs. In Bill Mackie's own words, he had looked at what was being offered locally and had found that 'there existed very little in the way of new or innovative design'; he felt 'confident' that something could be done to change this situation. In the years that followed, Mackie was awarded two patents for his height-adjustment mechanisms and became the first manufacturer in New Zealand to import and introduce gas-springs into his typist chairs. He continued to innovate and, when in the late 1970s he noted an upsurge in local competition, this produced a renewed 'motive to stay ahead in chair design'.

Around this time, Mackie added an industrial design graduate to his staff of nine. This graduate's presence in this very small company, combined with Mackie's collaboration with other local designers, lifted ergonomics capability at

Formway to a new level. Although this level reduced somewhat when the graduate left the company, a more substantial reduction occurred when Mackie sold the business in October 1981. There then followed a period of reduced ergonomic capability which was to last about a year until the new owner-managers hired an industrial design consultant. From this point on, ergonomics capability continued to develop once again.

The new owners' decision to employ an industrial designer can be linked to the goal they had set in relation to product quality once they had become more familiar with the company's operations and the sub-sector in which it operated; thus, the new owners confirmed in official statements that Formway was 'in business to design and manufacture high quality steel based office furniture, predominantly chairs'. Eventually, when it became apparent that they personally lacked the design expertise required to achieve their goal, the owners sought design assistance.

Reflecting this high quality position, Formway's owner-managers adopted a premium pricing policy. Although the company's products were significantly more expensive than products offered by major competitors, Formway was able to capitalise on rising expectations about the ergonomics of office furniture in New Zealand. The subsequent growth experienced by the company confirmed to the owners that this quality stance would reap dividends. In this, the contribution of ergonomics was also recognised and the ongoing development of ergonomics capability in the organisation was reinforced.

When commercial furniture markets started to open up to imports in the mid-1980s, the owner-managers of Formway responded by initiating the development of a new chair. As the following quote from one of the management team reveals, quality aspirations were also lifted upwards:

> We wanted a better quality chair from a functional point of view and long term performance. We wanted a chair that would be of a calibre to compete with imported chairs.

One of the owners, Brian Carter, took charge of the design project. From the outset he had a clear aim in mind:

> For me, when I started on that project I wanted it to be done well enough to win the Prince Philip Design Award ... I wasn't prepared

> to undersell any aspect of that and I wanted it to be the best that had been done here [in New Zealand]. Not only here. I certainly thought that we could make a product that would be as good as anything of its kind in the world and in a way it has been a pattern for what we have been doing since then.

This position was also strongly supported by the other two design team members who, as industrial designers, valued and welcomed the opportunity to help create a superior product. However, the design team's reluctance to compromise on the ergonomic, engineering, performance and aesthetic details meant that the new chair took longer than planned to develop. While this led directly to the introduction of tighter controls on the company's product development processes, Brian Carter later felt that the value of not making compromises was 'verified' when the Zaf was awarded the prestigious Prince Philip Award.

Following the release of the Zaf in early 1988, work continued on the development of Formway's next chair and as another owner-manager explained in late 1989:

> He [Brian Carter] has a vision of this chair already ... he is absolutely determined to produce a really good solution.

Once again, this determination was shared by the industrial designers who worked for the company. One commented in early 1990:

> The next chair is going to be - I'm going to do my damned to try and make it the best chair in the world.

These high aspirations contrast sharply with the situation at Feltex Furniture (latterly CoDesign-NZ) where successive management teams have been less concerned with product quality than with achieving cost-efficiencies in production. As an extension of this latter goal orientation, CoDesign-NZ has not invested greatly in research and development competencies. This, in turn, explains why ergonomics capability in this company has developed only to a moderate degree.

Although cost-efficiency has been the driving force with respect to Feltex Furniture's in-house product development, the company has also manufactured

the high quality CoDesign range on behalf of its parent since the mid-1980s. This has produced a rather incongruous situation in that Feltex Furniture's top management had to support the high quality goals imposed by the parent company, while they themselves were more accustomed to developing efficient ways of manufacturing 'middle of the road' products. Against this background it is not surprising that the company's top management tended to see new products developed by the CoDesign's Sydney-based R&D section as being something of a nuisance. At the same time, however, a top manager conceded that, had it not been given the CoDesign range to manufacture, the company may not have survived.

The case of Feltex Furniture not only provides an interesting example of goal conflict, it also shows how difficult it is to change from a low to a high quality goal position, or vice versa. This is because, over time, goals come to be reflected in the structural configuration of a particular organisation. Thus an organisation that has focused solely on achieving efficiency may not have developed adequate systems for co-ordinating the design and production phases of the development process. Similarly, such an organisation may never have learned how to search for ergonomics information. This 'embedding of goals' into an organisation may be reinforced by personnel processes. Perrow (1970: 173) suggests that goals will persist because those who support the prevailing goals tend to advance in the organisation. These personnel will subsequently recruit others with similar views, while those personnel with different values and aspirations will tend to leave.

Although in relation to its in-house development work Feltex Furniture has tended to emphasise efficiency, the appointment in 1986 of a new top manager with a sales background also saw the introduction of a 'customer orientation'. This manager was keen to see the company become more flexible in responding to specific customer needs. This meant that if the customer wanted to have a non-standard product then the company should be able to produce it efficiently. Although it was felt that this required 'an attitude change' among some company employees, the underlying idea was supported by other members of the management team.

However, in shifting from what may have been a 'production orientation' to a 'customer orientation', the development of the Feltex Furniture range remained a largely reactive process. Rather than being guided by in-house design research,

the company's product development team acted in response to customer requirements or the unsolicited advice of external experts. As acknowledged by a senior manager, the company is 'driven' by customer requirements to include ergonomic features in some of its products. Having provided these features, it is then left to the customer to make the decision as to which features are most appropriate to their needs. As a senior manager put it:

> I think manufacturers have got to provide the flexibility in their designs and in their products. They have got to give the customers as many options, as may choices as possible so that they can, based on what they are hearing about, what they want for their staff or what they want for themselves, then you can offer them something that will fit them. But I think to go out as a manufacturer and try to teach the public ergonomics is a waste of money and a waste of time.

On another level, it could also be argued that the customer orientation philosophy as it is interpreted at CoDesign-NZ, serves to legitimate a largely reactive, low-cost, approach to product development. By placing the onus on the customer, the company can avoid the expense of undertaking research as well as the uncertainty that design and development activity brings with it.

Nevertheless, the prevailing product goals of CoDesign-NZ do appear to be quite sensible given that the Feltex Furniture range is positioned for the mid-range of the market and, in the area of secretarial seating, has to compete with cheap imports. By providing a quality level not much higher than that demanded by guidelines, codes or industry practice, this aspect of the company's business remains viable.

As at CoDesign, the emphasis for Atlas has been on production. This is understandable given the fierce price competition between electric range manufacturers over the last two decades: all companies in this sub-sector had to minimise their costs and overheads in order to survive. Nevertheless, at the same time, these manufacturers did progressively lift their product quality through a spiralling process involving innovations of the 'nuts and bolts' variety (Marquis, 1982), while always conforming to a dominant design. Yet, while the design standards of New Zealand electric ranges have not varied greatly, consumer tests since the mid-1960s consistently ranked Atlas electric ranges lower than comparative models produced by Shacklock (latterly RDD).

The low cost position adopted by Atlas will be reflected in, and supported by, the expertise and aspirations of organisation members. Compared to organisations with high quality goals, organisations in which moderate quality aspirations prevail will tend to use a more limited range of design skills and knowledge (including ergonomics), at a lower level. This appears to be the case at Atlas where, in the mid-1970s, an apparent lack of R&D expertise attracted the attention of the evaluators of grant applications to the Industrial Research and Development Grant Scheme. At the time, some doubt was initially expressed as to whether the experience and qualifications of the company's development engineers was sufficient to make Atlas eligible for grant consideration. Since this application was lodged there have been changes in the leadership and composition of the company's development team. Nevertheless, the company appears to have continued to recruit staff who are comfortable with moderate product goals and skilled at containing production costs. In particular, the development team has continued to be dominated by production engineers who, according to an industrial designer with some knowledge of the company, seem to be 'more concerned about designing to get the thing out, than design for the market'.

While the product strategies of Atlas and RDD have diverged in recent years, a preoccupation with engineering problems and cost-containment is still evident at RDD. Although to some extent this reflects the structure of the industry in which it operates, the priorities of past managers and owners have also been important determining factors. For instance, while the company tried to improve its outdated plant and factory facilities in the late 1970s, the product side was largely neglected. A product engineer at that time recalls:

> They had made quite an effort to put in new manufacturing plant but the product was really, I guess, looking back, it was really not up to standard. I think that there was quite a strong push from some of the engineers here, from the plant side, and rightly so, into what the manufacturing process should be. But the product side of it was not there to really support it.

In the years that followed, the investment in product design did not increase. Although some new product development work was undertaken by F&P on RDD's behalf, the level of this effort was fairly minimal. As a result, the bulk of

product development was limited to making minor model changes and ensuring that products were cost-efficient to manufacture.

This situation did not alter immediately following the change in ownership in 1981. The company struggled for another two years until, in late 1983, the Board of F&P appointed a new divisional general manager (Ken Adams). Unlike past senior managers of RDD who had come from the financial and production functions of the company, Adams was 'strong on the design and marketing side'. An experienced member of the management team had this to say:

> I think that really the reason they [the Board] put him in there was just to put more marketing influence on the whole company, not just the engineers and sales people, but to try and push through the new quality ideas too.

Such was the scale of the ensuing changes to the product range, management structure, and staffing patterns that this time in RDD's history is looked back by some as 'the Ken Adams days'. Even those who did not experience the transition personally were able to relate details about this time. However, while Adams provided the immediate face for the change, his goals were also generally consistent with those articulated by the Board of F&P. These included expansion and international competitiveness through technological innovation, efficient production techniques such as continuous improvement and just-in-time, and personnel policies encouraging people development and teamwork. At RDD, this shift in priorities led directly to the emergence of an in-house ergonomics capability in product design. Furthermore, due to an ongoing support for product quality goals and an increasing receptivity in the organisation to new ideas, this capability continued to develop.

The discussion will now turn to Fuelquip where ergonomics capability emerged in the wake of a management buyout which produced a sudden upward shift in product goals. The sudden nature of this shift is notable and to some extent reflects a 'release' of those aspirations shared by (at least) four managers who, prior to the management buyout, had been unhappy about the direction taken by their Board in the area of product development. After the buyout, these managers, as the new owners, were in a position to adjust the quality of the company's fuel dispensing products. Such adjustments involved a greater emphasis on design for local conditions, a factor which Gilbarco New Zealand had tended to neglect.

As Gilbarco New Zealand's pumps were manufactured to specifications set down by Gilbarco Australia and little, if any, feedback was sought from the New Zealand operations, no use was made of the considerable knowledge and experience that the New Zealand-based service personnel had accumulated over the years in relation to pump design and maintenance. It was against this background of untapped in-house knowledge and design ideas, that the owners of Fuelquip decided to keep the manufacturing part of the business going. As an owner-manager explained:

> When we bought the company we made a decision that we would carry on with designing pumps and we made an effort, a conscious effort, not to copy what everybody else had done. We decided that we had to come up with a product that was different and would capture the market ... What we wanted to do was get back into the market.

At one level, a 'different' and 'good' product was required so as to establish the company's credibility in the industry as a developer of pumps, while, on another level, there was also a desire to do something about 'standard accepted practices' in the industry. In following this path, the owner-managers drew on design ideas in the company and made changes including the following. Firstly, by radical redesign of the pump interior, redundant parts were eliminated. This substantially reduced the cost of producing a pump and allowed the company to place its products on the market at prices 20-25% less than that of their competitors. Secondly, attention was given to improving the serviceability and maintainability of the pumps as it was realised that quick servicing times would give a competitive edge to the company's service operations. Fuelquip's manufacturing manager explained the rationale behind this approach:

> Competitiveness would be one of the reasons to do something different, to do it better ... if we can make the pump quicker and easier, then it helps us with our equipment, helps us with our service time and obviously it will assist other service businesses who are in competition with us, who have a little bit of influence perhaps in the purchasing of the equipment. So there is a money aspect to that one.

As leader of Fuelquip's first design project, the manufacturing manager was aware that these two areas of design improvement needed to be balanced by a 'different' pump exterior. This, combined with the realisation that the company lacked skill in this area, led to the employment of an industrial designer.

Organisational history and product strategy

The goals and perspectives of top management may influence the decisions and actions made within an organisation in relation to markets, products, investment in knowledge and information (such as ergonomics), equipment, and staffing. When the decisions in any of these areas exhibit a consistency over time, a strategy will be considered to have formed. The term 'strategy' is thus used here with the meaning proposed by Mintzberg (1978: 935), that is, strategy denotes a pattern that has been 'realised' rather than an intended plan of action. In other words, strategy refers to that which has occurred in the past, rather than to something that may happen in the future. Accordingly, strategy must be inferred either from the retrospective analysis of historical information, or from longitudinal studies of organisations in real-time.

When the various strategies pursued within different organisations are compared, patterns will usually emerge. On the basis of these patterns, typological classifications have been developed for marketing strategies (Ansoff and Stewart, 1967), technological innovation strategies (Johne, 1984), corporate strategies (Maidique and Patch, 1978), product strategies (Cullwick, 1978), competitive strategies (Porter, 1980), and organisation strategies (Miles and Snow, 1978). Despite the range of terms used to describe the focus of these various typologies, they are characterised more by their similarity than by their difference. Most classifications consist of either three or four types, and all reflect the simple dichotomy that either the firm is a leader or a follower (Saren, 1987: 125). In the present analysis, strategy will be examined primarily in relation to product development decisions including the use of specialist knowledge in that process. Although this particular area of strategy will be referred to as 'product strategy', the emphasis on realised patterns contrasts with the use of the same term by Cullwick (1978) and others.

Given the typologies mentioned above, it would appear that the development of ergonomics capability in the cases in this study can be understood by referring to

an organisation's *type* of product strategy. In particular, firms (such as PEC and Formway) that have often been 'early or first to market' (see Maidique and Patch, 1978) would be expected to invest more substantially in ergonomics capability as compared to those organisations (such as Feltex Furniture and Atlas) which have pursued 'late to market' strategies. This is because 'early or first to market' organisations will normally have had to invest in research and development activities including, where appropriate, the acquisition of ergonomics knowledge in order to achieve and maintain their position of leadership. By contrast, organisations characterised by a 'late to market' strategy will spend less on research and development and specialist knowledge acquisition. These organisations achieve their competitive advantage by investing in engineering skills which will reduce product design and production costs.

While this link between strategic type and ergonomics capability may be a useful conceptual tool, of greater significance to the present analysis is the argument that the development of ergonomics capability may be influenced by events that took place as part of an organisation's history. In other words, product strategy previously realised by an organisation may act as a force that shapes and constrains the future development of ergonomics capability. Similar views have been expressed in the literature on organisational creation. After consulting this literature, Miles and Randolph (1980: 45) concluded that

> choices made early in the development of organizations serve both to shape their enduring character and to constrain the range of options available to them in later stages of organizational life.

The influence of realised product strategy may be understood by referring to the concept of routines. Earlier, in Chapter 5, it was suggested that product strategy is a routine that, in turn, is associated with 'subroutines' such as the recruitment and training of staff, the structuring and sequencing of design activities, and the search for design information. Furthermore, in contrast to more rational views, it was argued that particularly on a day-to-day basis much organisational action is guided by pre-existing routines. This is not to say that goals do not guide action, rather, not all action is guided consciously towards goals.

As routines have a persistent character, so too does product strategy. Persistence of product strategy is evident in several cases in this study: Formway, PEC,

Atlas and Feltex Furniture all show remarkable consistency in their generic product strategy despite changes in leadership, ownership, and financial circumstances.

The persistence of a particular product strategy routine may depend on it being associated with success. In other words, as long as an organisation's prior product strategy is perceived to be successful by key decision-makers in the organisation, this particular routine (and its various subroutines) will tend to be continued. In this process, however, the routine does not necessarily remain static, rather it will tend to change incrementally as a result of experience and learning. For example, over a period of twenty years during which PEC has continued to pursue an 'offensive' development strategy, the company has also refined its product development routines to a very high degree. According to an outside observer, the degree of learning is what differentiates PEC from Fuelquip:

> There is no doubt about it that PEC are superior to Fuelquip in terms of design because they understand development projects. Because they have been developing projects for eons, since first their company has been going ... it has got to be properly managed ... They tend to be very broad in their thinking, but that is not fair on Fuelquip, because Fuelquip is still a relatively new company.

The age of companies is also mentioned by one of PEC's industrial designers:

> They [at PEC] just know how important it is to them and so they are prepared to listen very intensely to what an industrial designer will have to say and act on it, unlike in newer companies, younger companies, without that appreciation or knowledge, where you are having to try and sell it to them the whole time or suggest to them why it can't be done like that.

The company has also learnt to manage the risk associated with the 'offensive' type of strategy. According to a senior manager:

> Our success rate for new products is considerably better than what would have to be the average ... And I think we have refined the process over the last few years and I think we could say we are

> getting better at it. Not in the process of design or the process of product development so much as the process of choosing the winner.

Although the changes described above tend to be of an incremental nature, more extensive and sudden changes in routines may be associated with failure. Under these circumstances, top management may decide to modify routines substantially or discard them completely. Nevertheless, established routines may prove difficult to change, particularly if they are deeply ingrained (Winter, 1987: 161). Similarly, new routines can be hard to introduce and sustain. Both these situations are illustrated by the case of RDD where, around 1984, the company's management team signalled an intentional break with the division's prevailing 'defensive' product strategy when they started to push the idea of quality and marketing. Given that the organisation had had limited experience with product design activities, RDD's first industrial designer found this time quite difficult:

> The physical structure wasn't there to support what we actually needed to do ón a day-to-day basis, so initially it was really hard to make it all work ... it really improved when we got out to Taieri [the site of the new factory] because we had a proper industrial design lab there and so we started to put a few pictures up on the wall and started to build a few models. People started to see what you could achieve and they started to understand how it fitted into the design process and that it wasn't actually trying to do their job for them, it was complimentary to everything else that was going on.

In the years that followed, the product development team at RDD continued to expand as the division's product strategy was brought progressively into line with that of F&P. However, while this process of alignment was taking place, it is important to recognise that F&P's product strategy was itself undergoing transition. Specifically, during the 1980s the profile of product design and development increased within the company. This is reflected in the increase in the number of industrial designers employed by the various F&P divisions: numbers increased from 2 in 1983 to 6 in 1990. Despite this, however, the traditional dominance of the production engineering function in the company has persisted, as the following comment from RDD's marketing manager indicates:

> The company certainly in the past has been engineering driven, sales driven. Certainly not marketing driven. And even now that is probably still largely the case. The technology side of it has been strong, innovation and things like that. And it is probably going to stay that way because it has now become almost part of the company culture.

Consequently, while the official company line was increasingly supportive of product innovation, the emphasis still tended to be weighted more towards engineering performance rather than design. At the same time, moves towards greater product quality were also held back by another factor: the franchise agreement which bars F&P dealers from selling other products. While this franchise has obvious benefits, there are also disadvantages in that it requires the company to develop a full range of products. While this arrangement keeps the dealers happy, the production of cheap products is perceived by some groups in the company to be a waste of time. Furthermore, because the franchise requires the company to perform tasks that run counter to the company's official goals of making world class products, this situation generates confusion and criticism. This is reflected in a comment made by of one of RDD's industrial designers in early 1991:

> We can't compete on price. We have to compete on other things. We just have to compete on good value and honest products and good design and good engineering ... [yet] we are sort of diversifying our product that we make into the cheap end, and the medium to top end, and we don't make money off cheap products ... we really have to get our image right and have a nice little position that we want to be in.

While the franchise may have held back RDD's first steps towards a higher quality position during the period 1984-1990, other historical influences and traditions continued to play a role. During this period, for example, the company continued to define its competitive position by reference to other local manufacturers whose repeated formula of undercutting prices meant that RDD had to continue focusing on cost-efficiencies and minor model changes. This continuing need to focus on 'old rivals' may also explain why, in late 1991, RDD's management were surprised to learn that substantial inroads were being made by overseas imports into the top end of the market. Although new

development initiatives were then given more urgent attention, by this time it could be argued that RDD's product strategy had become somewhat 'stuck in the middle' (Porter, 1980: 41).

While old routines may be hard to change, new routines may be hard to introduce and sustain. This is because routines do not exist in isolation, rather, they form part of a collection of related routines which tend to support one another. For instance, if an organisation has not learned how to manage the design process and co-ordinate design teams, then a new routine such as the employment of an industrial designer may fail. An industrial designer (with no professional association with Feltex Furniture) offered the following scenario:

> If you took Feltex Furniture and you introduced an acknowledged master of design, somebody like Belini or something like that, and said "Design for these people a chair". That's not going to mean that they are going produce a good chair. Because I don't think that they have the all-round capability to produce it to the quality, and to be able to market it to the right people.

Although the reference to Feltex Furniture in the above quote was totally unprompted, the scenario does provide some insights into why this company did not repeat its first attempt to 'fully develop' a product (Le Chair). Prior to that time, Feltex Furniture had consistently developed products through practices such as license agreements and copying. All of these approaches avoided the need for a substantial in-house research and development capability (including expertise in the area of ergonomics) and the appropriate management expertise to support these tasks. The absence of these routines may explain why, after the Le Chair project, the company reverted to development routines that were similar to those that had been used in the past. Thus when in 1986, Feltex Furniture realised it should be able to offer its customers a range of computer furniture, top management avoided the unfamiliar path of full in-house development and opted instead to acquire a product range through an agreement with a small business specialising in computer furniture products.

While the above examples show how the internal configuration of an organisation may constrain major shifts in generic product strategy, it is also evident that product strategy (and its subroutines) may persist due to external influences. For example, organisations may become locked into a strategy

because to deviate from this would damage their reputation, credibility and image. An owner-manager at Formway acknowledged that if the company were to show a lack of commitment to ergonomics, it would lose much of the support from the networks it had built up over the years.

Discontinuity in product strategy: Change of ownership

Although, for the reasons discussed above, product strategies will tend to persist within an organisation over lengthy periods of time, sudden shifts may still occur. In this study, the few major discontinuities in product strategy that occurred followed directly from a change in ownership. In turn, under certain circumstances, these discontinuities led to the emergence of ergonomics capability.

With the exception of PEC, all organisations in this study experienced a major change in ownership at least once during the 1980s. This, in itself, is not surprising as during the same period changes in ownership had become an increasingly common experience for New Zealand business generally. This is borne out in a survey by Baird *et al.* (1990) which found that 56 percent of the New Zealand firms surveyed had had a significant change in ownership in the previous five years.

At Fuelquip, product strategy changed in 1984 immediately following a management buyout which saw the company revert from being a subsidiary of a large multinational company to being a private company. From the outset, the new owner-managers wished to develop their own products and were actively involved in this process. Also in 1984, RDD's product strategy changed as it was brought, under the guidance of a new top manager, more into line with that of its new parent company F&P. After this change the emphasis did not shift, even when the parent company itself changed ownership in the late 1980s. Although F&P was a public company it has retained a strong family influence. Consequently, when the ill-fated investment company, Equiticorp, acquired a 30 percent holding in F&P the Fisher and Paykel families were able to negotiate a deed of mutual co-operation which supported 'the preservation of the culture and philosophy of F&P'.

However, as the cases of Formway, Feltex Furniture and Atlas illustrate, not all major changes in ownership will result in strategic discontinuity. Despite changes in the ownership of these three companies there has been little change in the product strategy pursued. This is because in the transition from one mode of ownership to the next there was no major shift in top management goals or values.

Strategic diversions: Managerial attention and financial resources

Once ergonomics capability has emerged in an organisation, it will usually continue to develop as more practical experience is gained. The rate of development, however, will be influenced by the availability and allocation of resources within an organisation.

In the realm of organisational decision-making, attention resources tend to be scarce. Managers have finite attentional resources and, as a result, they will rarely search for information about all alternative courses of action. Similarly, it may not be possible for a management team to attend to all of an organisation's goals simultaneously.

Generally managers will selectively attend to some goals at the expense of others. To some extent, the selection may be determined by the skills background of the manager, as well as his or her experiences, interest, and values. However, it has also been suggested that managers will tend to devote more attention to activities that do not meet targets than to those activities that are meeting targets. This 'squeaky wheel conception of attention' (March, 1988: 3) may help explain why managers who are otherwise supportive of particular goals find that they do not get around to attending to them adequately.

In relation to the present study, the problem of attention is particularly evident when the company is presented with a threat to its survival or profitability. Under these circumstances, the company's management may have to divert their attention to those areas which are most under threat. For example, as a result of the sudden economic downturn which followed the 1987 share market crash, Formway's rate of growth rate fell to levels less than those budgeted for. This situation continued so that when, in 1990, Chalmers returned to the company

after an absence of three years he found that the company had lost some of its 'design direction'. As Chalmers explains, the company's owner-managers had been too busy dealing with other matters:

> I think that they are less design-aware than they used to be when I was here before ... I think that it's just they have had too many other things to think about in the last couple of years. There has been a lot of sort of hanging-on by the finger nails.

A lack of managerial attention can mean that decisions relating to long-term projects are put aside while short-term solutions are found to solve immediate organisational problems. However, while these diversions may only be temporary, the effect on personnel at other levels of the organisation can be significant. Such personnel may be led to question the commitment of management to particular goals that have routinely been pursued in the past. For instance, in late 1990, when RDD's management was struggling to adjust to a very weak domestic demand for appliances, Angela Roberts became confused about the level of priority that seemed to be given to the application of ergonomics and other initiatives. Whereas previously the drive has been 'very much team, just-in-time, quality', the emphasis seemed to have shifted to 'just managing' the business.

A further illustration is provided by events which followed shortly after Atlas was acquired by Simpson Appliances (NZ) Ltd in late 1988. The latter organisation set out immediately to increase the market share of Simpson brand products in New Zealand. However, rather than compete against its main competitor F&P on the basis of superior technology and product development, Simpson aimed to gain more share by getting wider access to distribution channels. The resulting court action had the effect of diverting the attention of F&P's management from other important areas of decision-making. As RDD's marketing manager indicated:

> We have had to spend a lot of time on distractions like fighting commerce commission hearings and things because of the franchise agreement, rather than getting on with the business. So there has been a lot of time and effort and energy wasted in those areas. Meanwhile there are more and more imported products arriving on the marketplace.

Besides managerial attention, another resource that impacts on the development of ergonomics capability is money. This study reveals that low profitability does not prevent the emergence of ergonomics. Indeed, as the examples of Fuelquip and Formway illustrate, the emergence of ergonomics was determined more by the aspirations of owners than by the company's financial situation. In both cases, the owners were heavily indebted but recognised that they needed design assistance if they were going to be successful.

Once an ergonomics capability has emerged, however, an organisation's financial resources will impact on the amount of further learning that can take place. Generally, where organisations have limited financial slack, managers will be careful in allocating money to design research and this can often severely limit a designer's activities in this area. This factor was frequently commented on by designers who were frustrated by this but also saw it as being part of the reality of business.

The impact of slack funds for design research is clearly illustrated by Formway, an organisation which during the 1980s experienced extremes in profitability. The company achieved very high levels of profitability as a result of the RSI 'epidemic'. According to a senior manager, this external factor was

> totally out of our control. And because we had developed a worksurface product which was adjustable before then and had been working in that area, that led to an incredible increase in demand for a product we were making ... that provided more money and resources to really look into ergonomics in more depth.

The profits generated during this time allowed the company to continue to support an in-house designer who during the period 1984-1987 undertook ergonomics research. In addition, funds were available for experimental activities and trips by managers and industrial designers to conferences and trade fairs. By 1987, this situation had changed substantially and the company had less money for this type of activity. However, rather than discontinue its investment in ergonomics, the company merely became more careful in this respect. Thus, when Chalmers returned to New Zealand, the company was keen to retain his expertise but his employment was limited to a part-time basis.

Summary

In focussing on the organisational context in which ergonomics capability emerges and develops this chapter had examined a number of interrelated themes including support and control, goals, ownership, resources and product strategy. What emerges from the analysis is the prominent role of top management in shaping this context. Over time, top management decisions and actions (which are directed toward goals, guided by routines and tradition but bounded by attention resources) translate into an organisational configuration that guides and constrains the options available to the organisation in the future. It is the role of management in contributing to this historically bounded process which helps to explain why ergonomics capability emerges in some organisations earlier and continues to develop with a greater momentum than in others.

The product strategies of the various organisations in this study showed a high degree of continuity. It was argued that as an organisation's product strategy emerges, it may become difficult to change. Although most organisations were periodically shocked into a burst of innovative activity by the action of competitors, major shifts in direction were generally related to changes in ownership which brought new leaders to the fore with goals and values different to those supported in the past. It is significant that in two of the six cases in this study, the emergence of ergonomics capability followed directly from a major change in ownership.

This chapter has also argued that ergonomics capability is to a large degree consistent with the 'customer orientation' which has in New Zealand business come to be regarded as 'good management practice'. Where ergonomics capability emerges in such a setting, its outright rejection would be an inconsistent step. However, over and above the basic tolerance (or even token adoption) that a customer orientation might engender, ergonomics capability will tend to be fostered particularly in contexts where top management support a goal of high product quality. Under these conditions, ergonomics capability will be supported in spite of the periodic diversions which arise from changes in the level of financial slack and attention resources.

Finally, in addition to setting the general scene for innovation, top management may promote the development of ergonomics capability through their active

involvement in this area. By mentioning ergonomics in their everyday conversations and by working closely with design team members and ergonomics advocates, top managers can provide a highly supportive environment.

Chapter Seven

Ergonomics Capability And The Knowledge Environment

Introduction

The purpose of this chapter is to extend on the contextual analysis commenced in the previous chapter by focusing on the *external forces* which were linked to the emergence and development of ergonomics capability in the six cases. In examining these external influences, the intention is not merely to provide a distant backdrop to the processes of central interest, rather an attempt will be made to establish significant linkages between these internal processes on the one hand and external forces on the other.

This chapter starts by presenting a conceptual model of the external environment. The model has four elements: the *firm*, the *government*, the *sub-sector* (of which individual firms are members), and the *knowledge environment* (particularly where this relates to the discipline of ergonomics). The elements of this model are reflected throughout the analytical discussion in the remainder of the chapter which proceeds under thematic headings including trade policy, research and development expenditure, the role of government-funded institutions including the New Zealand Industrial Design Council and the Wellington Polytechnic, the setting of standards, and the role of professional networks.

The external environment

In the present study, the emergence and development of ergonomics capability was found to be both constrained and enhanced by complex exchanges between individual firms and certain aspects of the external environment. These aspects are shown diagrammatically in Figure 7.1.

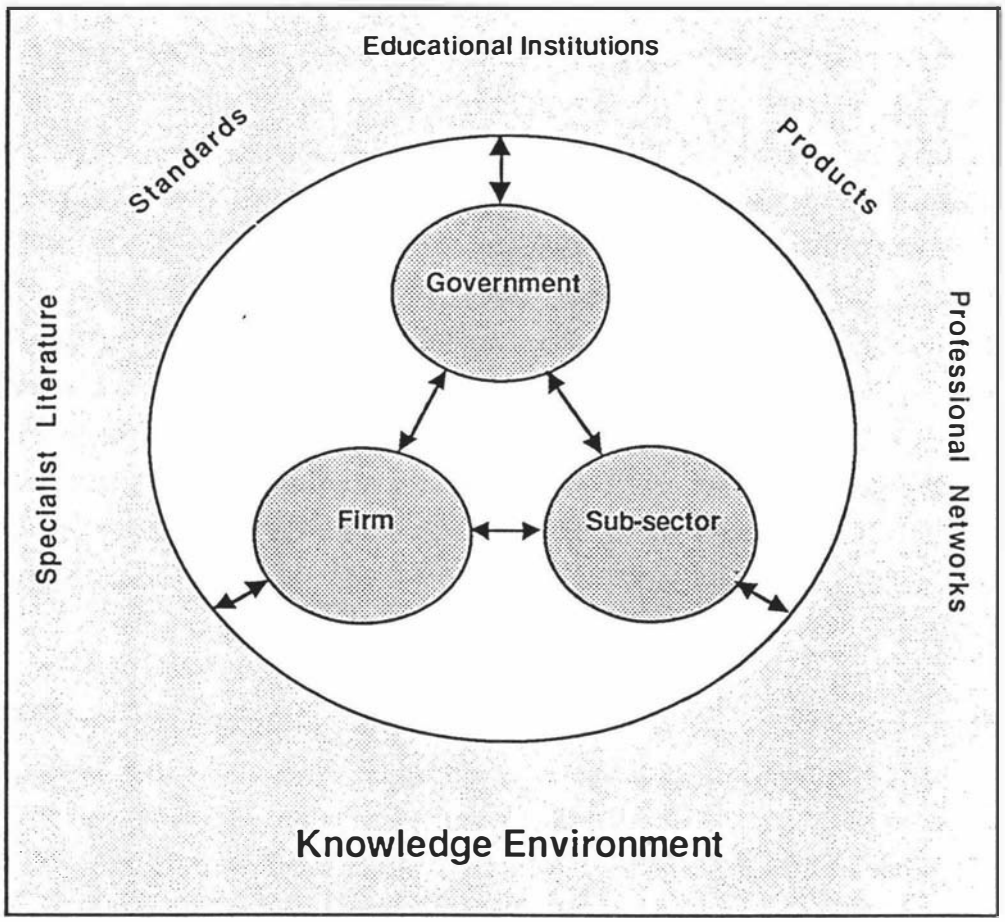

Figure 7.1 The external environment associated with changes in a firm's ergonomics capability

The model in Figure 7.1 shows that three elements (firms, sub-sectors, and government) are each linked to a wider knowledge environment (see Nelson and Winter, 1982: 64). This particular type of environment includes the knowledge that is available to society at large in the form of products, patents, standards, scientific journals, books, etc. It also includes those individuals and organisations who play a major role in the production, dissemination, and promotion of specialist bodies of knowledge. The *centre* of the model indicates that firms, the sub-sector, and government impact on one another. It is suggested that the latter relationships may influence the degree to which an individual firm will exchange ergonomics knowledge with the wider knowledge environment.

The arrows linking the parts of the model indicate that the various relationships are two-way. Thus, a firm which takes information from the wider knowledge environment may also contribute to it through the production and eventual sale of products. Also, by using two-way arrows, the model assumes that the nature of organisation-external environment relationships falls somewhere between the two extremes of 'environmental determinism' on the one hand, and a wholly 'enacted', cognitive view on the other (see Weick, 1969; March, 1981). This mid-position accepts that while external environments may be created and even 'negotiated' by organisation members (Cyert and March, 1963: 119-120), the external environment also has certain objective characteristics which are distinct from the perceptions of individual actors (Child and Smith, 1987; Pettigrew, 1985). These objective characteristics may (albeit through a process of subjective interpretation) bring about change within an organisation.

As the various elements in Figure 7.1 may relate *indirectly*, their various effects can be difficult to untangle. This is particularly true in respect of the effect of government practices and policies which tend to be particularly diffuse, but are nonetheless highly significant. By comparison, the impact of sub-sector conditions on the exchange of knowledge to and from organisations tends to be more immediate. Given this, the discussion will continue by focusing initially on this particular element of the model.

The term 'sub-sector' refers to a population of organisations which produce similar products and operate in the same product-market(s). As such, a sub-sector is broadly analogous to the 'sector segment' referred to by Child and Smith (1987: 572). In the present study, both RDD and Atlas are members of a

sub-sector of the whitegoods industry which produces electric ranges and other cooking appliances.

Members of the same sub-sector are linked through the effects of their actions on each other. Specifically, as one organisation innovates and proceeds to embody in its products what it has learned, these products in turn shape the competitive environment of other organisations. As indicated by Levitt and March (1988: 331), organisations innovate and learn in a complex context that is itself learning and changing at the same time. This effect is illustrated by Feltex Furniture's decision to produce an 'ergonomic chair' following the release of Formway's Cambio chair, and in PEC's response to the release of Fuelquip's C-shaped pumps (see Chapter 4).

The linkages between constituent organisations may be enhanced where rivalry prevails within a sub-sector. Under competitive conditions, organisation members may be inclined to closely examine the ergonomic practices used by competitors as well as the design features that they have incorporated into their products. In the competitive struggle for market share, survival or profits, organisations may be motivated to advance on these practices and product features, or at least follow them. This process lies at the heart of the ordinary, everyday, 'nuts and bolts' type of innovation which, as Marquis (1982: 43) argues, is largely motivated by the process: 'So long as your competitors do it, so must you'.

While an organisation may try to absorb some of the ergonomics knowledge which is already being applied by other firms in the same sector or sub-sector, there will be limits to the availability of this information. On the one hand, manufacturing organisations which *generate* ergonomics knowledge may choose not to release this into the wider knowledge environment. This information may be considered to be commercially sensitive. On the other hand, even if an organisation was prepared to share its information, it is unlikely that this would ever be written up in a form expressly intended for external dissemination. For most organisation members, including industrial designers, this dissemination role is not something for which they are rewarded.

Besides using ergonomics information that is available and directly applicable to members of a particular sub-sector, organisations may also reach out to the ergonomics knowledge which is available to society at large. This knowledge

can be tapped into by reading publications, seeking the advice of experts, or by attending conferences and lectures. All of these methods were used by organisation members in the present study. For example, at Formway, books and journals were consulted and international ergonomics conferences were attended, while at RDD, organisation members attended university courses in ergonomics.

While sectors are predominantly considered in terms of competitive forces which serve to constrain organisational action, sectors may also be viewed in terms of their ability to enable change and innovation. Child and Smith (1987), for example, have suggested that sectors may consist of 'networks' of potential and actual collaborators. In the present research, 'competitors' in the same sub-sector did co-operate to some extent because certain aspects of their respective businesses were complementary. For example, in the early 1980s, Formway held an agency for gas-springs and supplied these components to other furniture manufacturers including Feltex Furniture. Similarly, once the petrol pumps designed by PEC are installed on service station forecourts, they are serviced by Fuelquip. More *formal* collaborative mechanisms were evident in the 'skills arrangement' which gave RDD access to Fisher and Paykel's industrial designers from 1961 to the early 1980s, and in the relationship between Feltex Furniture and CoDesign. In none of these instances, however, was there a substantial exchange of ergonomics knowledge between organisations.

Members of the same sub-sector may be linked in more subtle ways through the language, constructs and strategies which characterise a particular sector. Citing evidence from research studies, Child and Smith (1987) note that senior managers may come to share a similar understanding of a sector's dynamics. Through the creation of this 'cognitive arena' (and its subsequent reinforcement), standards, norms, and rules of the game are established and communicated. These industry-wide 'conventional practices' may provide an important means by which organisations try to control or 'negotiate' their competitive environment (Cyert and March, 1963: 120). Cyert and March have argued that where practices are standardised, for example through trade associations, journals, word of mouth, and external consultants, there is a strong likelihood that all competitors will follow it. Rules and practices will be followed, according to Child and Smith (1987), provided there are no major shifts in market or technological conditions.

By following standard practices, organisations can buffer themselves from the costs associated with overcoming uncertainty and dealing with a moderate degree of environmental change. For example, rather than attempt to resolve apparent inconsistencies in the theories and ideas emanating from ergonomists, the designers of Feltex Furniture products chose instead to conform to the dominant designs in office seating that were emerging in the 'chair industry'. This is reflected in the following quote:

> The biggest problem is that you don't know what is ergonomically correct. We are quite lucky that the chair industry has sort of developed their own medium saying this is correct ... you find Formway, ourselves, Furniture Three, Damba, we are all starting to develop chairs that do ergonomically the same sort of functions.

Also in its role as 'cognitive arena', a sector or sub sector provides models and 'exemplars' against which an individual organisation's strategy, structure and routines can be compared (Child and Smith, 1987: 566). Such comparison can range from an informal scan of industry practices to the type of formal 'corporate benchmarking' exercise which was undertaken by Xerox Corporation to determine the structure of, and resources allocated to, industrial design and human factors activities in 'some of the best businesses in the world' (Wasserman, 1989: 36). When applied to the present study, the idea of the sector as 'a bearer of external exemplars' is most insightful, in that it highlights an absence of structural models which refer explicitly to ergonomics. This contrasts with the range of *explicit structural models* cited in the ergonomics literature such as human factors groups or sections (Meister, 1971; Crawley, 1972; Brown, 1984; Emmons and Neal, 1984; Wichansky, 1984), ergonomics groups (Blaich, 1987; Bosman *et al.*, 1990; McClelland, 1990), ergonomic steering committees (Heskett, 1989), ergonomic programmes (BCA, n.d.), ergonomic task forces (Joseph *et al.*, 1986), and the routine employment of ergonomists.

The only explicit model evident in the present study was the 'Ergonomics Group' which operated within RDD from 1987 to 1989. This group had, as an initial objective, the improved design of assembly and clerical workstations within RDD but subsequently it shifted its focus to issues including product design and manufacturability. By contrast, the inclusion of industrial designers in an organisation's design team, which has been identified in this research as a

primary factor in the emergence and development of ergonomics capability, is not an explicit model, in that to an outside observer, the linkage between the employment of an industrial designer and ergonomics capability is not immediately obvious. Instead, ergonomics is buried or hidden from view. Consequently, despite the widespread use of industrial designers in New Zealand manufacturing, this practice does not function directly as an exemplar that will encourage the diffusion of ergonomics capability. The general lack of explicit exemplars of ergonomic practice among the six cases reflects the situation in New Zealand business generally where there are few, if any, sections, groups or other relatively substantial structures which focus specifically on ergonomics. For example, large public sector organisations (such as New Zealand Post, Telecom, and New Zealand Railways) whose counterparts in other countries have ergonomics groups or sections have never adopted a similar practice, although they have employed consultant ergonomists and industrial designers from time to time on specific projects.

The degree to which an organisation is open to 'exemplars' may be related to the stability of its sector environment. For instance, it has been argued by innovation researchers that the higher the rate of environmental change, the more 'open' the organisation and the higher the degree of organisational innovativeness (Zaltman and Wallendorf, 1979: 241). Change may be indicated by shifts in the competitive structure of a sector which, in turn, is shaped by competitive forces. These forces vary over time and include the height of entry barriers, intensity of rivalry, the power of buyers and suppliers, and pressure from substitute products (Porter, 1980).

The structures of the three sub-sectors in this study differed and in all instances, there was evidence of substantial structural change during the mid to late 1980s largely resulting from government policies encouraging economic liberalisation. Of the three sub-sectors, the electric range sub-sector has become the most highly concentrated; by 1990 there were only 2 manufacturers remaining in New Zealand as compared to 4 in 1985 and 6 in 1965. This increase in concentration occurred against a background of intense rivalry (price wars), high entry barriers, and low market growth due to periods of weak domestic demand and the increased demand for (imported) substitute products (e.g. wall ovens and cooktops). By comparison, the office seating sub-sector has historically tended to be much less concentrated, with low entry barriers, and weak rivalry due to the adoption of niche positions. As will be discussed more fully later in this

chapter, these structural features tended to change during the 1980s: the presence of imports caused more intense rivalry, there were shifts in the customer base while the demand for more technically complex, 'ergonomically designed' furniture tended to lift entry barriers for local manufacturers. The final sub-sector to consider is that which produces petrol pumps. Consisting of three local competitors and no foreign presence, this sub-sector is only moderately concentrated. The sub-sector is characterised by a powerful customer base (oil companies) and moderate entry barriers.

Almost all aspects of industry structure are potentially influenced by government action. As Porter (1980: 28) explains, government may be a buyer or a supplier, and it can directly and indirectly influence competition by the policies it adopts. The varied, and significant, role of government in facilitating the emergence and development of ergonomics capability at the firm-level is clearly evident in the present inquiry and is a major theme that permeates through the remainder of this chapter. Firstly, it will be shown that, through their impact on the competitive structure of industry sub-sectors, government policies relating to industry assistance, competition, and trade have influenced the nature of the interaction between individual organisations and the wider knowledge environment. Secondly, it will be demonstrated that government policy also enabled the emergence of ergonomics capability in the six cases both through the establishment of government agencies and the support of particular training programmes. Throughout this discussion of government structures and policies, the significant role of key individuals will also become apparent.

Import control and technological dependence

Although each of the six organisations in this study forms part of an industry consisting of a relatively small number of local competitors and importers they all belong to the manufacturing sector of the New Zealand economy. This sector has, in the past, been subject to a high degree of government control. It has also been subordinate politically to the country's agricultural sector. Yet, while New Zealand is often viewed as an agricultural nation because the majority of its *exports* are of agricultural origin (see Table 7.1), in 1989 the manufacturing sector contributed more than agriculture to the country's Gross National Product and employed more people.

Table 7.1
Commodity composition of New Zealand's exports and imports 1967-1990
(Percentage shares of principal items in total export/import)

Exports				
Year	Wool	Meat	Dairy	Manufactures
1967	24	27	2	6
1980	18	24	14	16
1985	13	22	13	24
1990	9	15	14	25

Imports				
Year	Mineral Fuels	Chemicals incl. Fertilisers	Machinery and Transport	Manufactured Goods, etc.
1967	7	11	38	34
1980	20	12	30	20
1985	14	12	33	19
1990	6	13	39	25

Sources: Chatterjee (1988)
OECD Economic surveys: NZ (various years)
NZ Official Yearbook (various years)

The New Zealand manufacturing sector has largely been shaped by the import licenses and tariffs initially imposed by the first Labour Government in the late 1930s. These controls immediately restricted the flow of imported goods which had at the time been draining the nation's overseas funds. They also led to an increasing diversification within manufacturing and the emergence of industries increasingly dependent on non-indigenous materials (Golledge, 1964). In particular, the metal working industry became more significant, and there was also expansion in industries including footwear, carpet and chemicals. Further expansion occurred in the late 1950s as a result of the 'industrial development' policies of the second Labour Government which encouraged large scale non-traditional industries such as pulp and paper, and petroleum. In addition to this diversification trend, the overall size of manufacturing units continued to increase. By the early 1980s, the size profile of New Zealand manufacturing

businesses was not greatly different from that of the Australian manufacturing sector (New Zealand Department of Statistics, 1984; 1986).

The trade barriers imposed in the late 1930s encouraged overseas companies to set up their own manufacturing units in New Zealand. At the same time, some New Zealand-based importers (e.g. Fisher & Paykel) turned from importing to the manufacture of products under license. However, while this import-substitution activity resulted in the formation of new industries and the extension of existing ones, the manufacturing activity that took place generally lacked depth in functions such as research and development. The source of product designs along with process technology and components was usually overseas. This situation led Golledge (1964: 66) to conclude that 'much of the "manufacturing" in New Zealand consists merely of assembly, mixing, moulding or finishing functions'.

At the time, Golledge was hopeful that the skills, techniques and resources gradually accumulating as a result of exposure to imported technology would result in more production and processing functions being undertaken in New Zealand. However, by 1980, there was little evidence to suggest that research and development functions had developed to any great extent other than in large manufacturing units. Citing evidence from their own survey results, technology licensing payments and receipts, as well as official R&D expenditure statistics, Stuart and McCulloch (1980: 6) concluded that New Zealand manufacturing was still 'dependent on overseas developments for most of its technology, although this is more so in some industries than in others'. As a result, Stuart and McCulloch (1980) considered that New Zealand manufacturing had only reached the second (Dependent) and third (Imitative) stages of a five-stage model of technological development strategies and national technological capability derived from Halty-Carrere (1979). The characteristics of these two stages include the importation of know-how and proprietary technology, process improvement, foreign technology adaptation, and copying.

This overall picture of dependence has significant implications for product design and development. It is consistent with the widely held view that design plagiarism has been a common practice among New Zealand manufacturers. Although no systematic empirical research has attempted to determine the extent of design plagiarism in New Zealand, an informal survey of several organisations (Vause, 1979) concluded that original design content was

generally considered to be expensive and unnecessary, particularly given the low probability of a manufacturer being taken to task over this practice (a factor which may be linked to New Zealand's geographical isolation). Vause (1979: 24) also found that for those manufacturers approached, the issue of copying was largely 'one of economics, not ethics'.

Stuart and McCulloch (1980) considered that copying and other inward-looking approaches to technology acquisition and development had been fostered by New Zealand's 'history of protectionism'. They argued that protection levels for manufactured goods, which were high compared with other OECD countries (see Wooding, 1987), had stifled 'healthy competition' and under these conditions manufacturers had become complacent. As evidence, Stuart and McCulloch (1980) cited survey results which showed that while half of the manufacturers surveyed considered their *technology* to be at a high or moderate level, nearly all were satisfied, or more than satisfied, with the level they used. Furthermore, a high proportion (over 70%) of respondents were satisfied with their product *quality*.

Similar concerns relating to protectionism were later echoed in briefing papers presented to the incoming Labour Government in 1984:

> With minimum international competition, pressures to keep costs and prices down and to improve productivity and efficiency are greatly reduced. Similarly, the stimulus to innovate, to respond to technological change and to deal flexibly with variations in the pattern of market demand is also lowered. (New Zealand Treasury, 1984: 306)

In these briefing papers, New Zealand Treasury economists argued that international competitiveness had been reduced due to high and uneven levels of industry assistance. In line with their 'more-market' economic philosophies, which had to some extent been shaped by micro-economic theories of the Chicago School (Bollard, 1991), these economists urged that assistance levels be reduced. Their view - that government should 'get out of business' - contrasts with the recommendations of the DSIR scientists Stuart and McCulloch (1980). While these researchers were critical of protectionism they nevertheless still saw a continuing role for central government and had recommended that it develop a manufacturing plan, encourage co-operative government-industry projects,

reintroduce the Industrial Research and Development Grants Scheme, and provide incentives such as awards and prizes (see McCulloch, 1980).

In the present research, the impact of protectionism on product strategy is illustrated most strikingly by the case of Feltex Furniture (now CoDesign-NZ). Shielded from international competition, this company continued to manufacture the same Harter secretarial chair during the 1960s and 1970s. While the continued use of the same design enabled the company to minimise costs associated with new product development, by the late 1970s, a significant gap had developed between the Harter and design concepts being introduced overseas. There had been no real pressure on the company to change the design: as a result of relatively unsophisticated consumer demand, and an absence of choice, the Harter had remained a best-selling item in New Zealand. During the 1980s, Feltex Furniture continued to use a low-cost approach to product development which did not call for the employment of industrial designers and ergonomists. Furthermore, rather than obtain its designs for its Feltex Furniture range from license arrangements the company relied increasingly on copying. As acknowledged by a senior manager of the company, Feltex Furniture products were essentially 'a collection of bits and pieces and ideas that have come together' from various sources.

Although copying may be a successful strategy from the point of view of an individual company, it has some limitations for society in general. Copying may not develop the organisation's knowledge base to the level required to produce innovative products with potential in export markets (Stuart and McCulloch, 1980). Furthermore, a lack of design knowledge can lead to the removal of important ergonomic features, the addition of faults, and a lack of design integration (in that the product remains nothing more than a collection of 'bits and pieces'). In an interview in 1991, Formway's research director explained this effect, but suggested that the practice of copying may have decreased in recent years as a result of increased competition.

> People who take another product and copy it have the potential to design out the faults that are in it or, if they don't have the knowledge, to just add further faults. More often than not from my observation further faults get added rather than that existing ones are recognised and eliminated. I think that process, though, is increasingly becoming one of the past because the industry is changing and it is far more competitive.

The increase in competition referred to by Brian Carter is linked, in part, to the removal of centrally-imposed import controls during the mid to late 1980s. These deregulatory changes, and their subsequent impact on ergonomics capability in the six cases, will be discussed in the next section.

Trade policy liberalisation

Although the import controls introduced in the late 1930s varied from time to time in their severity (there was an easing of import licensing in the early 1950s), they were to remain largely unchanged until the late 1970s and 1980s (Rayner, 1988). Throughout this long period of relative economic stability, many New Zealand manufacturers were able to adapt their practices and products to weak levels of domestic competition and the requirements of a relatively unsophisticated customer base that was largely sheltered from a knowledge of what was available in international product-markets.

This situation changed when the fourth Labour Government came to power in 1984. With the objective of giving consumers 'a better deal' (Wooding, 1987: 97), most import licensing was removed by July 1988, export incentives were reduced between 1985 and 1990, and tariff rates in excess of 25% were reduced in 1986 (Wooding, 1987). In introducing these sweeping changes, the fourth Labour Government greatly accelerated a deregulatory trend which had been gaining momentum since the late 1970s (Bollard, 1987). The 1979 budget had introduced import license tendering and modifications to export incentives (Wooding, 1987: 94) and in 1982 these changes were followed by the publication of proposed arrangements for an Australia New Zealand Closer Economic Relations Trade Agreement (ANZCERTA).

According to Campbell *et al.* (1989), the main aim of trade liberalisation, and other post-1984 deregulatory changes, was to eliminate the type of 'satisficing' behaviour identified by Stuart and McCulloch (1980). Under these new economic conditions, firms would be forced to compete, following 'a survival of the fittest' scenario. Individual manufacturers' rates of structural adjustment to these radical reforms have since been examined in a series of surveys (Roseveare *et al.*, 1986; Savage, 1986; Staley *et al.*, 1988; Campbell *et al.*, 1989; Baird *et al.*, 1990; Harper and Malcolm, 1991). These surveys show that after 1986 there

was a marked increase in the rates of adjustment to a variety of within-firm factors which ranged from changes in ownership, plant closures, redundancies, enhanced product quality, product mix changes, to improvements in technology. The latest survey in the series (Harper and Malcolm, 1991) concluded that the rates of structural adjustment had started to decline after what appeared to have been a peak between Campbell *et al.*'s survey in 1989 and Baird *et al.*'s survey in 1990. Although manufacturers had been 'traumatised' by economic deregulation, most of the respondents surveyed by Harper and Malcolm (1991) considered that their internal restructuring processes were complete or near complete.

The major deregulatory changes described above, and the firm-level adjustments that these provoked within the New Zealand manufacturing sector, occurred towards the *end* of the time span covered by the present study. In this respect, it should be remembered that in the case of both Formway and PEC significant events relating to the emergence of ergonomics capability took place in the 1960s (see Chapter 4). Nonetheless, the period from 1984 onwards was a time of major upheaval for all of the six companies. Interestingly, the same period also saw an increased development of ergonomics capability within some of the companies concerned.

The impact of the economic changes of the mid to late 1980s was, however, mediated by other factors internal and external to each of the six organisations. In particular, the effect of trade policy reform varied between the three sub-sectors both in terms of intensity and timing (a factor also noted by Campbell *et al.*, 1989). By the early 1990s, the presence of imports had impacted to a much greater degree on the product-markets for office seating and dishwashers, than on the product-markets for free-standing electric ranges and petrol pumps. The slight impact in some sub-sectors can, in part, be attributed to the presence of dominant designs and relatively inflexible industry standards. These standards afford some sub-sectors a (temporary) measure of protection from imports because the latter products may be incompatible with user requirements. The following discussion will examine how these government-led changes in the broader external environment were linked to changes of ergonomics capability within the six companies.

The forces linking trade liberalisation and ergonomics capability can be seen most clearly in the cases of Feltex Furniture and Formway. In both these

organisations, the rise in office seating imports during the 1980s was paralleled by an increase in the level of in-house ergonomics capability. However, it is significant that import liberalisation did not lead to the initial *emergence* of ergonomics capability; this capability had already emerged within Feltex Furniture and Formway before the first office chair imports were introduced around 1982/83. Import liberalisation, through its complex linkage with 'demand sophistication', did, however, facilitate the further *development* of ergonomics capability.

During the mid-1980s the domestic market for office seating became more sophisticated and demanding. The source of this trend can be found in events such as the publication of the brochure *You and the Way You Sit* by the ACC (1978), a major research study (New Zealand Department of Health, 1980; Cook *et al.*, 1980), and the 1979 PSA Conference which culminated in the February 1982 PSA/SSC agreement. This agreement is particularly significant in that it directed the equipment specifier for New Zealand's large public sector (i.e. the Government Stores Board) to purchase and provide 'adjustable' chairs for VDU workplaces. Here, the role of government as an influential buyer is evident.

While the upward trend in customer sophistication encouraged local manufacturers to acquire more ergonomics capability, the trend was also influenced by the actions of local manufacturers, in particular Formway. In the mid-1980s, for example, the management of this organisation consciously tried to 'educate' their potential customers by providing seminars dealing with aspects of ergonomics. Formway's managing director Mark Carter considered that the release of the Cambio chair had also been a significant event:

> I think in many respects we [Formway] created some of the waves, we weren't the only one, but I think the Cambio chair was probably an event which had an effect on us all. It became so many, we made so many thousands of them, and they were costing quite a bit more than chairs that were the same size, so I suppose the users identified the benefits and the word of mouth of the user to the buyers became a more important factor than in the past. They were no longer just prepared to say "We'll just have a chair", particularly if they were doing keyboard work.

At Formway the presence of imports was welcomed. Not only did they provide the company with new ideas, they also helped generate a more sophisticated

level of demand that would favour the sale of Formway's products. Mark Carter again:

> I think we were influenced, we had to be influenced, by some of the best chairs that came into New Zealand being picked up the likes of Stathams [an interior design firm] and others who saw a need for better design particularly being articulated by the designers and the specifiers. So those products were good for us because they did two things: they created demand for much better products and we learnt some things from studying those products that we could apply ourselves. Although I think in saying that, by then, there were probably quite a few things that we could have improved in those products as well.

Similarly, Formway's industrial designer Ian Chalmers had this to say:

> The good thing about having the overseas involvement [of imported products] is that it often raises the standards that these firms, or that everybody, is working to. And the furniture market is a case in point. Back when I started at Formway, back in the dark ages, the chair market was not very sophisticated at all.

RSI was another force which impacted on demand sophistication. In 1985, as a result of the media attention given to this work-related disorder, and the information that was subsequently disseminated by manufacturers (particularly Formway), government agencies (see New Zealand Department of Health, 1985a; 1985b) and unions (PSA, 1985), the demand for 'ergonomically designed' furniture was greatly increased. As a result of this demand and the easing of trade restrictions, the flow of imported chairs increased significantly. According to Johnston of Feltex Furniture, the market got 'flooded with ergonomic operator chairs'. At the same time, demand was boosted by a second factor, namely the office refurbishment activity that resulted from the deregulation of the financial sector and the state sector corporatisation programme. Some of this demand was focused more around visual appeal and corporate image, rather than on obtaining furniture that met ergonomic criteria.

The resultant rapid 'upward movement of the market' meant that local manufacturers suddenly lacked suitable products. Feltex Furniture responded

quickly by introducing the Ergotec, while Formway initiated a major development programme. According to Formway's research director Brian Carter:

> We wanted to make a chair that would be of a calibre to compete with imported chairs because at that stage we believed that the New Zealand market was going to be dominated by chairs designed and largely manufactured in Europe. To that end we have looked closely at what was being done in Europe.

The flow of office furniture imports peaked around 1987/early 1988. At this point there were, as Mark Carter of Formway recalled, about '30 to 40 overseas chair lines' on the New Zealand market. Following this, the commercial furniture market slumped as a direct result of the October 1987 share market crash and the subsequent downturn in the level of local construction and refurbishment activity. The impact of this downturn on the commercial furniture industry, in combination with trade policy liberalisation, was severe. A senior manager of Feltex Furniture had this to say:

> Yes it [the impact of imports] hurts ... personally I'm a bit two-minded. OK, I'm in favour of free enterprise. I can see how it is going to make us more competitive and that. But I think it is going to hurt a lot more people in the long run. We will survive, but I think some companies won't. Our industry goes along with what the economy is doing, building construction and things like that. In the good times people have a bit of spare money so they do up their image and they buy new furniture. The crash really hurt us because people couldn't afford to spend any money on their image anymore. Or they folded altogether.

Although the share market crash caused the flow of imports to reduce, Mark Carter also considered that the release of the Zaf helped stem the tide somewhat. Nevertheless, even the success of the Zaf could not protect Formway from the depressed demand and intense competition that characterised the furniture industry in the late 1980s and early 1990s. Although Formway survived the subsequent shakeout in the industry mainly through boosting exports to Australia, the company's poor performance meant that there was less money to spend on R&D. In particular, poor sales prevented the company from re-

employing its 'ergonomics champion' on a full-time basis. In addition, the company had to postpone some of its product development work.

By contrast, the two electric range manufacturers which had survived the intense domestic competition and industry shakeout in the late 1980s were only really faced with substantial competition from imports in the early 1990s. Prior to that, according to the marketing manager of RDD, imports in the area of electric ranges had been 'hurting a little but not a great deal'. The demand for imported free-standing electric ranges had been limited because these appliances did not fit in the spaces provided for ranges in most existing New Zealand kitchens. However, by the early 1990s, the placement of imported ranges, wall ovens and cooktops into new kitchens was becoming a more significant trend as European modular sizes for built-in products had been adopted by the New Zealand kitchen industry.

The threat presented by imports increased the sense of urgency at RDD surrounding the release of new products. During 1991, design teams were actively working on replacements for both of RDD's major products, the basic designs of which were at least 14 years old and at the end of their life-cycle. In this context, there was evidence that RDD's design teams would be looking seriously at the ergonomics of the overall product concept and its detail design. This, however, was very much part of the general movement forward in terms of product design which had been encouraged by the deregulated environment. As RDD's marketing manager explained:

> The one thing it [deregulation] has done, it's probably forced us to look more critically at where we are going with our products. It will eventually up the rate of change of our products, all those economic changes - the opening of the borders, the lowering of the tariffs - these will force us to do that. Short term they are painful, long term they are still going to be painful ... but basically the standard of products will rise in the long term.

Nevertheless, this same manager could also see that, in those industries where there is already an innovator serving the domestic market, deregulation could lead to less risk-taking and prevent major shifts in the dominant design. Citing the example of Fisher & Paykel's Gentle Annie electronic auto washer, the marketing manager argued that a protective environment had in the past allowed

the company to introduce major design changes in the knowledge that survival would be assured.

Export promotion

The contribution of manufactured goods to New Zealand's total exports has increased significantly since the 1960s. Whereas in 1967, manufactured goods represented 6 percent of total exports, by 1990 this percentage had risen to 25 percent (see Table 7.1). This diversification can, in part, be attributed to government export promotion schemes and, in particular, export incentives. Introduced in 1962 against a continuing background of import protection, export incentives were initially 'modest in size and fiscal cost' (Wooding, 1987: 90). Over time, however, they showed a tendency to increase sharply and they also came to apply to an increasing proportion of exports. Export incentives were phased out between 1985 and 1990.

The New Zealand manufacturing sector is roughly characterised by 'two legs' one of which rests firmly in the domestic economy, while the other has stepped forward into export markets. While export incentives may have encouraged more of a numerical balance between these two legs, for the majority of exporters this aspect of their business only represents a small part of the total. This is shown in Stuart and McCulloch's (1980) study: one in every three manufacturers surveyed exported, but for many this only represented a small proportion of total sales. Furthermore, in some industries, the survey revealed that 'low level' exporters incurred proportionately less expenditure on research and development that those organisations which derived a substantial proportion of their sales from exports. This association between the latter group of 'manufacturing exporters' and investment in technology development is also borne out in a study by Cullwick and Kan (1983) which identified the characteristics of 'technologically innovative' New Zealand firms. Most of the latter firms were highly committed to exporting. Furthermore, these firms were also committed to in-house product development: among the product innovations introduced in 1980 by these firms, 60 percent were internally developed.

In this study, there are clear links between the level of export activity and investment in ergonomics capability: those organisations that are committed to

operating in export markets (i.e. PEC, Formway, and RDD) have developed their ergonomics capability to a higher level than those organisations (i.e. Feltex Furniture, Fuelquip, and Atlas) that are focused on domestic markets. The two factors (export activity and ergonomics capability) appear to be highly interdependent in that while ergonomics capability contributes to export success, it is also in turn *produced* by an organisation's experience in export markets.

As export activity and ergonomics capability are closely linked, it seems reasonable to conclude that the development of ergonomics capability may have been indirectly *encouraged* by the incentives provided by central government. However, as is revealed clearly in the case of PEC, the nature of government encouragement took on forms other than that of a purely financial nature. Now a successful exporter, PEC achieved its first export sales of high-tech products in the early 1970s immediately following a step-shift in the company's ergonomics capability which resulted from the employment of an industrial design consultant. These events were, in turn, triggered by the encouragement and advice provided by officials from New Zealand Industrial Design Council (NZIDC). The role of this government agency will be discussed later in this chapter.

Unlike PEC, which has been exporting for some time, the commitment towards exporting at Formway and RDD is of relatively recent origin. During the mid-1980s to the early 1990s, these companies were forced to invest more heavily in product design in response to heightened competition from imported products in the domestic market. Against this background of improved in-house product design capability, a period of weak domestic demand encouraged both these companies to look to export markets either for growth or merely to maintain past turnover levels. Again the influence of government policy on exporting activity has been subtle, but present, nonetheless.

R&D expenditure and encouragement

The biennial or triennial censuses of manufacturing published by the New Zealand Department of Statistics have provided a profile of research and development expenditure which is consistent with the dependent/imitative national technological strategy described earlier in this chapter. During the 1970s, these figures indicated that R&D expenditure by the New Zealand manufacturing sector was a mere 0.2 percent of GDP.

The low overall level of R&D expenditure in New Zealand manufacturing would suggest that relatively few R&D personnel are being employed. Indeed, available figures for the New Zealand 'business sector' bear this out. These figures indicate that there are 1.8 full-time equivalent R&D personnel per thousand labour force as compared to higher rates of 8.4 for Japan and 11.1 for Switzerland (see Table 7.2).

Table 7.2
Full-time equivalent (FTE) business enterprise R&D personnel per thousand labour force, 1989

Country	R&D personnel (FTE) per thousand labour force
Switzerland	11.1
Japan	8.4
Sweden	7.5
France	6.1
Finland	5.6
Denmark	4.9
Canada	3.8
Italy	2.7
New Zealand	**1.8**
Iceland	1.2
Greece	0.5

Source: OECD (1992), Tables 9 & 28.

The figures in Table 7.2 suggest that there is comparatively low scope for employment in R&D-related activities in New Zealand. This situation will undoubtedly have a bearing on opportunities for design-related professionals such as industrial designers. This issue was raised by Probine (cited in King, 1979) in a speech to the 1979 conference of the New Zealand Society of Industrial Designers:

> there are some indications that all is not well with the industrial environment in which designers are expected to work. My concern

> is based on figures that relate to New Zealand's research and development (R and D) performance because, at least in the area of development, there may be parallels between the use of scientists and technologists in industry and the use of industrial designers.

While official statistics give a bleak picture, there has been some concern about their accuracy and comparability. This is because full definitions of what ought to be included as R&D activities were rarely given to survey respondents. As a result of the uncertainty created, officers of the Manufacturers' Federation commissioned their own survey (see Healy *et al.*, 1984). However, while the Manufacturers' Federation believed that the official statistics understated the manufacturing sector's investment in R&D, the report of a recent survey of 'business enterprise R&D' which used OECD definitions indicated that the earlier census statistics probably overestimated R&D expenditure. This survey (MoRST, 1991) revealed that expenditure on R&D carried out in the business sector for the year ended June 1990 totalled NZ$200 million or 0.29 percent of GDP. This is considerably lower than the average of 1.1 percent for all OECD countries. The level is lower than in Australia (0.5 %), the UK (1.4 %), Japan (2.1 %), and the USA (2.0 %) (*Sci-Tech*, No. 6, 1991).

In the light of this comparative information, it has for many years been widely argued that the level of R&D performance in New Zealand manufacturing has to be improved if this sector is to become internationally competitive (see Stuart and McCulloch, 1980; Healy *et al.*, 1984; Beattie, 1986; Healy *et al.*, 1987). In the past, successive New Zealand governments have responded to repeated calls for industry assistance mainly through the operation of grant schemes. Unlike in Australia, tax incentives have not been offered as a means of stimulating R&D expenditure. Instead, tax neutrality is provided (see Winsley, 1990).

Although the costs and long term benefits of incentive schemes at the national level are difficult to measure, incentives do generally help to encourage and sustain R&D activity within individual firms. In some organisations, this R&D activity will extend to product design and may include the development of ergonomics capability. This encouragement can be inferred from the applications lodged by PEC to the Industrial Research and Development Grants Scheme. During its operation from 1970 to 1976, this particular scheme provided grants to companies who could show an increase in their R&D expenditure on salaries and wages in the previous year. It has been claimed that

the scheme contributed to almost a doubling in the number of professionally qualified staff employed by participating organisations (New Zealand Industrial Research and Development Grants Advisory Committee, 1977: 5). PEC's first application to this scheme (in 1971) was for costs incurred during the development of the M-system. The supporting evidence included reference to the employment of an industrial designer (Paul Costello) and a statement that members of the New Zealand Industrial Design Council staff had been 'so impressed with the M-system development and the impact the industrial designers had made on the project, they intend to produce a 6 page article on the system in their magazine "Designscape"'. Shacklock (now RDD) and Atlas also received grants from the Industrial Research and Development Grants Scheme. No mention was made in their applications relating to the employment of an industrial designer (National Archives, IC Series 1, Accession File w2680).

After the Industrial Research and Development Grants Scheme ceased operation in 1976, PEC continued to make good use of an R&D environment that was eager to provide assistance to technologically advanced companies and exporters. Thus the company negotiated loans from the Development Finance Corporation in the late 1970s, and sought assistance from the Applied Technology Programme (which operated between 1976-1986) and the Electronics Industry Research and Development Grants Scheme (1984-1986). Against this background of support and encouragement, R&D grew in strategic importance within PEC to the point that when the fourth Labour Government 'pulled the plug' on grant schemes in 1986, PEC continued to increase the number of its R&D staff and employ the services of an industrial design consultant. To allow for this expenditure in the absence of government assistance, however, the company grew more careful in its selection of projects for further development, and became increasingly 'lean and mean'.

While the rapid dismantling of assistance structures for the New Zealand manufacturing sector brought about a major shift in the external context of the six companies in this study during the mid to late 1980s, other external forces have exerted a more consistent influence over the full time period spanned by this study. One such 'constant' relates to the training of New Zealand industrial designers. This particular aspect of the knowledge environment will be examined in the next section.

Education for industry and the training of industrial designers

As was indicated in Chapter 5, a level of ergonomics capability was first introduced into the organisations in this study through the employment of an industrial designer. With only one exception, all of the industrial designers received their initial professional training from a single state-funded training provider which, in 1961, introduced New Zealand's first tertiary qualification in industrial design. Prior to this development, it had not been possible to study industrial design formally from within New Zealand. Instead, most of the individuals who were attracted to the emerging industrial design profession came from architectural, interior design, or graphic design backgrounds. Although some overseas-trained industrial designers came to New Zealand as part of the immigration waves of the 1950s, most were self-taught (Simpson, 1962).

Aside from the fact that the above mentioned industrial design programme was the first of its kind to be offered in New Zealand, the programme is significant in the context of this study because the subject of ergonomics was incorporated as a fundamental component from the outset. The events surrounding the introduction of this programme and the factors supporting its continued emphasis on ergonomics will be discussed in this section.

The introduction of New Zealand's first qualification in industrial design must be placed in the context of those developments within the country's technical education system which, in the early 1960s, resulted in the transition of technical education from the secondary to the tertiary level. This restructuring led to the formation of new institutions (such as the Central Institute of Technology) and the creation of polytechnics out of the evening classes and the trade-training parts of existing technical colleges in the main centres. As a result of these structural changes and the subsequent shift in focus towards the training of technicians for industry, technical courses were modified and added where the need could be demonstrated. In other words, this was an opportune time to introduce new courses.

While these changes were precipitated by a growing recognition that the structure of technical education needed to be changed to meet the 'world-wide scientific revolution' (Beeby, 1956: 31), mounting pressures for economic change in New Zealand also directly stimulated the reform process. Captured by

the phrase 'industrial development', this new economic direction emphasised a broad-based approach involving the diversification of industrial outputs and 'manufacturing in depth'. The latter concept implied the extension of functions beyond the assembly, mixing and moulding activities that were so characteristic of New Zealand manufacturing at the time (Golledge, 1964) into areas such as product design and development.

Although the ideas underlying 'industrial development' had been forming within the Department of Industries and Commerce (latterly the Department of Trade and Industry, and the Ministry of Commerce), the implementation of 'industrial development' policies gained momentum in 1957 when the second Labour Government came to power. These policies emphasised 'training for industry' and supported the formation of a Council for Technical Education and a Technicians' Certification Authority in 1958. Around this time, New Zealand's first Director of Technical Education was also appointed.

The view that reform in technical education was a prerequisite for industrial development is reflected clearly in the statements made by industrial development's most outspoken advocate, W.B. Sutch. Appointed in 1958 from within the Department of Industries and Commerce as its permanent head, Sutch believed that through the expansion of industry, the New Zealand economy would become more 'balanced', that is, less dominated by the agricultural sector. On the other hand, Sutch (1968: 94) believed that industrial expansion could not proceed without a parallel development of a supportive infrastructure:

> Development involves structural changes in both industry and institutional organisation; changes that will make possible a more balanced and mature economy comprising the skills, techniques and financial facilities necessary to produce more, better and varied goods.

In an address to the Technical Education Association of New Zealand in September 1959, titled 'Education for Industry', Sutch observed that the technical skills required for 'manufacturing in depth' had not been fostered in New Zealand. Sutch noted that in this sector there had been a heavy reliance on the skill, inventiveness and design abilities of the outside world: 'Most of the goods we manufacture derive very directly from the brains and abilities of people abroad. The payment of £1 million a year in royalties is an indication of

this' (Sutch, 1959: 25). As a result of this reliance on overseas technology, there had been little demand for the New Zealand educational system to provide technicians for industry. Sutch (1960: 16) linked this absence of demand to the dearth of technical educational programmes:

> Even New Zealand's excellent school system provides agricultural colleges but no industrial centres, no design schools, no technological institutes ... The lack of insistent demand for technological and research institutes mirrors of course, the lack of balance of the economy.

However, while Sutch was indicating in his public speeches that technical education institutions were lacking in New Zealand, their appearance in the form of a new polytechnic system was, in fact, imminent. Indeed, the Wellington Technical College was already in transition: from 1959, courses were being offered in a Prospectus bearing the name: 'Wellington Technical College Polytechnic'. The period of transition continued until 1962 when the Wellington Polytechnic was established.

The former School of Art of the Wellington Technical College emerged out of this transition period as the School of Design of the Wellington Polytechnic. The Head of this new School was James (Jim) Coe who, in 1959, had accepted the position of Head of the School of Art on the condition that he would be given support for the initiation of a course in industrial design, something which he and fellow members of the Wellington Architectural Centre executive had been pressing for since the early 1950s (Coe, 1981). In 1961, a three year diploma course in Industrial Design was offered for the first time and in 1965 this course was extended to four years.

From the outset, ergonomics was a core subject in the diploma programme. This positioning stemmed from Coe's belief that an industrial designer should be able to ensure that the function and purpose of their designs would be compatible with the requirements of the user. This implied that an emphasis merely on styling and visual appeal was inadequate. The relative importance of the various disciplines in the diploma curriculum is indicated clearly in the following statement by Coe (1967: 91):

> In the training of an industrial designer at the Wellington Polytechnic the study of man himself is the most important of these

> disciplines. Environmental sociology and human engineering are taught under the heading of "ergonomics" (the study of man in his working environment). Closely associated with this subject is "cybernetics" (the study of communication and control of mechanisms in machines and living creatures). This latter subject will become increasingly important as the designer is involved in computer control of production. Aesthetics is not taught as a subject.

Coe developed his own ergonomics modules and continued to teach the subject while also performing his duties as Head of the School. After he retired from this senior position in 1976 he continued to teach ergonomics at the School on a part-time basis until he took up a Fellowship at the RMIT in Melbourne in 1981. During the two decades of his tenure at the Polytechnic, Coe undertook his own research into workstation design, seating, and sedentary postures (see, for example, Coe, 1968). He also was involved in a variety of extension activities which included giving public lectures on ergonomics and industrial design (see Anon, 1965), becoming the longest serving member of the New Zealand Industrial Design Council, and forging a significant link with the Architecture School of Victoria University of Wellington. Coe's position as ergonomics tutor was eventually filled by a former student of his (Leong Yap) who had gone on to pursue advanced studies in ergonomics in England.

Nearly all of the industrial designers associated with the six organisations were graduates of Wellington Polytechnic, and most had also been taught by Coe. While these designers were careful to distance themselves from Coe's ideas, particularly his controversial theories relating to seating design, they were quick to recognise his contribution in relation to ergonomics. As indicated by three industrial designers:

> Jim Coe had a strong impact in that area, in terms of the visibility of ergonomic design. Did a tremendous job, whether you philosophically agree with him is not really the point. A real pioneer that guy.

> You know, Jim Coe was an evangelist, and I think that the older I get the more I appreciate what Jim Coe managed to achieve in New Zealand in terms of ergonomics. Amazing. Whether you agree or

> disagree in detail with what he said or did, he certainly made New Zealand manufacturers and so on aware of ergonomics.
>
> I think Jim Coe had a substantial impact through his students. They have gone out and they are now working with manufacturers and I think that that influence has been substantial. I have spoken to some who have said that "Well, I don't always agree with what Jim taught us, but you have to admit the man was committed and he passed some of that on to us".

In terms of understanding the development of ergonomics capability in the organisations in this study, the events around the time of Coe's appointment are important. It could be argued that without the support that was mounting for industrial design and the changes that were occurring in the education system, Coe may not have been able to introduce the diploma programme, at least at that time. On the other hand, if Coe had not been a part of the picture, industrial design education in New Zealand would probably have taken an altogether different direction.

The latter claim has its basis in the different philosophies which tend to underpin the industrial design curricula adopted by design schools. Some of these philosophies have been described by Crist (1966) in a comprehensive article about design education in the USA. Crist (1966: 364) suggests that while the early programmes in industrial design had a heavy emphasis on visual aspects (as they were offered from within aesthetically-oriented departments), this eventually gave way to a range of curricula shaped to a greater or lesser degree by three main influences: (1) the School (later Institute) of Design in Chicago established by Moholy-Nagy in 1939; (2) the highly personalised and intuitive approach to design espoused by Kostellow which emphasised the designer's 'aesthetic awareness'; and (3) Antonin Heythum's functional approach which borrowed from the Bauhaus but also placed emphasis on human factors in design.

Although the philosophical approach adopted by Coe would come closest to that espoused by Heythum, Coe was more directly influenced by the work of a more contemporary figure who also emphasised human factors in design - Henry Dreyfuss. Since the Second World War, Coe had been monitoring developments in human factors engineering and thus came to learn of Dreyfuss' books

Designing for People (1955) and *The Measure of Man* (1959; 1967) soon after they were published. Thus, when Coe started his ergonomics course at the School of Design in the early 1960s, he incorporated Dreyfuss' charts from *The Measure of Man* into the programme, but only as an adjunct to the study of functional anatomy, physiology and living models using mockups.

In making ergonomics the core subject of the industrial design programme, Coe was able to use his influence as School Head to slant the curriculum in this way. Crist (1966: 361) has observed that this exercise of influence is not unusual:

> In certain [design] schools, a common point of view among the faculty, or the dynamic personality of a particular faculty member, will create a curriculum sharply oriented toward a particular facet of design.

What is significant, however, is that the industrial design programme at Wellington Polytechnic has continued to maintain an emphasis on ergonomics until the present day. This can be attributed in large part to the *length* of Coe's tenure as School Head. This amounted to a total of 17 years. During this time, Coe remained committed to ergonomics and this, combined with an emphasis on an ornament-free Modernist aesthetic, led to the dominant approach espoused at the School being that of 'good design' (see Collins, 1987: 117). By the mid-1970s this 'serious' and somewhat 'clinical' approach to design had become so entrenched in the School that it was able to continue forth, albeit softened somewhat by the challenge of Post-Modern design which emerged as a force during the late 1970s and 1980s.

This continuity of emphasis is reflected in the total content hours given over to ergonomics in the curriculum. When Coe retired from his position of School Head in 1976, ergonomics represented 9% of the total contact time in the Diploma in Industrial Design course. By comparison, in 1991, the estimated timetabled hours formally allocated to the teaching of ergonomics for the course was 10 percent of total (Yap, 1991). Both these figures exclude the ergonomics content covered in other timetabled subjects and in project work, which could bring the actual ergonomics content of the programme up to 25-35 percent (Yap, 1991).

When the ergonomics content of Wellington Polytechnic is set against that of Australian design schools, the Polytechnic's programme ranks very highly.

Ward (1990) found that of the ten institutions in Australia providing courses in industrial design that met the requirement for Design Institute of Australia accreditation, ergonomics subjects made up from 0 to 9.5 percent of the total contact time. The average was around 4.5 percent. A similar comparison within New Zealand is not meaningful as, at least until recently, Wellington Polytechnic is the only institution in New Zealand to have offered a qualification in the subject. Despite an early interest in the subject, none of the universities ever introduced a programme that would lead to a qualification (see Saunders, 1965). In recent years, Carrington Polytechnic has offered a Diploma in Design (with concentrations in furniture, interior, or product design). The latter Diploma has yet to match the standard of the programme offered by the Wellington Polytechnic which, since 1966, has been recognised internationally as equivalent to a first degree level qualification. Graduates of the programme have gone on to study Masters degrees at Loughborough University and at the Royal College of Art.

Given New Zealand's small population and the lack of employment scope for graduates in a local manufacturing industry which has relied heavily on imitative design strategies, it is almost inevitable that few programmes in industrial design have emerged. This, in turn, has led to an unusual situation in that a single educational institution with a strong 'ergonomics pedigree' has totally dominated industrial design education at a national level. Furthermore, it has resulted in the presence in New Zealand of a relatively *homogeneous* group of practicing industrial designers, most of whom have been exposed to ergonomics as part of their training.

In concluding this section, it must be noted that the role of the Wellington Polytechnic in the knowledge environment of individual firms extends beyond the mere training of young graduates. In the present study, various linkages between organisations and the Polytechnic are evident, all of which allowed for the ongoing exchange of information. On the one hand, some of the consultant industrial designers were also part-time tutors at the Polytechnic. Consequently, if they required specialist ergonomics knowledge, this could easily be obtained by seeking the advice of colleagues tutoring in this subject area. On the other hand, organisations provided the Polytechnic with a source of part-time tutors, invited speakers, and external examiners, as well as a source of realistic design problems. For example, both Bill Mackie and Brian Carter of Formway, and PEC's consultant industrial designer Mark Ryan have all been involved by the

Polytechnic in at least one of these ways. In return, by offering realistic problems for students to work on, the contributing organisations were provided with solutions and ideas often at limited cost. This can be seen in the case of Feltex Furniture which, in the early 1980s, approached the Polytechnic regarding the design of an adjustable office chair.

From the foregoing discussion of the training of industrial design students at the Wellington Polytechnic, the attention now shifts to another *government-funded* institution, the New Zealand Industrial Design Council. These two institutions were closely related. Not only did they share similar goals, they were also linked through the common presence of James Coe in senior positions in both organisations. These areas of overlap help to explain why the New Zealand Industrial Design Council was able to encourage the emergence of ergonomics capability in some of the six organisations.

The New Zealand Industrial Design Council

The New Zealand Industrial Design Council (NZIDC) facilitated the emergence of ergonomics capability in at least three of the six organisations in this study. This link is most evident in the case of PEC. According to a senior manager, NZIDC staff came out to the premises of this company, which is located in a small rural town, and 'knocked on our door'. Subsequently, in December 1969, several PEC managers and design engineers attended one of NZIDC's first public seminars and as a direct result of this 'initial exposure' to industrial design, PEC went on to employ its first industrial designer on the basis of names supplied by NZIDC's Designer Service. Years later, in the early 1980s, this same service was also the means by which Fuelquip and Formway were able to identify and recruit their first industrial design consultants. On both these occasions, however, the initiative to contact the NZIDC came *from* the company as, by this time, there was a general awareness among New Zealand manufacturers of industrial design as a distinct activity. This general awareness, however, along with the increased recognition of industrial designers as a legitimate professional group, had been greatly bolstered during the 1970s and early 1980s by the presence and high profile of the NZIDC.

The NZIDC was established in the late 1960s, some ten years after the formation of the Industrial Design Council of Australia, and twenty-five years after the

Council of Industrial Design in Britain. These large time differences may be attributed in part to the initial lack of an organised push for the formation of such an agency (Fairburn, 1949; Parsons, 1965). In 1959, this situation was to change.

In the late 1950s, a growing appreciation of the link between industrial design and industrial development policies was evident within the Department of Industries and Commerce (IC). Staff from within this department had come to learn that an Industrial Design Council of Australia had been established in October 1957, and in May 1959, at the personal direction of Sutch (the Department's permanent head), 'all possible details' relating to the Australian Council were requested via the Senior Trade Commissioner based in Australia. There followed an intense period of activity during which time ideas about industrial design were formulated within IC. Thus, by July 1959, an IC official had prepared a brief report on 'Industrial Design in Development' which suggested, amongst other things, that 'the stage has now been reached when the products of NZ industry should be given the stimulus of systematic research into industrial design'. Then, at a public address in September 1959, Sutch (1959: 21) stated publicly that 'we need an institute of industrial design'.

IC officials were to learn that simultaneously and independently two other parties had also sought information about the Australian Council. These were the newly established Auckland-based New Zealand Society of Industrial Designers (NZSID, formed May 1959) and a group of individuals in Christchurch who, in December 1959, formed the Design Association of New Zealand (DANZ) (Anon, 1962). Unlike NZSID, the latter organisation offered membership to anyone who had an 'interest in design', and had as one its main objectives the formation of an industrial design council.

While both DANZ and NZSID proceeded to lobby for a design council, Sutch echoed his earlier call at the Industrial Development Conference in June 1960 (Proctor, 1963; Anon, 1974). Attended by the main economic and administrative groups in New Zealand society, the conference's recommendations highlighted a need to provide industry with the same financial, technical, advisory and administrative support as existed for agriculture. The recommendations also called for the establishment of an industrial design council. Following the conference, Sutch continued to promote industrial design by writing about this topic (Sutch, 1961; 1962). He also established a new

position of Industrial Design Officer within IC. Although the primary function of this position would be 'to assist in the establishment of an industrial design council' it would, however, still be another eight years before a council would emerge as an active organisation as several forces were to mitigate against this including a change in government (Sutch, 1966: 430), and the lack of consensus among design groups concerning the structure and funding of the proposed Council (DANZ, 1962; Underwood, 1965: 8-9).

When the Industrial Design Act 1966 finally came into force in November 1967, Council members were appointed to oversee the introduction of a range of services. A Design Index and the Designer Recommendation Service were created so as to 'provide direct and practical advice and encouragement to manufacturers'. At the same time, in order to 'promote the widespread understanding of good design throughout the community' (Proctor, 1968: 25), a membership scheme, a seminar programme, and a high profile magazine (*Designscape*) were introduced. Of these services, the seminar programme was the first to get off the ground: NZIDC's first seminar was held in early 1968 in Wellington.

One of the sessions at this one day event was presented by James Coe who had been appointed as a foundation Council member of the NZIDC. At this, and future seminars, organised by the NZIDC, Coe took the opportunity to speak about ergonomics as a fundamental aspect of industrial design (see Coe, 1968). Furthermore, through his position on the Council, Coe was able to ensure that ergonomics was given attention in other activities of the NZIDC. In particular, ergonomics was one of the criteria assessed in the Design Index scheme, which allowed those manufacturers whose products were included in the Index to use the NZIDC's Designmark in advertising and on approved products at their point of sale. The inclusion of ergonomics is noted in the following description of Design Index criteria in *Designscape* (No. 1, February 1969):

> Products submitted for inclusion will be evaluated by expert selection committees who will consider function, ergonomics, inventiveness of approach, standard of manufacture, economy of production, appearance and sales appeal.

Although the Design Index/Designmark scheme was to be revised on several occasions in the years that followed, ergonomics continued to be a criterion in

the evaluation process. Although, from an early stage, professional designers were to criticise NZIDC for not setting high standards (see Anon, 1972), the panels did provide some degree of feedback to New Zealand manufacturers with respect to ergonomic criteria. The rigour and detail of ergonomic criticism, however, will have varied according to the composition of the panel as well as their expectations of the competence of applicants. The latter is clearly evident in respect of the experience of Formway, whose Designmark applications for both the Cambio chair and the Ergostation were initially rejected. Sitting on the panels which respectively assessed these two products were Coe, and Yap. On both occasions, these panel members were critical of the ergonomic aspects of the Formway designs. As Chalmers recalls of the Ergostation application:

> When we applied for Designmark for the workstation, the Ergostation, we had Leong [Yap] on the assessment panel. And Leong said "It's all very well", but cited a few examples of opposing viewpoints [relating to sitting postures at computer workstations], which made us run like startled rabbits and head off for all the books and publications we could find, trying to figure out what Leong was talking about.

This challenge was experienced positively by Ian Chalmers:

> It was very positive. And that was really quite interesting. That taught me quite a lot. You know, I can't say that everything I came up with at the time was right, but it taught me a hell of a lot.

When asked if he considered that Formway had been singled out for special treatment, Chalmers replied:

> I don't think he [Yap] picked on us unfairly, but I don't think he would necessarily do it for other companies. Because if you said those things to other companies I think most people would have gone: "Huh"?

To some extent, it appears that the level of criticism was mediated by the expectations that panel members such as Yap and Coe had of the company and, more importantly, the design skills of their former students.

This story also demonstrates that the Designmark evaluation had a small but direct and beneficial effect on the development of ergonomics capability at Formway. This finding can be set against a series of case studies which have been cited in support of a claim that the Design Award assessment procedures of the Australian Design Council have been able to bring about product improvements and redevelopment with a greater emphasis on ergonomics (Harris, 1990). Harris does concede, however, that product assessments tend to encourage the application of ergonomics at a rather late stage in the development process when change is very costly. As a result, ergonomics (and industrial design) may become linked with expense and delays and this unfortunate association may in turn limit the development of ergonomics capability. This, according to an experienced New Zealand industrial designer, was also a major problem with the NZIDC's Designmark scheme:

> The first introduction that many clients had to a professional designer was when they failed their Designmark. It [the product] had been frog-marched off to a designer to make it all better and what the designer gets presented with is a finished product all tooled up, packaging printed, all ready to hit the marketplace, saying "Can you please improve this product for us?" ... and you kept on finding that professional designers worth their salt would refuse to sit on any more bloody [evaluation] panels because they were so flawed in the whole concept of what they were doing.

By the early 1980s, more and more industrial designers were becoming disenchanted with the practices of the NZIDC. Although this organisation had initially created a sense of identity for their young profession, industrial designers felt that the NZIDC had progressively lost much of its initial 'vitality' and 'optimism' (as is reflected in the early issues of *Designscape*). In their view, NZIDC was becoming too narrow in focus. In part, this was attributable to a succession of staff changes within NZIDC which had resulted in a predominance of engineers. These engineers were primarily interested in product design, design engineering and quality assurance. At the same time, the representation of professional industrial designers and design educators on the Council had decreased: by 1983 James Coe had resigned and there was only one industrial designer still serving on the Council. The associated shift in culture, along with incessant Treasury pressure on the organisation to become less reliant on government funding, resulted in a gradual change in the NZIDC's role and

definition of its customer base. Rather than try to instill a level of design-awareness in the public at large, the NZIDC had identified its primary customer group as consisting of (fee-paying) manufacturers. Although it never would manage to generate enough funds from these manufacturer 'customers' to fully support its activities, the NZIDC did continue to maintain a relatively high profile among this group. This profile was largely due to the prestigious Prince Philip Design Award competition which the NZIDC organised on an annual basis between 1981 and 1987.

The NZIDC ceased to exist as a separate entity in April 1988, when its functions were brought under those of the Testing Laboratory Registration Council (TELARC). Just as the birth of the NZIDC can be related to the economic and political priorities of the late 1950s and 1960s, so too can its eventual demise be located with the context of a broader deregulatory trend which saw many other New Zealand quangos disappear during the 1980s. Regardless of the question as to whether such an organisation should still exist today, the link between the NZIDC and the six organisations in this study is clearly evident. In at least three of the cases, NZIDC was instrumental in enabling the employment of industrial designers. This practice then led directly to the emergence of ergonomics capability. It is likely, given the NZIDC's high profile, that more New Zealand manufacturers will have been influenced in a similar way.

The impact of standards

In the present study, published standards had a facilitating effect on the development of ergonomics capability, although this was only clearly evident in the cases of the two office seating manufacturers. That the effect of standards is greater in some sub-sectors than in others can generally be attributed to the presence or absence of relevant standards which deal directly with ergonomic issues. The presence of these standards is, in turn, dependent on a range of factors including the potential impact of the product on human performance, and health and safety. Thus, because office seating is a widely used piece of equipment which, if poorly designed, can lead to considerable discomfort and loss of performance, it has attracted much attention from ergonomists. Indeed, some of the early work on the ergonomics of seating was produced as a standard: BS 3044 (see Floyd and Roberts, 1958). By comparison, standards that deal with the ergonomics of kitchen appliances only specify their overall

dimensions, while for petrol pumps, such standards do not exist at all although designers can make use of standards that relate to the design of controls and displays (see Pheasant, 1987).

From an analysis of the Formway and Feltex Furniture cases it would appear that published standards impact on the development of ergonomics capability in a number of ways. Firstly, the introduction of new standards or guidelines may force the organisation to respond by acquiring more ergonomics expertise. This is particularly the case where powerful customers use these documents to inform their purchase decisions. Secondly, during periods of slack, achieving compliance with a standard may be used by an organisation as a target or opportunity. In the process of reaching this target further learning may occur. For instance, while Formway had earlier used British seating standards as a design reference, DIN 4551 was purposively adopted in the 1980s as part of an effort to lift the company's overall level of design performance. As Brian Carter explained:

> Upon evaluating the two major standards in this field, the British standard and the German DIN standard, we decided to work with the DIN standard which at that stage was in the process of upgrade ... the Germans seemed to have a higher performance requirement than the British at that time, especially for gas-spring type chairs.

While standards may promote the development of ergonomics capability, they may also lead only to a superficial level of learning, in that as long as the provisions are followed the designer does not need to understand the underlying issues. In the case of Feltex Furniture, it is evident that this company has learnt to follow standards fairly closely. This approach enables the organisation to design acceptable products without having to go through the process of evaluating potentially contradictory ergonomic evidence. It also minimises the risk associated with taking a position that might deviate markedly from the standard. By contrast, Formway's design team has tended towards a higher degree of engagement with standards and guideline documents in that these are evaluated, compared, interpreted, and - as in the case of the Australian standard (AS 3590) - critiqued. An outcome of this critical process has been the development of Formway's own 'standard' (as expressed in a 1987 in-house document called *SEATING performance and dimensional guidelines*) and other explanatory documents including a booklet titled *Ergonomics rationale: Zaf*

Task and Strategy chairs which in 1990 was distributed to the company's sales agents.

As the owners and design team members of Formway learned more about ergonomics, they were increasingly able to see the errors and inconsistencies in those guideline documents which had been published at intervals during the 1980s by unions and government agencies including the New Zealand Departments of Health and Labour. Consequently, when the opportunity arose for local manufacturers to become involved in a working party coordinated by the New Zealand Department of Health to develop a *Seating for Office Workers* guideline, Mark Carter from Formway was keen to work together with the team to 'help repair and build on some of the mistakes and things in some of those other publications'. Also represented on the working party were unions, employer groups, government agencies and two other local manufacturers: Precision Engineering and Feltex Furniture. However, compared to these groups, Formway had a 'fairly substantial' involvement in the preparation of the guideline. For instance, the checklist incorporated in the final document was based on a questionnaire developed initially within the company. Formway's tactics earned the respect of CoDesign-NZ's national marketing manager:

> They [Formway] marketed well, you know all credit to them, they picked on it beautifully - the government specs were effectively written [by them], they wrote them effectively. They did a lot of research on it.

Despite the fact that its competitor had had a definite influence on this document, Feltex Furniture (and CoDesign-NZ) proceeded to support it. Indeed, guidelines such as this were an inexpensive means of linking Feltex Furniture with ergonomic design. In one instance, Feltex Furniture sales representatives handed out copies of a guideline document which had been overprinted with 'promotional stuff' to their clients.

This technique of legitimating products by incorporating references to the ergonomics literature is a ploy commonly used by office furniture manufacturers. However, it was a practice that the management of Formway, given the company's role of industry 'expert', disapproved of and wished to control. Thus, when a local distributor of office furniture reproduced the 'Joe and Josephine' anthropometric charts from Dreyfuss' *The Measure of Man*

(1959) on their product brochures, a letter was sent from Formway to the importer highlighting an apparent breach of copyright.

As their involvement with *Seating for Office Workers* continued, Formway also established contact with the person co-ordinating the revised *Code of practice for visual display units* for the New Zealand Department of Labour (1988). As with most of Formway's relationships with external contacts, this too had a reciprocal effect: 'we gave her some assistance and she gave some to us and that was good'.

Professional networks

The final theme to be considered in this chapter is the role of professional networks and their influence on the ergonomics capability of the six companies. These networks comprise individuals who are personally knowledgeable and/or interested in the subject of ergonomics. These networks not only form part of the wider knowledge environment but they also, in some cases, extend into those companies which have members who are themselves part of the network. Under the latter conditions, personal contacts between members of the organisation and the wider environment may become an important conduit for the transfer of knowledge which, in turn, may trigger innovative activity (see Drazin, 1990).

From the six cases, it appears that where industrial designers required specialist advice on specific ergonomic matters they made use of their network of industrial design colleagues and their links to their *Alma Mater*. For instance, when both Mark Ryan (PEC) and John Crozier (Fuelquip) felt a need for assistance with an ergonomic problem, they contacted an industrial design colleague (Leong Yap), who was also a qualified ergonomist and ergonomics tutor at the Wellington Polytechnic. These designers were satisfied with the quality of the advice that they obtained and saw no need to search much further. Moreover, if another problem arose they would tend to just repeat this practice. As one the designers recalled:

> Leong [Yap] would be my first port of call for an ergonomist. I would see no need to go beyond him, unless someone came in with a very very particular strength in some area that I was working in. And Leong would have to recommend them, him or her.

While Ryan and Crozier have either used their own resources or their colleagial networks to obtain the ergonomic inputs they require, these avenues have until recently been the only real options available to them. In particular, until the New Zealand Ergonomics Society (NZES) was established in February 1986, there had been no active local network specialising in ergonomics that New Zealand industrial designers could belong to, or call upon for assistance. This situation had persisted in spite of the existence, since 1966, of the Ergonomics Society of Australia and New Zealand (ESANZ) (see Sell, 1969; Howie *et al.*, 1988). This Society had failed to encourage the formation of an effective local network between the very small group of ergonomists working in New Zealand and other individuals interested in ergonomics including industrial designers. In the absence of a formalised and locally-based organisation, these individuals had few, if any, links with each other.

Unlike already existing ergonomics societies which tended to be demarcated along national boundaries, ESANZ was different in that it embraced a region consisting of two separate countries. Yet, while New Zealand appeared to be represented in the international ergonomics community, in reality ESANZ remained almost exclusively an Australian organisation. Thus, while ESANZ eventually established branches in all Australian states except Tasmania, no branch was ever established in New Zealand. More significantly, in 1986, out of a total membership of 600, only 4 members lived in New Zealand (*Ergonomics Australasia*, February 1986). By comparison, NZES attracted a membership of 73 within its first year (*Ergonomics New Zealand*, June 1990). The apparent 'growth' was assisted by NZES's local focus and its more open membership criteria.

None of the organisations in this study were in any way associated with ESANZ and the tendency for links to be established with the professional network provided from 1986 onwards by the NZES varied across the six organisations. Apart from Ian Chalmers of Formway, none of the industrial designers employed by the six companies were at any stage associated with NZES. From this it may be concluded that the formation of NZES generally had little immediate impact on their use of information channels and personal networks. By contrast, at RDD, two members within this organisation (i.e. Karen Fraser and Angela Roberts) became members of NZES in 1988. They were later joined by RDD's product engineering manager Noel Anderson.

Neither Fuelquip, PEC, nor Atlas were ever associated with NZES either indirectly through employees or consultants, or more directly at a corporate level. On the other hand, both the office furniture manufacturers, Formway and Feltex Furniture, became corporate members of NZES when this society was established in 1986. Such a move made sense as, around this time, ergonomic design had become a major issue for both of these manufacturers. From mid-1985 onwards the attention given to repetitive strain injury had stimulated a demand for 'ergonomically designed' office furniture and both Formway and Feltex Furniture were promoting their products under this banner fairly heavily. It was, as a result, in the public relations interest of these two companies to be seen to be supportive of a new local professional network that was setting out to promote ergonomics.

In the case of Formway, however, the formation of NZES merely served to organise a part of the network of physiotherapists, ergonomists and designers that this company had been cultivating since 1982. Soon after they had acquired the company in the early 1980s, the owners of Formway (Mark Carter and Peter Stevens) recognised the value of using an 'open approach' which involved extensive external networking. In particular, the owners came to realise that if they responded to the needs of specialists, these individuals would in turn support the company by recommending the purchase of Formway products. However, a story told by a Formway sales representative indicates that the support of these external specialists was by no means automatic. He recalled that when it was learned that a well-known ergonomist was being openly critical of one of the company's products, senior Formway personnel made a special effort to meet with this individual to discuss his concerns.

In spite of some obvious benefits, the case of Formway also shows that maintaining an 'ergonomics network' is not without risk and cost. Firstly, Formway has had to continue to invest in its ergonomics capability in order to maintain its 'ergonomics credibility'. In a sense, Formway has become 'locked into' its high ergonomics profile in that if it were to lower this substantially, it could risk losing the support of its network. Secondly, the company must also be seen to apply ergonomics in its production area, as Formway's research director explained:

> We have an open door policy to people being able to see through our factory ... and a lot of those people are people who are sensitive

> to the claims that we have made and to the strengths that we have been promoting in the marketplace and it would be totally inappropriate if the emphasis in our own production area was entirely different to that.

While an ergonomics capability was already developing within Formway before the advent of the NZES, the impact of this society's network did impact more directly on events at RDD in 1987. According to Roberts, RDD's industrial engineer, the society had a 'very big impact' on her own understanding of ergonomics and on her work at RDD. Her involvement with a local branch of NZES put Roberts into contact with other people interested in the subject who could provide her with information to supplement the channels she was already using including F&P's library service. Roberts also used her contacts with the Society to find ergonomists who were interested to run a series of in-house ergonomics training sessions at RDD in 1990. These external contacts not only provided Roberts with support on a personal level, it could be argued that they also helped her to establish the legitimacy of her ergonomic initiatives within the company.

The involvement of RDD and Formway personnel in external ergonomics networks contrasts with the relative insularity of Feltex Furniture (latterly CoDesign-NZ). Even though this organisation was, for a time, a corporate member of the NZES, its association with the society was relatively weak. To some extent this can be attributed to the ambivalence that was felt by key organisation members towards ergonomics and ergonomists. For instance, despite the fact that in 1990 the company was still promoting its office furniture products as being of ergonomic design, Gardiner was critical of ergonomists and the uncertainty that they had created. He considered that 'ergonomists were 'holding a rod for their own backs':

> I think ergonomists have lost face over this, because they are always coming up with new theories that don't relate to old theories, and they are always arguing with each other.

Although Gardiner's responses were triggered in particular by his negative experiences in relation to the promotion of the Ergotec range (see Chapter 5), his avoidance of specialists was nonetheless consistent with past practice in the company. Feltex Furniture had never cultivated an extensive network of

external contacts in the design area. Aside from the company's brief encounter with the Wellington Polytechnic in the early 1980s, Gardiner could only recall the company working with one specialist - a controversial physiotherapist - who in the mid-1980s provided advice on the shape of lumbar supports.

Summary

This chapter has identified a set of external events which are important historical antecedents of the emergence of product-related ergonomics capability in the six cases. These events took place within a relatively short period of time toward the end of the 1950s and included the formation of the Industrial Design Council of Australia in 1957, the formation of NZSID and DANZ in 1959, the 'industrial development' thrust of the Department of Industries and Commerce and the second Labour Government (1957-1960), the creation of the polytechnic system, and the appointment of James Coe as Head of the School of Art of the Wellington Technical College Polytechnic in 1959. The role of James Coe, in particular, shows that external influences may not always be of the impersonal, structural, type. Had Coe, for example, not been employed as Head of the School of Design in 1959, then the experience of the organisations in this study in terms of ergonomics capability might have been quite different. This study demonstrates that innovation processes may be shaped by the actions of key individuals external to the organisation.

Guided by a simple model of the external environment, this chapter has also described how exogenous influences such as sub-sector composition, standards and professional networks combined to both constrain and encourage the development of ergonomics capability once it had emerged within the six organisations. At the same time, however, it is also evident that the ergonomics understanding of some organisation members was such that they were able to act on the outer context to make this more receptive. This ability is reflected, in particular, at Formway where owners and design team members contributed to the development of standards and gave seminars as a means of 'educating' their customers in the basics of ergonomic principles.

Finally, the pervasive influence of government is highlighted in this chapter. Government policies, through their ability to shape the structural characteristics of sectors and features of the knowledge environment, impacted substantially on

the growth of ergonomics capability within the cases in this study. This finding contrasts with the lack of reference to government policy in the 'mainstream' literature on organisational innovation in organisations (see Zaltman *et al.*, 1973; and King, 1990).

Chapter Eight

Conclusion

Introduction

The analysis in the previous chapters has provided insights into the processes by which ergonomics capability emerged and developed in the product development function of six New Zealand manufacturing organisations. In addition, the role and significance of various contextual factors has been examined. While the insights may not be immediately generalisable to other organisations, they allow for the statement of propositions which, upon further investigation, may be found to have broader application.

In this chapter, the major concepts and themes used to interpret the empirical data have been brought together in a framework which focuses on the emergence and development of ergonomics capability. The major relationships in this framework will be explained briefly and, where appropriate, propositions will be advanced. In addition to this theoretical exposition, the chapter will also discuss the overall significance of the findings and highlight the implications of this study for further research and ergonomic practice.

A study of process and context

The previous four chapters have provided a detailed analysis of the emergence and development of ergonomics capability in product design and development. The analysis centred on events which occurred over time in six manufacturing organisations in three different sub-sectors. The organisations included two petrol pump manufacturers (PEC and Fuelquip), two electric range manufacturers (RDD and Atlas), and two office seating manufacturers (Formway and Feltex Furniture).

In developing and analysing the six cases, a principal aim was to build further on the position adopted by researchers such as Perrow (1983) and Liker *et al.* (1984). This position was discussed at some length in Chapter 2 and is based on the argument that organisation-level factors may impact significantly on the use of ergonomics knowledge. This particular argument departed from earlier research efforts (e.g. Meister, 1971) which had attributed the limited application of human factors in systems design to the problematic relationship between human factors engineers and design engineers. Perrow (1983) considered that while the attitudes and work practices of design engineers did play a role, the impact of the social structure in which the two professional groups were situated was a more powerful force. Particular aspects of the social structure which Perrow discussed were top management goals and perspectives, the reward structure of the organisation, the insulation of design engineers from the consequence of their decision, and some aspects of organisational culture. Liker *et al.* (1984) considered that ergonomic practice was impeded by factors such as poor interdepartmental communication, organisational politics, and unfavourable perceptions of costs versus benefits.

While this argument was to provide a point of departure for this study, the focus on organisation-level factors has been extended to include contextual factors that lie beyond an organisation's boundary. These factors include aspects of the wider economic and knowledge environment in which individual firms operate. By focusing on these external factors as well as on the organisation's inner context, a comprehensive contextual analysis of ergonomics capability has been attempted. At the same time, by constructing retrospective case histories, the research has tried to locate the varied contextual forces within a longer time frame that extends over periods of up to thirty years. By focusing on these longer time spans, it has been possible to describe the processes which underlie

changes in an organisation's use of ergonomics knowledge. By examining processes (rather than identifying key variables by way of cross-sectional survey methods), this study has shown that ergonomics capability emerged largely unintentionally and then continued to develop to varying degrees in each of the six organisations. This study has also shown that the interpretation of these processes may be assisted by employing analytical concepts from the literature on organisational learning and innovation in organisations.

Through its use of a broad contextual approach and a focus on processes over time, this study shows another way forward for the investigation of ergonomic practice in organisational settings. It is suggested that new theoretical insights may be offered by using the comparative case study method, particularly where this is combined with a longitudinal focus.

Finally, this research provides insights into the practice of ergonomics in New Zealand manufacturing organisations. Given that no other major research exercise has systematically described or analysed ergonomic practice in this particular national context, the findings of this study represent an important contribution to the study of ergonomics in New Zealand. Furthermore, by providing a basis for comparison with research undertaken in other countries, the findings may also contribute to a more general, cross-national understanding of ergonomic practice.

Ergonomics capability in product design and development: A process framework

The major themes to emerge from the present study relate to staffing routines, the orientation of top management, organisational configuration and history, and aspects of the external environment. The major interactions between these elements are indicated in the framework below.

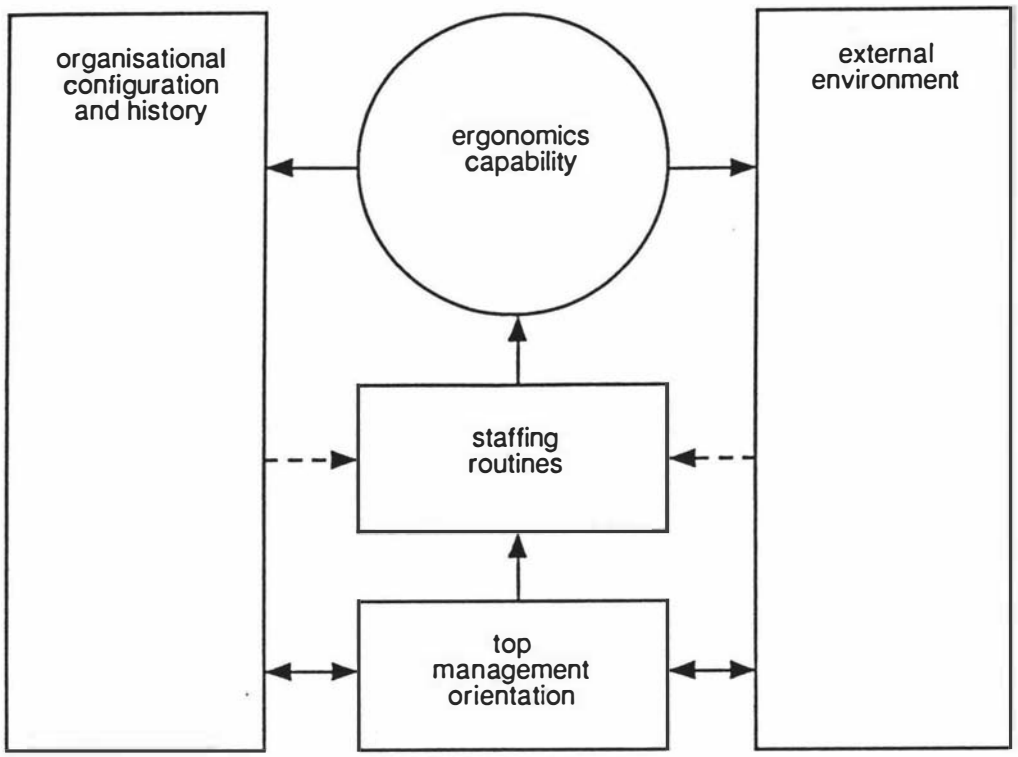

Figure 8.1 Ergonomics capability in product design and development: A process framework

The cornerstone of the framework is the concept of ergonomics capability. As was discussed in Chapter 6, this concept came to be used and defined as a means of more fully capturing the emphasis of this study on process and change. In particular, phrases which have been extensively used in the literature such as 'the adoption and utilisation of ergonomics knowledge' were considered to be too limiting. They reflect a viewpoint of knowledge acquisition and use that is mechanistic and overly consumptive in emphasis. Instead, phrases such as 'emergence and development of ergonomics capability' which make use of the language of process or 'language systems of becoming' (see Pettigrew, 1985: 36) were deemed to be more suitable.

The concept of ergonomics capability has a broader meaning than that which is given to ergonomics knowledge. The latter term tends to be used to refer to the formal and systematic body of knowledge that is found within the published literature. Ergonomics capability, on the other hand, embraces additional forms of knowledge such as perspective knowledge, and the practical knowledge generated and accumulated by individuals in the process of designing. In the search for an improved understanding of ergonomic practice, the latter forms of knowledge should not be overlooked.

The main relationships between elements in the framework will be summarised and a total of twelve propositions will be advanced.

Ergonomics capability and staffing routines

This study found a close link between the emergence of ergonomics capability in an organisation's product development function and the employment of an industrial designer for the first time. For the organisations concerned, this first-time practice of employing an industrial designer usually represented a significant departure from the type of recruitment routines that had been used in the past. For instance, new patterns of search activity were used to identify suitable designers. These patterns involved establishing contact with a high profile intermediary, the New Zealand Industrial Design Council.

The initial emergence of ergonomics capability was an *unintentional outcome* of using this new recruitment routine. In other words, ergonomics capability was not purposively 'adopted' as part of some preplanned effort to acquire skills in this specific disciplinary area. Rather, a degree of ergonomics capability was introduced through the employment of industrial designers who subsequently applied ergonomics in their work as a matter of routine.

The link between industrial design and ergonomics often came as something of a surprise for design team members who found themselves working alongside industrial designers for the first time. Given their lack of familiarity with the work practices of industrial designers, design team members had tended to assume initially that the professional role of industrial designers was to improve the visual appearance of the exterior of the company's products. In making this assumption, design team members were influenced by role stereotypes which

tend to associate the industrial design profession with artistic and creative individuals who focus on visual appearance and styling. This role perception is understandable in so far as an emphasis on visual aesthetics is a common denominator linking all industrial designers, despite considerable differences in their backgrounds and their personal approaches to design.

While all industrial designers will give emphasis to visual appearance, some will attend to ergonomic considerations more so than will others. In other words, the link between industrial design practice and ergonomics is not self-evident. Indeed, the strength of this link depends on several interrelated factors. Firstly, the designer's exposure to ergonomics during their formal training appears to have a lasting effect on their approach to design. During the three or four years of their training, industrial design students will usually be exposed to different design philosophies and their experiences in this respect will help shape their own orientation towards design practice. This personal orientation, in turn, governs the attention that individual industrial designers will give to ergonomic considerations. This attention is also influenced by the attraction that the subject of ergonomics holds at a personal level for the industrial designer.

These factors may help explain why, in this study, ergonomics capability was so consistently linked to the recruitment of industrial designers. With only one exception, all of the industrial designers directly associated with the six cases had been trained at the same design school which, as a result of the educational philosophies of its head, had during the 1960s and 1970s placed a very high degree of emphasis on ergonomics in its industrial design programme. This exposure to ergonomics has given many New Zealand industrial designers a fundamental appreciation of the subject.

This study also shows that where individual industrial designers are strongly interested in ergonomics and find themselves in particularly receptive organisational settings, they may come to be recognised by their colleagues as an ergonomics advocate. However, it would appear that such a role may be untenable for industrial designers, except perhaps in those situations where an organisation has more than one industrial designer. If an industrial designer is seen to emphasise ergonomics at the expense of other considerations, this may be interpreted by top managers as a 'lack of balance' (see Chapter 6). As a group, industrial designers were also generally sensitive to this aspect. While they considered that ergonomics was an integral aspect of industrial design, they believed it should nevertheless only be a part.

Where industrial designers explicitly applied ergonomics as a matter of course in the design process, this approach was generally accepted by other design team members. In one organisation, an ergonomic approach brought about a major shift towards a concern for the end-user, while in other instances an ergonomic approach was at least tolerated because this was consistent with the customer orientation and the marketing philosophies that were being espoused by top management. By the mid-1980s, all of the companies in this study had announced officially that they subscribed to the latter way of doing business.

Over time, ergonomics capability would continue to develop as industrial designers learned more about the ergonomics of particular products, and design team members learned about ergonomics from working alongside an industrial designer. The extent of learning undergone by industrial designers was influenced by factors such as their own interest in the subject, and the extent to which employing organisations allowed for design research and experimentation. Learning by individuals other than the industrial designer was enhanced by factors such as a personal interest to know more about the subject, a low degree of specialisation in design teams, and an ability to see how ergonomic design fitted into a wider picture. However, even where some design team members learnt a great deal about ergonomics, industrial designers usually remained the main source of expertise in this subject. For this reason, the ongoing development of ergonomics capability was still largely dependent on the continued employment of industrial designers over successive projects.

Under certain conditions, ergonomics knowledge was transferred from the product development function and 'absorbed' into other areas of the organisation such as marketing and operations. Transference of capability was encouraged where the level of interaction between industrial design consultants and personnel from other functional areas was relatively high. The level of this interaction is influenced by a range of factors including the decision to use in-house industrial designers versus consultants, the extent to which cross-functional team structures are used, and the presence of social and physical barriers which tend to segment the organisation. Transference was also influenced by the extent to which other individuals, particularly top managers, were interested in the subject of ergonomics. This interest was not merely the result of a personal predisposition, but it also reflected the ability of these individuals to see how ergonomics could be utilised in areas in the business

other than product design. This lateral thinking was enhanced where top management had acquired expertise in different functional areas of the organisation. For instance at Formway, the ergonomics knowledge acquired in product development was subsequently applied by top managers to the design of Kanban trolleys which reduced the need for excessive manual handling in the company's manufacturing operations.

This summary leads to the following propositions:

> *Proposition 1: Ergonomics capability will emerge initially in the product development function through new staffing routines involving industrial designers. The strength of this relationship depends on the extent to which industrial designers have received substantial prior training in ergonomics and hold to design philosophies which support or advocate ergonomic design.*

> *Proposition 2: The degree to which ergonomics capability will be transferred from the product development function to other areas of the organisation will depend partly on the degree to which industrial designers refer explicitly to ergonomics in their design work.*

Staffing routines and top management orientation

In the organisations in this study, top managers were very much involved in events surrounding the recruitment, and ongoing employment, of industrial designers. Not only did top management assume overall responsibility for major design initiatives undertaken in the organisation, it was also usual for at least one top manager to lead the organisation's design team(s). In the latter role, top managers would tend to become actively engaged in detailed design and development work. This 'hands-on' involvement of top managers was particularly evident where the total number of people employed in the design and development function was small, i.e. less than ten. Under these conditions of small size, the design and development function tends to be characterised by relatively low task specialisation and few hierarchical levels.

Top managers, as leaders of design teams, were key initiators of the decision processes which led ultimately to the recruitment of industrial designers. By

participating directly in design team activities it appears that top managers became more acutely knowledgeable of the design skills available within the organisation. From this position, top managers were able to determine whether the available skills would be sufficient to achieve the required level of product quality.

In Chapter 7 it was argued that a low level of design skills is more likely to be deemed to be adequate in those organisations where a goal of high product quality does not feature. This finding reinforces and extends Perrow's observation that top management goals and perspectives are a significant influence by specifying the *type* of goals which support ergonomics capability. This study has argued that if top managers are satisfied with achieving a level of quality that is no higher than that offered by competitors or specified by minimum standards, it is likely that their requirements for specialist research and development expertise will be minimal. Under these conditions, adequate design quality can be achieved through 'low-expertise strategies' such as copying and reverse engineering.

Although management action will be bounded by the configuration of the organisation and the targeted market positioning of products (see Vink, 1990: 258), the interests and preferences of top management may still impact on their use of staffing routines. Where managers become more concerned about the cost of employing an industrial designer than with achieving high product quality, they may tend to overly limit the involvement of industrial designers. Under these restricted conditions, there may be a preference for using consultant industrial designers only during certain stages of the design process. However, if industrial designers are called in after key decisions have already been made they may not be able to effectively apply an ergonomic approach. Similarly, if they are not present during the later stages of design (and even production), industrial designers may find that the ergonomic features they have advocated are compromised or dropped altogether. These staffing decisions will impact on the development of ergonomics capability.

> *Proposition 3: The degree to which ergonomics capability will develop further in the organisation will depend on the extent to which industrial designers (a) continue to be employed on successive projects, and (b) are involved throughout the various phases of the design process.*

Proposition 4: The emergence and development of ergonomics capability in product development will be influenced by the degree to which top managers pursue a goal of high product quality and are supportive of a customer orientation.

Proposition 5: The extent to which ergonomics capability develops in an organisation will be dependent upon the degree to which top managers (a) participate in design team activities and (b) give support to individuals who emerge as ergonomics advocates.

Organisational configuration, top management and staffing routines

While the goals and perspectives of top management may influence the decisions and actions made within an organisation in relation to markets, products and staffing, top management will be constrained by the particular configurations of structure and product strategy previously realised by the organisation. In other words, the choices of top management will be influenced by what has happened in the past. One explanation for this is that, over time, top management goals tend to become embedded in organisations. Top management assist in this 'embedding process' as their decisions in relation to organisation structure, skills, and physical facilities help to give the organisation its shape and character. However, as the organisation acquires its distinctive characteristics, the resulting configuration will also tend to constrain the options that are available to it in the future.

The product strategies of the six organisations in this study showed a high degree of continuity. It was argued that as an organisation's product strategy emerges it may become increasingly difficult to change. Indeed, the difficulties associated with changing from one generic product strategy to another should not be underestimated. Thus, while most of the organisations in this study were periodically shocked into a burst of innovative activity by the action of competitors, major shifts in direction were generally related to changes in ownership which brought new leaders to the fore with goals and values different to those supported in the past. It is significant that in two of the six cases in this study, the emergence of ergonomics capability followed directly from a major change in ownership.

Ergonomics capability emerged at an earlier date in those organisations operated by owner-managers than in those organisations run by professional managers. This study also found a strong relationship between owner-managers and an emphasis on high product quality and product leadership.

Proposition 6: The emergence and development of ergonomics capability is supported where an organisation consistently pursues 'early or first to market' product strategies.

Proposition 7: The product strategy previously realised by an organisation will shape and constrain future decisions relating to staffing routines. As such, the past may impact on the future development of ergonomics capability.

Proposition 8: The practice of employing industrial designers will continue as long as this routine is aligned with the organisation's configuration.

Proposition 9: Ergonomics capability will be stimulated by changes in ownership and leadership only in so far as these bring about a major shift in top management goals and values toward those favouring high product quality.

The external environment, top management and staffing routines

External forces may indirectly influence the emergence and development of ergonomics through their effect on top management actions in relation to product development. In two of the cases in this study, top managers were to come to believe, as a result of unsolicited encounters with external agencies, that the quality of their products could be improved by employing an industrial designer. As a result of this 'opportunistic' decision to use a new recruitment routine, the organisation's ergonomics capability was lifted.

Acute pressure from product-markets may also have similar innovative consequences. Thus, in response to the release of a product by a competitor, Feltex Furniture decided to fully develop a product and sought assistance from

the School of Design at the Wellington Polytechnic. However, in this particular case, the practice of using industrial design expertise was not repeated. It could be argued while product-market pressures forced the company to innovate, this practice was not routinised because it was fundamentally inconsistent with a strategy-structure configuration which support copying strategies and only low levels of research and development activity.

External factors also impacted on the development of ergonomics capability by supporting the continued employment of industrial designers. External factors which had this effect included trends in the regulatory environment affecting trade, and shifts in the sophistication of consumer demand. This study found that while accelerations in the liberalisation of trade (which reduced protection levels for the New Zealand manufacturing sector from the mid-1980s onward) did not lead directly to the initial emergence of ergonomics capability in the six cases, these changes did cause some organisations to raise their product quality aspirations. This resulted in the continuing use of industrial designers and the continued development of ergonomics capability.

While trade policy liberalisation may have highlighted a need for improved product design, the depressed economic conditions of the late 1980s were to place a limit on what could be achieved in this respect. However, rather than not employ industrial designers at all, some organisations in this study responded by controlling and limiting the level of involvement of these specialists.

> *Proposition 10: The development of ergonomics capability in manufacturing organisations is influenced by the extent to which institutions (e.g. design schools, design councils) exist for the promotion of industrial design. This relationship is strengthened by the extent to which individuals in positions of power within these institutions consider ergonomics to be a fundamental component of industrial design.*

> *Proposition 11: Ergonomics capability will persist and develop more strongly in those organisations where its initial emergence is associated with an opportunity. By comparison, acute external pressure exerted by competitors and by regulatory change may lead to relatively superficial and short-lived responses.*

The consequences of ergonomics capability

Although the question of whether the six organisations applied their ergonomics capability effectively was peripheral to the main objectives of this study, it is clear that some of the ergonomics knowledge they acquired and generated was embodied in products. Through the release of these products and various other mechanisms, the ergonomics capability of the six organisations indirectly shaped aspects of both the organisational context and the wider external environment.

The effects of ergonomics capability on the external environment may be as follows. Firstly, the organisation's products and practices will contribute to the wider knowledge environment of competing firms. The diffusive effect of these products and practices will be greatest where these are explicitly associated with the term ergonomics. Secondly, by producing leading-edge products and informing customers of the significance of ergonomic features, organisations can impact on the level of demand sophistication. This may generate a requirement for all firms in a particular sub-sector to give some attention to basic ergonomic considerations. Thirdly, organisations may use their capability to control the wider environment. The involvement of manufacturers in the standards formulation process is an example of this. Organisations may also act to control the 'poor' ergonomic practices of competitors.

Ergonomics capability may have an influence on the inner context of organisations by encouraging new patterns of interaction between design team members and end-users. For instance, the ergonomic approach used by PEC's first industrial designer led other design team members in this company to give greater consideration to the requirements of end-users. Similarly, the activities of RDD's Ergonomics Group helped to encourage a higher degree of interaction between assembly workers and design engineers than existed previously.

Experiences surrounding the use of ergonomics knowledge become a part of an organisation's history. This history is communicated by stories and physical artifacts (such as files, drawings, and products) which provide a point of reference for practices which an organisation uses in the present and might use in the future. This is illustrated by the case of PEC where this company's first industrial designer was remembered as having been a very strong proponent of ergonomics.

This leads to the final proposition:

> *Proposition 12: Organisations which develop a substantial level of ergonomics capability are able to shape their external knowledge environment.*

Implications for innovation theory and ergonomic practice

This study has argued that the use of ergonomics knowledge can be understood as a complex process of innovation which is shaped by a combination of forces both internal and external to an organisation. This position has been argued for on the basis of six cases which have focused on the emergence and development of ergonomics capability in product development settings. From the insights provided by the cases a framework has been proposed in the previous section. While this framework is offered as a contribution to what is already known about ergonomic practice, some additional general implications may also be drawn. The first of these relates to the field of innovation theory.

By using a contextual and processual approach to the study of innovation processes, this study has highlighted the pervasive influence of government policies and the agencies which support, and are supported by, the policies. Through their ability to shape the structural characteristics of industry sectors and features of the knowledge environment, these policies and agencies supported the growth of ergonomics capability within the cases in this study. This finding is significant in that while government policy has been linked to technological innovation and product innovation (see Baker and Sweeney, 1978; Rothberg, 1976), this aspect has generally received limited attention in the 'mainstream' literature on innovation in organisations as reviewed for example by Zaltman *et al.* (1973) and King (1990). The latter situation may be attributable to the predominance of variance research studies in this body of literature (see Mohr, 1982). In variance studies, the focus tends to be on quantifying those extra-organisational influences (such as competition and environmental turbulence) which have a direct, measurable effect. As the influence of government policy is often indirect and diffuse, it is difficult to quantify in variance studies.

That government policy does have an influence, albeit an indirect one, on the innovative performance of individual firms, has implications for the debates which centre on the role of government in fostering innovation in the manufacturing sector. This debate is particularly relevant to the New Zealand context where central government has, since the early 1980s, reduced the level of industry assistance on the assumption that this will make the country's manufacturing sector more innovative and competitive. This study, however, shows that the withdrawal of some forms of government support may impact negatively on the general knowledge environment from which manufacturing organisations have in the past obtained valuable new ideas and competencies. This effect can be illustrated by referring to the history and influence of the New Zealand Industrial Design Council. Whereas this government-funded organisation was a part of the knowledge environment of manufacturers during the 1970s and into the 1980s, it ceased to exist in 1988.

The impact of specific government agencies and policies should, nevertheless, not be overemphasised. Thus, while deregulatory change may help to stimulate the development of product-related competencies at the level of the firm, this impact may be blunted by a number of factors. Firstly, as this study has shown, product strategies tend to be relatively persistent. This is because it is no easy task for an organisation to bring about a major shift in its overall structural configuration. Secondly, economic changes may not fundamentally alter the 'strategic stratification' which characterises particular industry sub-sectors and places limits on the degree to which innovation will take place. Under this stratification arrangement, there will always tend to be leaders who are followed by less innovative (and less ergonomically aware) but equally profitable others. Thirdly, as has been indicated by various researchers (see Hedberg, 1981; March and Simon, 1958) acute competitive pressure may only explain a proportion of all innovative activity in organisations. As was evident in two of the six organisations in this study, ergonomics capability emerged when an opportunity that was presented to organisation members was taken up.

This study also has implications for ergonomic practice. In particular, it does appear that the role and contribution of industrial designers needs to be understood more fully by other advocates of ergonomic design. Although, in this study, staffing routines involving industrial designers were found to be the major mechanism by which ergonomics capability was introduced into product development settings, it is unfortunate that the role of industrial designers has

tended to remain hidden from view. There are a range of possible reasons for this including the lack of involvement of industrial designers in professional ergonomics networks (and vice versa), and the limited inclination of designers to disseminate or promote their activities in relation to ergonomic design. These factors are, in turn, influenced by the pragmatic orientation of most industrial designers, and by the organisational context of industrial design which may not reward information dissemination or permit disclosure of commercially sensitive information.

While it could be argued that the ergonomic activities of industrial designers should be brought more to the fore, it can also be argued that New Zealand industrial designers have failed to recognise that their emphasis on ergonomics may be a common source of strength. This strength could be developed further through the formation of links between industrial designers and ergonomics networks. There may also be some scope for the offering of professional development programmes, directed specifically at industrial designers and dealing with advanced aspects of ergonomics. These programmes should build skills in pre-production evaluation methods, rather than emphasise the mere transfer of textbook knowledge to the designer (see Ward, 1992).

Although it is easy to recommend that more effort should go into enhancing the level of co-operation between industrial designers and other groups interested in ergonomics, potential areas of conflict do need to be recognised. Conflict may revolve around fundamentally different emphases and orientations. In particular, those who favour a scientific approach may have some difficulty accepting the designers' view that ergonomics is but a part of design and that user-centred design can be approached 'intuitively'. Further conflict may arise where industrial designers perceive that other, less well-established, professional groups are encroaching on their area of activity.

Further lessons may be drawn from the constraining effect of an organisation's configuration. This study found that there were strong links between an organisation's realised product strategy (and strategic type) and the use of staffing routines involving industrial designers. A knowledge of this strong relationship could be used by ergonomists and industrial designers to 'diagnose' an organisation's configuration prior to, or upon, entry (*cf.* Shipley, 1990). However, while this may help ergonomists to better understand the organisational context in which they may have to work, attempts to modify

aspects of the organisation to make it more receptive may be limited by the persistent nature of generic product strategies.

Finally, this study has suggested that new concepts may be needed that more fully capture the dynamic nature of ergonomics knowledge use and generation in organisations. Unless a more dynamic terminology is adopted there is a danger that the narrow focus on the problem of ergonomics knowledge 'utilisation' will continue, while the knowledge-related activities that do take place in organisations will be overlooked. As this study has shown, organisations have the potential to generate and create new ergonomics knowledge. Unless this aspect of knowledge production is more fully recognised, we may fail to fully understand the circumstances and processes which help to shape an organisation's ergonomics capability.

So far in this concluding section, implications for innovation theory and ergonomic practice have been identified. Attention now will be drawn to the managerial implications.

Managerial implications

Ergonomists are concerned that the use of ergonomics knowledge available is not used extensively by organisations. This thesis has identified a number of issues that should concern the managers of New Zealand.

Since the study was exploratory in nature involving six companies one cannot generalise, but can offer certain directions as well as suggestions for future research for New Zealand management.

Managers should be aware of the processes in capability development which occur in organisations as identified by this study (Figure 8.2).

Although Figure 8.2 may be interpreted as yet another linear model of the innovation process, it should be noted that a strict *sequential order* is not implied. It is possible that the capability development and tranference stages will proceed concurrently.

Capability Emergence	New knowledge/capability emerges through a new staffing routine.
Capability Development	(A) The staffing routine is continued/discarded/modified thereby impacting on capability development.
	(B) As a result of (A), learning occurs in relation to the knowledge domain, knowledge acquisition routines, and the practical application of specialist knowledge.
Capability Transference	The capability acquired is 'transferred' to other functional areas, and applied to different types of problems.

Figure 8.2 Four stages in the emergence and development of ergonomics capability

The four stages outlined in Figure 8.2 provide a basis for a discussion of what managers can do if they wish to promote the development of particular new capability (such as ergonomics) in their organisation.

Managers ought to have a greater understanding of what innovation involves. This understanding ought to include a knowledge of different innovation types, significant innovation determinants, innovation processes (including decision-making and learning), as well as the relationship between organisational performance and innovative activity. An appreciation of the latter relationship is important; while innovation is often assumed to be 'good' and desirable in its own right, in certain instances (see Miller, 1988) it can be counter productive. Consider, for example, a company which has made a commitment to product innovation. While this strategy may be profitable in highly changeable markets, the same approach may lead to failure should the company be confronted with weak and unsophisticated demand conditions. Aspects of such a scenario are found in the Formway case. An understanding of the relationship between innovation and performance, along with other aspects of innovation theory, may thus help managers decide *when* to push for more innovation in their organisations, while it may also assist them in finding ways to make their organisation more receptive to innovative activity. In saying this, however, it must be recognised that what managers can do will be limited by other factors such as the configuration of structure and strategy that has characterised an organisation in the past. The overall position taken in this study is that managerial action is, to a degree, constrained by the contexts in which managers are required to operate. The case study evidence further lends support to the limits of managerial action.

However, while much could be learned from the existing innovation literature, this study also provides insights for managers of the product design and development process, particularly where scope exists for the application of ergonomics knowledge. In particular, this study suggests that the clearly delineated decision-making stages which tend to feature in models of the innovation process may not apply well to the introduction of ergonomics capability. As was concluded from the analysis presented in Chapter 5, it was not possible to say exactly *when* ergonomics was 'adopted' in that no exact moment of decision could be easily identified. Instead, the 'adoption' of ergonomics knowledge appears to be a state or outcome of certain organisational processes involving new staffing and search routines. Given the inapplicability of the adoption concept, this study has instead referred to the 'emergence' of ergonomics capability.

New staffing routines have been shown by this study to be a critical factor in the emergence of new capabilities in organisational settings. Given this, managers may need to appreciate more fully the link between staffing and organisational innovation. While it is, of course, possible that managers, as a group, already have a good understanding of this relationship, some researchers (e.g. Clark and Staunton, 1989) have argued that there has been a widespread tendency toward the 'objectification' of innovation. In other words, innovation has become associated with the adoption of a new piece of technical equipment or the introduction of a new product. Where managers also subscribe to this narrow conception of innovation, they may fail to adequately understand the role of knowledge in the innovation process and the link between new knowledge and staffing routines.

If staffing routines are recognised to be an important aspect of the innovation process, then managers may be able to encourage the emergence of new ideas through careful appraisal of the staffing routines they use. In this respect, it would appear to be desirable to establish an appropriate balance between internal and external recruiting. By recruiting people from the outside, for example, the organisation may become exposed to new ideas and perspectives more quickly than might occur through programmes of professional development involving existing employees. This rapid exposure to new ideas may be particularly important in fast changing technological and competitive environments in which organisations will need to keep abreast of relevant professional specialisms and knowledge bases as they emerge and evolve. Obviously, if top management wish to be relatively early in becoming aware of new knowledge areas, then there are obvious implications for their organisation's investment in environmental scanning and external networking activities.

Having addressed what managers might do to encourage capability emergence, the discussion now turns to consider those managerial implications which can be drawn from consideration of the capability development stages in Figure 8.2. Managers will influence each of these stages as their priorities and decisions will have a bearing on what happens to new staffing routines. Managers will usually have some say as to whether these routines will be continued, discontinued, or modified. However, while managers may base their decisions on a range of factors including cost or the perceived success/failure of a particular routine, they should also consider how different staffing practices might impact on

organisational innovation. This recommendation will be illustrated by reference to specific practices which, in this study, influenced the extent to which an ergonomics capability developed.

The choice of whether to employ in-house or external industrial designers can influence the success of capability emergence. Although various considerations such as cost, familiarity and workload fluctuations will determine the balance struck between these two staffing practices, some managers in this study were of the opinion that an external design consultant would expose the organisation to new ideas more effectively than would an in-house design consultant. However, while this may be the case, the use of consultants, particularly where they work at a distance, may limit the degree of learning within the organisation itself. A consultant may only meet with the design team for short periods of time. As a result, there may not be the opportunity for the consultant to interact more informally with people working in different functional areas. This may, in turn, limit any chance transference effects. A more serious concern, however, when relying on design consultants, relates to the timing and extent of their involvement. A consultant may be pulled in at too late a stage in the design process, and for such a limited period of time, that learning (e.g. though experimentation and other forms of time-consuming design research) by the consultant, and by other members of the organisation may be severely compromised.

Related to the timing problem is the issue of how frequently an organisation should change its consultants. Rapid turnover among design consultants may be detrimental to the innovation process because it interferes with the learning process. It is significant that those organisations in this study which had achieved a reputation for excellent design had built up relatively stable and long-term relationships with their design consultants.

Furthermore, this study suggests that managers should plan for unexpected changes in staffing routines which might, for example, involve the resignation of a designer. In small organisations, the latter situation can cause the innovation process to be severely disrupted. It can also lead to a massive loss in organisational capability. To protect the organisation from this sort of event, managers should ensure that the accumulated expertise and experience of key individuals is stored in a relatively permanent form of organisational memory. This may involve ensuring that the findings of design research and the rationale behind key decisions are documented.

The final staffing issue to be considered here relates to task specialisation. Generally, this study provides support for the view that excessive role specialisation may limit the learning and capability transfer that might potentially occur as a result of team work. As such, managers should give careful consideration to the degree of specialisation that will be accepted in these situations. This, in turn, has implications for recruitment, professional development and team composition.

While staffing routines may be necessary for the emergence of a specialist capability, they will not be a sufficient means of promoting further capability development. Those individuals who are brought into the organisation through new recruitment routines will only be able to learn more themselves and pass on their knowledge effectively if the organisational setting provides a conducive environment in which these processes can take place. In this respect, the receptiveness of the environment will depend on a range of factors over which managers have some degree of control. These include: attitudes of organisation members toward theoretical knowledge; the nature and extent of communication supported by particular organisation structures and physical facilities; and the support available for knowledge champions.

These are all issues for managerial attention.

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