BEHAVIOURAL MODELS OF DECISION MAKING IN ECONOMICS:

An Exploratory Study in the Application of Information Processing Methodology

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Needless to say, I alone am responsible for any limitations in the finished product that has finally emerged.

ABSTRACT

Economic theories of decision making under uncertainty have experienced a rapid development in recent years and this has resulted in a significant contribution to our understanding of economic behaviour. The subjective expected utility (SEU) paradigm has dominated much of this research and it has been characterised by the increasing realism of the assumptions that describe the task environment surrounding economic agents. Concomitant with these developments has been the growing concern about the behavioural assumptions implicit in the neoclassical framework of analysis.

The work of Herbert Simon has been at the forefront in questioning the validity of the neoclassical paradigm as an appropriate framework for studying economic behaviour in complex and uncertain task domains. Following Simon's work, this thesis views economic agents as information processing systems. Specifically, we advocate an inter-disciplinary approach to the study of economic behaviour and we illustrate and evaluate the application of techniques from information processing psychology to economics.

The main contribution of this thesis is the presentation of a framework of analysis for the development of behavioural process models in economics. In adopting a process perspective we highlight the need to study actual decision making behaviour through the combined use of laboratory experiments and verbal protocol analysis. Within this framework we can study the way economic agents structure decision making problems and also examine the differences in strategies between decision makers. We illustrate and evaluate our approach with reference to business decision making and present the results of analysing the behaviour of subjects who participated in an experimental decision making exercise.

INTRODUCTION

Economists have modelled behaviour in a wide range of environmental conditions and increasingly this has included uncertain task environments. In this respect, contemporary microeconomic theory has progressed considerably since the pioneering work of von Neumann and Morgenstern (1944) and SEU theory has become the established paradigm in economics for modelling behaviour under conditions of risk.

The SEU framework is not without its critics and an extensive debate has developed in the literature regarding the value of neoclassical methodology for studying particular aspects of economic behaviour. The majority of this criticism has come from economists sympathetic to the behavioural approach to economics. However, despite the extent of the behavioural literature, a large proportion has been concerned with discussing methodological criticisms of neoclassical economics and as a result no widely accepted framework for developing behavioural process models in economics has emerged.

The major criticism of neoclassical economics has been the assumption that economic agents are able to optimise in a given decision making situation. It is argued that the substantively rational framework of neoclassical economics is inappropriate for two main reasons. First, the nature and structure of many real world decision making tasks makes the identification of optimal choices impossible. Second, even where the structure of a decision problem is well-defined (in some objective sense), its complete specification by the neoclassical economist fails to recognise the limited information processing capacity of economic agents.

The research presented in this thesis is behavioural in tradition and complements orthodox neoclassical analysis by emphasising the need for the economist to consider both the nature of real world decision making tasks and the information processing constraints on human behaviour. The inter-disciplinary nature of behavioural research highlights the contribution of this thesis in terms of establishing important conceptual links between information processing theory and the nature of behavioural process models. Specifically, we shall introduce production system (PS) models and demonstrate their potential contribution for modelling behavioural processes. PS models have a close association with the information processing theory of human behaviour put forward by Newell and Simon (1972).

The intellectual inspiration for this thesis owes much to the research of Herbert Simon, particularly his joint work with Allan Newell in the 1970's. A major contribution of Simon's work has been the signposting of possible methodologies for the study of procedural rationality in economics. Simon has argued that economists should examine the research methods and results on decision making from other disciplines. Particular emphasis is placed upon research in artificial intelligence, cognitive psychology and management science. With few exceptions behavioural economists have been slow to respond to Simon's initiatives and this thesis provides a contribution (albeit a small one) to the task of applying ideas and techniques from other social science disciplines to economics.

While the work of Newell and Simon (1972) provides a clear statement of the theoretical framework that underpins this research, it is the work of Bouwman [see for example Bouwman (1983, 1985)] which has guided our application of PS modelling outside the field of cognitive psychology. Though we adopt a similar research methodology to Bouwman, we can contrast the present work in terms of our study of decision making behaviour in ill-structured task domains. Bouwman's research involved the study of actual decision making behaviour for a well-structured experimental financial diagnostic task.

The emphasis upon procedural rationality in behavioural research implies a need to observe and model human decision processes. However, one limitation of the substantively rational framework of neoclassical economics is that it does not provide the economic researcher with the necessary tools to study actual behaviour and model decision processes. The intellectual re-tooling we advocate for conducting the kind of research presented in this thesis demands a sympathetic view as to the role of inductive research methods in economics. For this reason we explore the use of laboratory experiments and verbal protocol analysis in behavioural research. Laboratory experiments provide a great deal of scope and opportunity for the study of actual decision making behaviour. Protocol analysis offers a structured approach to the recording and analysis of high density behavioural process data. Protocol analysis is a technique that has been widely used in the cognitive psychology literature and underpins the use of PS modelling.

The use of laboratory experiments and verbal protocol analysis in economics is not without problems. For example, the uncertainty surrounding how to proceed in the application of non-standard research methods. Moreover, in breaking from the orthodox framework of economic analysis we face high risks in terms of achieving academically satisfying output as well as results that are likely to be of interest to economists not sympathetic to behavioural research. In this respect the research presented in this thesis has an important contribution to make in terms of identifying the difficulties and problems of new and novel research methods. Our discussion of these issues will, hopefully, be of value to others who follow a similar research method in the future.

In sum, the exploratory nature of this research will probably raise more questions than it answers. However, in embarking upon this research our intention was to investigate a particular problem. Behavioural economics focuses upon procedural rationality in contrast to the substantively rational tradition of neoclassical economics. This requires that we study and model the decision processes resident in the 'black box' which characterise the psychology of economic agents. However, there is no clearly established framework of analysis to which the behavioural economist can turn to conduct this type of research. It is this issue which has been of central concern in this thesis.

In addition to making a methodological contribution we also present an application of human information processing theory. While the behavioural process model which results from our research is interesting in its own right, there is much scope for development and refinement of our basic experimental application. However, we are also able to examine the advantages and disadvantages of using laboratory experiments and verbal protocol analysis for this type of behavioural research. We conclude that there is considerable scope for extensive research in economics using the information processing framework introduced in the early chapters of this thesis.

CHAPTER 1

OVERVIEW

1.1 INTRODUCTION

The study of decision making is central to the research effort of many disciplines, including: artificial intelligence; behavioural decision theory; cognitive psychology; economics; operations research and many more. While the focus of research in each discipline is different there are some common themes that emerge regarding the nature of human behaviour [see for example the survey work of Slovic, Fischoff and Lichenstein (1977) and Einhorn and Hogarth (1981)]. For example, it has been observed that human behaviour is adaptive and characterised by constraints on human information processing capacity. These findings (and others) are just beginning to become incorporated into the study of economic behaviour.

A major theme of Herbert Simon's work [see, for example, Simon (1978b, 1979a)] is that economists should explore more fully the use of ideas and techniques from other disciplines. The substantively rational framework of neoclassical economics is challenged as a framework for the study of behaviour in complex and uncertain task environments. Instead, Simon highlights the role of procedural rationality as a basis for the study of decision processes in behavioural research. Following the work of Simon the research in this thesis has been conducted with the belief that the study of economic decision making demands an inter-disciplinary perspective.

In this chapter we shall first outline our basic research philosophy. Second, we assess the relevance of this research and summarise our methodology. Finally, we outline the design of the thesis.

1.2 RESEARCH PHILOSOPHY

As economists, we still know very little about the decision making activities of the agents whose behaviour we purport to model. How are decisions actually made? How do economic agents perceive and structure decision problems? What information is used during decision making and how is it processed? How can we distinguish between good and bad decision making strategies? How can decision making be improved? What is the role of learning in understanding decision making behaviour? The nature of these questions emphasises the importance of studying the process of decision making.

The above questions have received attention in the economics literature but there remains much work to be done. Moreover, these questions are not simply the concern of the behavioural economist. There are many areas of neoclassical economics where the failure to examine the process of decision making has highlighted the limitations of orthodox theory. The economic theory of the firm is one example of where extensive criticism of neoclassical analysis has been made [see for example, Winter (1986)].

Answering the questions posed above requires a detailed knowledge and understanding of the thought processes involved in decision making. However, economists are not particularly well equipped to carry out research of this type. Indeed, the neoclassical framework of analysis provides strong justification for avoiding the necessity of studying behavioural decision processes. This thesis presents a structured framework for the study of human decision processes in economics. It provides some guidelines on how we might begin to answer the questions posed above and presents an operational framework for future behavioural research.

The basic research philosophy of this thesis is to view decision makers as information processing systems. The work of Newell and Simon (1972) is recognised as one of the definitive expositions of the human information processing perspective and it has dominated the study of human behaviour in the field of cognitive psychology. The significance of this theory for current research is the view that we can study and model human behaviour in terms of information processing activity. The ability to process information (symbol structures) is the basis for humans displaying intelligent behaviour (ie. expertise).

One implication of adopting an information processing perspective in this research is that we focus upon certain aspects of economic behaviour that otherwise would not be investigated. The extent of this effect will become fully apparent in later chapters but one obvious difference is the ability to observe decision processes in some detail rather than simply decision outcomes.

A further important impact of adopting an information processing philosophy will be in terms of the design and structure of behavioural models. Information processing models are dynamic in the sense of focusing upon the adaptive behaviour of systems. Simon (1980) has called this the study of adaptive systems. A natural formalism for representing information processing models is that of a program (a set of symbolic relationships) [Newell and Simon (1972)]. One particular form of information processing models that dominates research in the cognitive psychology literature is that of production system (PS) models. The architecture of PS simulation models is closely associated with the information processing theory of Newell and Simon. Later we illustrate the suitability of PSs for modelling the behaviour of adaptive systems. In brief, the structure of a PS model is particularly appropriate for capturing the nature of symbol processing behaviour and is easily transformed into a computer simulation model.

Information processing theory is largely concerned with the construction of models of individual behaviour [see

Newell and Simon (1972) p 10]. This has two important implications. First, individual differences in decision making behaviour can be investigated in some detail. This seems of fundamental importance for the type of decision making tasks that are the focus of behavioural research, eg. strategic decisions. Second, the possibility of developing generalisations about decision making behaviour are limited within an information processing framework. As this research demonstrates, the number of subjects whose behaviour can be studied is typically very small. However, the building of a behavioural process model for an individual subject is an important step towards generalising about the behaviour of other subjects. Importantly, the information processing perspective does not assume away differences in behaviour between subjects.

Finally, an essential feature of the information processing theory paradigm is the collection and analysis of large amounts of data concerning what information has been used and how it has been processed by a subject during problem solving. In this context, the analysis of verbal protocols has become the hallmark of information processing theory.

1.3 RESEARCH METHODOLOGY

In adopting the procedurally rational framework of behavioural economics, we face two important issues that are central to this research. First, is there an appropriate theoretical language for modelling behavioural process phenomena? Second, how should actual decision making behaviour be studied for the purpose of capturing the richness of detail necessary to develop behavioural process models?

As a first step in this research we examine the nature of PS models and assess their value as a theoretical language for modelling important relational concepts in behavioural economics. This establishes the important case for studying decision processes in economics because of both the structure of different types of decision making tasks and the nature of information processing limitations on human behaviour.

In going beyond a simple 'black-box' analysis of decision making behaviour we shall focus upon the need to observe actual behaviour and collect data on the processing of information that takes place during decision making. This requires a consideration of the conditions under which behaviour can be observed and also how detailed behavioural process data can be collected and analysed. The combined use of laboratory experiments and verbal protocol analysis offers a very important direction for research in behavioural economics. The design and running of experiments and the collection and analysis of verbal protocols are resource intensive research methods. However, they offer the opportunity for the collection of high density behavioural data. Moreover, it needs to be remembered that behaviour central to the focus of behavioural research is typically associated with those decisions that are difficult to observe (in a process sense) in the 'real world'.

The successful completion of this thesis essentially involves two tasks. The first, which we have just outlined, is the presentation of a framework of analysis for a structured approach to the study and modelling of human decision processes. The second task is concerned with the application of this framework and involves the study of subject behaviour in an experimental decision making task. The detailed analysis of our subjects' information processing behaviour is demonstrated for the purpose of developing a PS model of decision making behaviour.

Developing a behavioural process model of subject behaviour for our decision making task will proceed from two directions. First, we present a global model of subject behaviour against the background of the structure of the task environment. To support this analysis we shall examine the behaviour of other subjects who participated in our experiment and present a classification of the different generic strategies that were used. This preliminary analysis is important in providing reference points for a more detailed analysis of individual subject behaviour.

The second level of analysis builds upon the first stage and attempts to define a set of information processing operators used by an individual subject. Essentially, this involves specifying a set of decision rules that have been "revealed" by the subject in the protocol evidence collected during the running of the experiment. Protocol analysis requires subjects to 'think aloud' while problem solving. These thoughts are recorded for subsequent analysis. It is important to recognise here the validity of using protocol analysis as a technique for eliciting information processing behaviour.

Typically, protocol analysis provides an incomplete picture of subject behaviour since it is highly unlikely that a subject will provide a complete record of all their thoughts during a particular task. However, careful experimental design has an important role to play in facilitating the ability of subjects to reveal fully their information processing activities when giving verbal reports. An important role of protocol analysis is to minimise the need for the researcher to incorporate 'ad hoc' decision rules (information processes) when developing a behavioural process model of subject behaviour within a PS framework. Arguably, protocol analysis is the most effective technique for providing the volume of detailed behavioural data required for the study and modelling of human decision processes.

The final phase of developing a behavioural process model is the building of an executable simulation program and comparing its behaviour with that of an individual subject. Given the strong similarity between an information processing system and a computer (in a symbol processing sense), PS models can appropriately take form in the shape of computer simulation models. The comparison between the simulated behaviour generated by the PS model and that of the actual subject can take place at a variety of levels. First, the behavioural model should be capable of generating the type of behaviour displayed by the actual subject. Second, the model should be able to simulate the decisions of the subject on which it was based. Finally, we can assess the model in terms of its capacity to simulate the information processing activities that characterise a subject's behaviour in the task. It is important to note that building PS models of the type developed in later chapters is an iterative process. Inevitably, there will be scope for further improvement and refinement.

1.4 DESIGN OF THE THESIS

The design and structure of this thesis reflects upon the previous discussion regarding our research philosophy and methodology.

In Chapter 2 we discuss the nature and role of behavioural economics as an alternative framework of analysis to neoclassical economics. Inevitably, this chapter reflects upon the origins of the present research and in particular concern with the study and modelling of decision processes. We introduce some important concepts from information processing theory and examine the nature and role of PS models. Finally, we present an introductory application of the PS modelling framework, highlighting the architecture of PS models and illustrating their suitability for modelling learning behaviour.

Chapter 3 considers the problems associated with the observation and modelling of human decision processes. Specifically, we consider the problem of collecting detailed behavioural process data. It is difficult (if not impossible) to observe actual behaviour in many real world tasks. For this reason we consider the combined use of verbal protocol analysis and laboratory experiments as an approach to observing actual human behaviour. An important link is developed between the use of protocol analysis and laboratory experimentation in terms of satisfying the necessary conditions to validate the use of verbal reports as behavioural data.

The remainder of this thesis presents a detailed application of the methodological framework we have constructed in Chapters 2 and 3. Chapter 4 describes the design and structure of a business decision making exercise developed for this research. This was a laboratory-based simulation exercise run on IBM micro-computers. The decision task facing subjects was characterised by complexity and uncertainty. It was designed to capture important elements of strategic decision making behaviour in business.

In Chapters 5 through 7 we present a detailed analysis of the verbal protocols collected during the running of our experiment. Chapter 5 provides an examination of the behaviour of a single subject. At this stage of development the behavioural process model is 'global' in nature. In Chapter 6 we analyse the protocol data at a lower level of aggregation and consider the protocol data of other subjects. This provides an insight into the nature of the decision rules (production rules) that reflect the various decision making strategies used by subjects in our experiment. Finally, Chapter 7 completes the final stage of developing our behavioural process model. We return to the case of subject S7 and contrast the output of our computer-based PS simulation model with the actual behaviour of S7.

In Chapter 8 we summarise our main findings and highlight some limitations of our research method.

CHAPTER 2

MODELS OF ECONOMIC BEHAVIOUR: THE UNDERPINNINGS OF A PROCESS PERSPECTIVE

2.1 INTRODUCTION

Economic theories of behaviour under uncertainty have largely developed over the last 40 years within the SEU framework of von Neumann-Morgenstern. While there are alternative perspectives to the study of economic behaviour under uncertainty [see for example, Shackle (eg 1972); Earl (1984); Heiner (1983); Machina (1987)], the general acceptance of SEU theory has led Schoemaker (1982) to argue that it has been the major paradigm of decision making research since the Second World War. Despite the elegance and rigour of SEU theory and the generality of its predictions, its achievements have been accomplished by the use of extreme assumptions about the behaviour of economic agents in the face of complexity and uncertainty. Critique of the substantively rational framework of neoclassical economics has been particularly directed at the information processing constraints that limit the ability of economic agents to compute optimal decisions.

Since the late 1950's behavioural economists have challenged optimisation theory as an acceptable explanation of economic behaviour in complex and uncertain environments. The early work of Simon [see for example, Simon (1959)] and Cyert and March (1963) provides a clear methodological statement of the behavioural approach to studying economic behaviour. Of particular note is the emphasis upon modelling economic behaviour as a process and the empirical base of behavioural theories in terms of the need to observe how economic agents actually make decisions. Despite this common purpose, there has emerged a variety of different approaches amongst behavioural researchers [see for example, Gilad and Kaish (1986)]. In this research we link some of the important ideas from early behavioural research with the findings from the fields of artificial intelligence and cognitive psychology. Specifically, we establish the value of production system modelling for developing behavioural process models in economics. In this sense, the ideas discussed in this chapter will firmly establish the origins of our research in what might loosely be called the 'Carnegie School' of behavioural economics.

In this chapter we present a brief summary of the critique of neoclassical economics as a framework for studying economic behaviour in complex and uncertain environments. Second, we review some elements of the behavioural approach to modelling behaviour under uncertainty. Specifically, we consider the implications of focusing upon issues of procedural rationality. We then introduce information processing theory as a framework for underpinning many of the important concepts and ideas in behavioural research.

In the final sections of this chapter we introduce the nature of production system (PS) models and examine their origin in the AI and cognitive psychology literatures. We complete our discussion with an illustration of PS modelling and present the results of a model that simulates the learning behaviour of a firm operating in a duopolistic market environment. Many of the arguments discussed in this chapter will be concerned with the study of business decision making.

2.2 NEOCLASSICAL ECONOMICS: THE LIMITATIONS OF SUBSTANTIVE RATIONALITY

Orthodox theories of economic behaviour have been extensively criticised for their failure to grapple with the empirical realities of actual decision making behaviour. Much of this criticism has been directed towards the theory of the firm and in particular the inability of neoclassical economics to explicitly account for the impact of uncertainty on business decision making [see for example, Shubik (1970); Morgenstern (1972); Cyert and Hedrick (1972); Loasby (1976); Simon (1978a) and Nelson and Winter (1982)]. It is very difficult to add any original or novel insight to what are now well established criticisms of neoclassical economics. In this section we review some important issues for the discussion in later sections of this chapter. The discussion reflects not only a general critique of orthodox economic theory but also the specific problems of studying the economic behaviour of firms. In both cases the limitations of not considering process phenomena are highlighted.

The role of the firm in neoclassical theory is well established in terms of an alternative resource allocation mechanism to that of the market [Coase (1937)]. The firm is an abstract concept that is assumed capable of maximising a well specified objective function by transforming inputs into outputs subject to market and technological constraints. This holistic or 'black box' view of the firm bears little resemblance to business firms in reality; indeed it was never intended that it should.

The confusion over the distinction between an economic theory of the firm and the neoclassical theory of the firm has led to much misguided discussion in the literature. For example, Cyert and Hedrick (1972, p 409) concluded:

> ". . . there is a great diversity of views about the proper objectives of a theory of the firm. The fundamental difference centres on the question of whether the theory should explain actual decision making in firms."

However, the dominance of positivist methodology in mainstream economics leaves very little doubt amongst orthodox economists as to the role of the firm. Machlup (1967, p 9) presents one of the clearest statements of this position; the firm in economics is a hypothetical construct which:

"is not, as so many writers believe designed to serve to explain and predict the behaviour of real firms; instead it is designed to explain and predict changes in observed prices as effects of particular changes in conditions."

Machlup's argument is, of course, in the tradition of the "as-if" framework of positive economics. It emphasises the methodological position that the critical test of a theory is not the realism of its assumptions but its ability to predict [Friedman (1953)].

The critique of this orthodox position has been on two fronts. First, it is argued that the underlying assumptions of orthodox theory deny the very existence of a genuine theory of choice in economics. The classic presentation of these arguments can be found in the work of Shackle (1972, 1979). Second, criticism has been directed at the predictive content of orthodox economic theory. As Heiner (1983, p 561) argues in relation to the unfalsifiable predictions of orthodox economics:

"Suppose we really asked to see the list of clearly implied, unambiguous predictions that have been derived from our basic optimisation models.

The answer to this query, one that would be admitted by many practitioners in the field, is that at best we have developed a very short list."

The study of business decision making in economics is notably absent of unambiguous predictions. How do business firms operate and develop strategy? How are investment, financing and dividend decisions actually made? How do firms develop effective competitive strategies? These questions (and many others) are of central concern to economic theory. However, neoclassical economics does not lend itself to the study of decision processes within firms and, in consequence, it is limited in its capacity to consider the type of questions posed above.

The rejection of economic theory as a theory of choice is founded upon the orthodox assumption of substantively rational behaviour. Simon (1976) distinguishes between two concepts of rationality: substantive rationality and procedural rationality. Substantive rationality refers to the ability of economic agents to achieve goals within the constraints and conditions imposed by a particular task domain. In contrast, procedural rationality is a much broader concept and refers to behaviour that is the outcome of appropriate deliberation. In sum, procedural rationality of behaviour depends upon the process that generates it, while substantive rationality depends upon the output of rational choice.

The substantively rational framework of neoclassical economics has been described by Latsis (1976) as a research programme of "situational determinism". Given the goals of economic agents (eg profit maximisation, utility maximisation), rational behaviour is determined entirely by the characteristics and structure of the task environment. In essence, the assumption of substantively rational behaviour implies that economic agents have the ability to optimise in a particular task domain, irrespective of the complexity of the task. Heiner (1983) has referred to this ability of economic agents in terms of the absence of a C-D (competence-difficulty) gap. In consequence, decision outcomes (choices) have no behavioural content since they can be logically deduced from the assumptions specified about the nature of economic problems and the ability of economic agents to solve them.

While abstraction is central to economic theorising and model building, it is important to consider whether the process of abstraction fundamentally alters the nature of the problem that is being investigated. This has been the basis of Herbert Simon's critique of economic theories of uncertainty [Simon (1979a)]. SEU theory assumes that economic agents are capable of identifying all possible future states of the world and all possible choices, together with the associated consequences (outcomes) for each of these states. Essentially, the economic agent is presented with a highly structured and well-defined environment in which a single decision problem exists. Even within models which incorporate Bayesian learning there is a highly structured and known environment in which learning takes place and, given the rationality of economic agents, the existence of a single best (optimal) strategy. The basis for rejecting the notion of substantively rational behaviour in complex and uncertain environments is essentially twofold.

(a) Limited Information Processing Capacity

First, it is argued that the information processing capability of economic agents is limited. This view is associated with the work of Herbert Simon and with his concept of bounded rationality [see Simon (1955)]. There is also an extensive literature in the field of cognitive psychology that provides experimental evidence supporting the view that human behaviour is boundedly rational. For example, the work of Tversky and Kahneman [eg. Tversky and Kahneman (1974) and Kahneman and Tversky (1984)] has questioned whether individuals behave according to the axioms of SEU theory and the Bayesian principles of learning. Their work is also important for providing support for the view that cognitive simplification mechanisms are an important feature of decision making behaviour. Hogarth (1980) presents a summary of some of the different types of judgmental biases that have been identified in experimental work and the decision making situations prone to such biases. Of particular concern within the orthodox framework of economic analysis is the role of cognitive heuristics influencing the ability of decision makers to perceive the structure of decision problems.

The unwillingness of orthodox economists to abandon the concept of substantively rational behaviour effectively reduces the impact of limited information processing capacity to its treatment as any other constraint on behaviour. Paradoxically, the behavioural (psychological) impact of limited processing capacity is eliminated by increasing the computational ability of economic agents and, thereby, moving economic models further away from the experimental evidence on human behaviour.

In highlighting the importance of limited information processing capacity cognitive psychologists emphasise that decision outcomes cannot simply be deduced from some objective specification of the decision problem. Simon (1978a) argues that it is both the task environment and the cognitive characteristics of the decision maker that determine behaviour. Heiner (1983) has used this argument as a basis for predicting behaviour in complex and uncertain task domains. The presence of a C-D gap arising from limited information processing capacity results in the emergence of regularities in human behaviour in the form of heuristic decision rules. In contrast, substantively rational behaviour implies the ability of decision makers to completely adapt to every change in the task environment. Modelling such behaviour merely provides insight into the task environment and not the underlying (regular) processes that characterise economic phenomena.

Limited information processing capacity of economic agents is now a well established critique of neoclassical economics and underpins much of recent behavioural research. However, in recognising the inability of economic agents to optimise in complex decision making tasks, we are presented with the difficulty of how information processing constraints can be incorporated in models of economic behaviour. How can we study their impact upon decision making and develop models of economic behaviour that capture important cognitive features like problem perception? We explore these issues more fully below.

(b) The Nature of Business Decision Making Tasks

A second critique of the assumption of substantively rational behaviour focuses upon the nature and structure of different decision making tasks. Within mainstream economics a distinction is not generally made between different classes of decision in terms of their impact upon the process of decision making. Indeed, given the assumption of substantively rational behaviour such a distinction has no significance. However, the business and management literature views such a distinction as essential to the understanding of business behaviour. In particular, the contrast is made between operational decisions and strategic decisions and it is argued that they are so fundamentally different that they require a different method of analysis. For example, consider the alternative approaches to the study of decision making behaviour in the operations research literature and the business policy and corporate strategy literature.

Numerous schema have been proposed for classifying decisions. For example, Ansoff (1968) distinguishes between strategic, administrative and operating decisions. Simon (1960) has classified decisions in terms of programmed or non-programmed and Gore (1964) presented a classification in terms of routine, adaptive and innovative. Mintzberg et al (1976) provide a similar dichotomy to the later work of Simon (1973) and distinguish between structured and ill-structured decisions.

It is clear that there is an element of commonality between the alternative classifications noted above. What is important is not the terminology one uses but the implication of the different types of decision for the way actual decisions are made and also for the approach that should be adopted in studying each type of behaviour. For the remainder of the discussion we shall adopt the operational-strategic classification. This is the most common distinction made in the study of firm behaviour in a number of different disciplines (though not generally in economics).

Operational decisions are routine and often repeatedly taken in business, eg production scheduling; inventory control; invoicing customers; payment of wages and so on. These decisions are typically handled with a high degree of certainty and are characterised by low cost decision processes with the emphasis upon concepts of efficiency and optimisation [Harrison (1981)].

In contrast, strategic decisions are ill-structured problems that are characterised by novelty, ambiguity and ignorance [Mintzberg et al (1976)]. In the context of the theory of the firm, strategic decisions are concerned with the scope of the firm's activities and often involve change of a significant nature. An important feature of strategic decisions is that the environment and resource position of a firm are not given and will be shaped by the firm's own strategic decisions (and those of competing firms). In the business policy literature strategic decisions are viewed as being concerned with the adaptive behaviour of the firm to its environment. In these circumstances, it is not uncommon to observe highly skilled management teams pursuing quite different strategies in what appear to be similar environmental conditions.

Strategic decisions are "messy problems" [Ackoff (1970)] and their ill-structured nature denies the relevance of the substantively rational concept of optimality. Strategic decisions cannot simply be reduced to the optimal choice of a strategy from a pre-determined set of alternatives. As with the significance of limited information processing capacity it is difficult to see how the logical consistency of the deductive techniques that characterise neoclassical economics can incorporate (meaningfully) the nature of strategic decision making tasks.

The distinction between operational and strategic decisions is not generally made in the mainstream economics literature. However, the similarity between the description of strategic decisions that can be found in the business policy literature and the discussion of the 'true' nature of uncertainty (if such a concept has meaning) in the economics literature can, we believe, be usefully developed [see Loasby (1976)]. In highlighting the significance of strategic decisions we are able to recognise the variability of human behaviour. It is possible that two individuals will behave differently in the same environmental conditions and that any one individual may behave differently in the same circumstances at different points in time. In the business policy literature the concept of a strategy is of importance because it highlights that there is some degree of choice in a particular task situation, ie. there is no pre-determined optimal strategy.

Economics has a theoretical framework for the study of uncertain behaviour (albeit based on a particular interpretation of the meaning of uncertainty). Rather than challenge this theoretical framework in terms of the meaning of uncertainty [see for example, Loasby (1976)], it may be productive to complement the existing approach with a framework that gives explicit recognition to strategic behaviour. This is, of course, the realm of the behavioural economist. However, what must be stressed is the opportunity for economists to explore the research findings and methods of the business policy and corporate strategy literature, notably the focus upon studying decision processes and the observation of actual behaviour.

Some attempts have been made to incorporate strategic aspects of firm behaviour in economic theory. For example, the work of Baumol, Panzar and Willig (1982) introduced the notions of 'market contestability' and 'economics of scope' and made some attempt to study strategic problems of the multi-product firm. Earl (1984) abandoned the neoclassical framework of analysis to develop a theory of corporate strategy that explained how firms make mistakes. Other interesting work which considers strategic aspects of economic behaviour can be found in Porter and Spence (1982); Rao and Ruttenberg (1981); Klein and Leffer (1981) and Moss (1981).

From the discussion above it is clear that one implication of the substantively rational framework of neoclassical economics is to view all decisions "as if" they were operational decisions. We define an operational decision as a problem that has sufficient structure to determine an optimal outcome. The Economics of Uncertainty, underpinned by the SEU framework, has extended the concept of substantive rationality beyond the boundaries of static optimisation under certainty [Simon (1976)]. This has not been without cost. Even without giving recognition to the impact of information processing constraints, the methodological underpinnings of substantive rationality essentially abstract away the very essence of a major set of economic problems. As Kuhn (1970 p37) has noted:

> "A paradigm can, for that matter, even insulate the community from those socially important problems that are not reducible to the puzzle form, because they cannot be stated in terms of the conceptual and instrumental tools the paradigm supplies."

A good example of where the neoclassical concept of substantively rational behaviour breaks down is the economic theory of oligopoly. Shubik (1970, p415) has described oligopoly theory as "one of the clearest examples of the malaise in microeconomics" and Simon (1976, p141) refers to economic theories of imperfect competition as a "scandal". It is not possible to identify a theory of oligopoly in economics and there are many different models of oligopolistic behaviour that attempt to address similar questions to those examined when investigating the behaviour of perfectly competitive markets. However, the precepts necessary for the application of the neoclassical framework of analysis are not satisfied within the context of oligopolistic markets. Simon (1976, p141) has argued:

> "There remains . . . a lingering reluctance to acknowledge the impossibility of discovering . . . 'The Rule' of substantively rational behaviour for the oligopolist. Only when the hope of that discovery has been finally extinguished will it be admitted that understanding imperfect competition means understanding procedural rationality."

One distinctive feature of oligopolistic markets is the interdependencies between the decision making behaviour of different firms. In addition, the fundamental characteristics of strategic decisions noted above can be clearly identified with oligopolistic market situations. Game theoretic models [eg Green and Porter (1984); Rotemberg and Saloner (1986)] provide an attempt to take account of how economic agents consider the possible reactions to their own decisions by other economic agents. However, such models have been extensively criticised [see for example, Winter (1986)] as highlighting the limitations of the orthodox concepts of equilibrium and optimality when studying the strategic behaviour of firms.

The need to complement the substantively rational framework of neoclassical economics with an approach to modelling procedural rationality is a central concern of behavioural research in economics. We now discuss some possible directions for future research on procedural rationality in economics.

2.3 BEHAVIOURAL ECONOMICS: SOME IMPLICATIONS OF MODELLING PROCEDURAL RATIONALITY

Research in behavioural economics covers a broad range of approaches to the modelling and study of decision processes. As such it is probably useful not to view behavioural economics as a separate field in economics but as an alternative way of examining traditional areas of economics research [Gilad and Kaish (1986)]. A major force in influencing the direction of this alternative approach to studying economic behaviour has been the work of Herbert Simon and the research presented in this thesis builds upon many of the arguments put forward by Simon.

In shifting from models of substantive rationality in neoclassical economics to models of procedural rationality that characterise behavioural research, we require a change in research method. The change is quite fundamental and one that requires economists to explore more fully concepts and techniques employed in the study of decision making outside the domain of economics [Simon (1978a)]. The elements of a framework for the study of procedural rationality can be found in disciplines such as artificial intelligence, cognitive psychology and business policy. There has, of course, been progress in developing such a framework for behavioural research in economics [see Gilad and Kaish (1986)] but a considerable amount of work remains to be done. This much is clear by the diversity of different styles and approaches to behavioural research.

In contrast to orthodox economists, behavioural theorists adopt an inter-disciplinary perspective in the study of decision making behaviour and emphasise the need to observe actual behaviour. The focus upon studying actual decision processes takes on increasing significance where the substantively rational choice for a particular task or problem is neither defined nor obvious given the behavioural limitations that constrain problem solving. In these circumstances, problem solving is non-trivial and will typically involve economic agents gathering and processing information in an attempt to determine a satisfactory solution to a problem.

One difficulty facing the behavioural researcher is our lack of knowledge about human decision processes. The deductive reasoning that characterises neoclassical economics is not founded upon the understanding of human behaviour that we require for developing behavioural process models. In general, inductive research methods are uncommon in the discipline of economics. Attempts by behavioural economists to investigate the contents of the 'black box' requires consideration of two particular problems:

(a) What is an appropriate theoretical language for modelling behavioural process phenomena?

(b) How should the actual decision making behaviour of economic agents be studied for the purpose of capturing the richness of detail necessary to develop behavioural process models?

In the next section of this chapter we shall consider the first problem as we look at information processing theory and the role of PS models. We examine the second problem in the following chapter. It is useful at this stage to consider the central ideas and themes of behavioural research in economics. This is important for providing an insight into the appropriate form of theoretical language for modelling decision processes.

The original work of Simon (1959) and Cyert and March (1963) are probably the best examples of the key ideas that underpin much of the subsequent research in behavioural economics. The following themes appear common to a variety of behavioural research studies (particularly those conducted from the 'Carnegie School' perspective):

- the study of behaviour in complex and uncertain environments demands the examination of decision processes. That is, decision making is non-trivial and is the result of considerable deliberation (ie procedural rationality);

- a rejection of orthodox concepts, notably equilibrium and optimising behaviour [see Gilad and Kaish (1986)] except in simple task domains where the process of decision making is trivial;

- an emphasis upon studying actual decision making processes. This focus upon inductive methods of research is in contrast to the deductive reasoning that underpins neoclassical economics. From a practical perspective this has a number of implications; for example, the collection of detailed process data by studying actual behaviour typically demands observing individual behaviour;

- research in behavioural economics is an inter-disciplinary study and attempts to be consistent with the findings of other disciplines in the study of decision making [Gilad and Kaish (1986)];

- an explicit consideration is given to elements of human behaviour as variables which are the subject of analysis, eg cognitive simplification mechanisms. This emphasises the significance of information processing constraints in determining behaviour.

An important issue facing the behavioural economist is the adoption of an appropriate language for representing and modelling decision processes in a meaningful way for studying important behavioural relationships. The rigorous use of mathematical analysis in neoclassical economics has provided the formal language for developing substantively rational models. However, from our previous discussion it is not clear that mathematics is the most suitable language for behavioural modelling [Nelson and Winter (1982)].

Cyert and March (1963) addressed the issue of identifying an appropriate theoretical language for behavioural process modelling. They suggested this language problem might be resolved through the use of computer simulation. Computer simulation models present a potentially rich theoretical language within which complex dynamic models can be represented. Indeed, over two decades of behavioural research has established computer simulation as an important tool for modelling and testing theories in economics [see Simon (1979a) and Nelson and Winter (1982)].

Whilst Cyert and March introduced the importance of computer simulation in behavioural research, they did not present a structured approach to computer based modelling. Thus, they failed to establish important conceptual links between the form of the natural language they adopted and the behavioural phenomena that underpinned their theory. Arguably, these links still remain to be established with regards the role of computer simulation in economics. In the next two sections we develop the links between a particular formalism of computer simulation models, notably PS models, and some important relational concepts that are central to behavioural research. In sum, we argue that there do exist theoretical underpinnings for the use of computer simulation programs as a formalism for representing procedurally rational models of human behaviour in economics.

The choice of an appropriate formal language is not a trivial issue. The rigorous mathematical analysis of neoclassical economics has underpinned the important concepts of equilibrium and optimality. In the process of economic theorising the nature of any abstraction in model building is fundamentally influenced by the choice and structure of the formal language used to represent the economic phenomena of interest. In part, the criticism of substantive rationality as misrepresenting the reality of actual decision making reflects the limitations of the orthodox economist's formal language - mathematics. While computer simulation allows a much richer and more detailed representation of economic behaviour than formalised mathematical modelling, the latter is much more general. The behavioural economist, attracted by the need to observe and model detailed decision processes, has rejected the analytical techniques of the neoclassical economist as a formal language and resorted to the use of computer simulation and detailed case based analysis [Earl (1984); Nelson and Winter (1982); Eichner (1983)].

The classic examples of the use of computer simulation models in behavioural research are the departmental store price mark-up model of Cyert and March (1963); Bonini's accountancy and management information system model [Bonini (1963)]; and Clarkson's protocol based model of the behaviour of an investment trust officer [Clarkson (1962)]. More recently, the seminal work of Nelson and Winter (1982) used computer models to simulate evolutionary processes for establishing the conditions necessary to generate industry equilibrium. However, it is a notable feature of the behavioural research literature that computer simulation still plays a relatively small role.

Any formal language has limitations in terms of its ability to capture interesting phenomena and relationships relevant to describing various aspects of system behaviour. Computer simulation models have been used to provide a rich and detailed insight into behavioural process phenomena; for example, the modelling of learning and adaptive behaviour; the study of heuristic decision rules; the role of multiple goals and conflict resolution. Moreover, as the work of Nelson and Winter illustrates, simulation models can also yield many of the same predictions that emerge from standard neoclassical analysis. However, it remains an important task of behavioural research to establish the link between the structure of computer simulation models as a formal language and their role for modelling behavioural process phenomena. Information processing theory provides the opportunity for establishing this link.

2.4 INFORMATION PROCESSING THEORY AND THE ROLE OF PRODUCTION SYSTEM MODELS

An important aspect of this research is the application of ideas and techniques from the fields of artificial intelligence and cognitive psychology to economics. Cognitive psychology is concerned with the study of knowledge and how people use it during problem solving. As a study of aspects of human behaviour, eg perception; problem solving; judgemental processes; thinking; and so on, cognitive psychology is concerned with generalising about the way individual decision makers process information. Indeed, the dominant approach to cognitive psychology is based on the view that man is an information processing system (IPS) [see Simon (1979b)]. The seminal work of Newell and Simon (1972) in provides a good historical summary of the development of the information processing perspective of cognition. It is not appropriate to review the origins of the information processing perspective in detail here other than to note some important aspects of its development.

The impact of the computer was fundamental to the development of information processing theories of human cognition. Indeed, computer programming languages have become a formalism for information processing models

[Simon (1979b)]. The development of computer based simulation models in the 1950's and 1960's [see for example, Newell, Shaw and Simon (1958)] began the process of integrating the findings from information processing psychology with the techniques of simulation modelling. An important aspect of this research was recognition of the similarity between man as an information processor and the computer as a symbol processor. Indeed, it is this view that has provided the basis for a wide variety of research in the field of artificial intelligence (AI) [see Waterman and Hayes-Roth (1978) and Davis and Lenat (1980)].

While there are strong links between the field of AI and cognitive psychology, it is important to distinguish their different perspectives with regards developing models of procedural rationality [Simon (1978b)]. AI is a discipline concerned with normative aspects of procedural rationality. For example, the development of expert systems as a field of research has been influenced by the normative perspective of the AI literature. AI is concerned with the programming of computers to behave in an intelligent (and human) manner, though not necessarily using the same information processes. In contrast, cognitive psychology is more concerned with how humans perform complex tasks. In this sense, cognitive simulation can be viewed as a positive science of procedural rationality and is characterised by the development of simulation models that capture the information processes actually used by humans during task performance [Simon (1978b)]. A formalism common to both AI and cognitive psychology for modelling and simulating problem solving strategies is the use of PS's and we shall describe these more fully below. It should, however, be noted that production rules are not the only form of knowledge representation adopted in the AI literature. Alternative schema include frames, semantic nets and scripts [see Garnham (1988)].

In addition to the use of computer simulation models in psychology research, there also emerged in the 1950's and 1960's a substantial body of research in information processing psychology. For example, the importance of limited capacity in human memory was addressed in the work of Miller (1956). Miller made a distinction between short-term memory (STM) and long-term memory (LTM) and provided evidence that STM is of a notoriously small capacity with a low level of information recall. The behavioural significance of limited capacity in STM can be appreciated in the context of Simon's concept of bounded rationality. Bounded rationality can be attributed to the operation of cognitive strain, where the limited capacity of the decision maker produces a state of information overload [Svenson (1979)]. Miller introduced the importance of chunking and pattern recognition as mechanisms which aid learning and help overcome the limited capacity of STM. The concept of STM is also of importance in our discussion of protocol analysis in the following chapter.

Information Processing Theory

The information processing systems perspective is not unique to cognitive psychology nor is it the only approach adopted by cognitive psychologists. The survey work of Slovic, Fischoff and Lichenstein (1977) and Einhorn and Hogarth (1981) provides a good overview of the variety of research methods in the fields of behavioural decision theory and cognitive psychology. However, the information processing framework is the dominant approach to research in cognitive psychology [see for example Lindsey and Norman (1982)]. The work of Newell and Simon (1972) is arguably the most articulated and developed version of information processing theory. They illustrate how models of human behaviour can be developed from the analysis of decision rules observed to have been used by individuals in experimental and field settings. Extensive use is made of computer simulation as a central tool for developing and testing these theories [Simon (1979a)]. The inductive base of information processing theory provides support for it as a study of how individuals tackle complex and uncertain problems (ie. it is a positive theory of procedural rationality).

Hogarth (1975) identifies two important conclusions to emerge from research on human information processing theory. First, that individuals have limited information processing capacity and, second, that decision makers can be viewed as adaptive systems. An important implication of these conclusions is that human behaviour is determined by both the structure of the task environment and the cognitive characteristics of the decision maker. Within the orthodox framework of neoclassical economics it is assumed that the information processing system (the economic agent) has the ability to discover appropriate adaptive behaviour. To predict behaviour in these circumstances simply requires information about the external environment and the system's goals (as defined by the inner environment). Significantly, orthodox economics breaks the link between substantive and procedural rationality by assuming the economic agent is always capable of selecting the right course of action.

Cognitive psychologists have a fundamentally different model of behaviour. Given the complexity and uncertainty that characterises the external environment and the limitation on the internal environment to process information - adaptation is problematic. The link between substantive and procedural rationality becomes significant and processes as well as outcomes are important to gaining an understanding of decision making behaviour. Indeed, an optimal or best strategy may simply be unknowable. In these circumstances it becomes meaningless to study behaviour by focusing upon the content of a particular decision without examining information about the way the decision was made.

It is against this background that Newell and Simon argued that the behaviour of intelligent systems can be examined by means of an information processing theory. The abstract model of man as an information processing system introduced by Newell and Simon emphasises that intelligent behaviour involves the processing of symbolic information. The model is, of course, an abstraction and assumes that man can represent the internal and external environment of a problem by symbols. A basic set of elementary information processes (eip's) for transforming symbol structures are recognised and provide the basis for intelligent and adaptive behaviour. Newell and Simon identified four key propositions in their theory:

i) a few characteristics of human information processing behaviour are invariant over task and decision maker. The identification of these invariants allows the possibility of finding regularities in behaviour and, therefore, the making of general predictions;

ii) these characteristics are sufficient to determine some important features of human behaviour. For example, a small set of basic eip's have been identified as sufficient for describing and explaining behaviour. These eip's capture the information processing behaviour of an individual in the context of the problem space perceived by the decision maker. Decision making takes place within an individual's perceived problem space;

iii) the structure of the task environment determines the structure of the problem space; and

iv) the structure of the problem space determines possible decision strategies selected by an individual.

The important distinction between a task environment and a problem space underpins the role of perception in understanding human behaviour. The task environment can be viewed as the omniscient observer's interpretation (if such an interpretation has meaning for complex and uncertain tasks) of the decision problem. The problem space represents the abstraction of the task environment as perceived by a particular decision maker. Given the presence of uncertainty and the limited information processing capacity of individuals, problem space representation is problematical. It should not, as is the case with the substantively rational framework of neoclassical economics, be an aspect of behaviour that is simply assumed away.

The importance of the problem space concept to understanding human behaviour is emphasised by Simon's distinction between ill-structured and well-structured problems [Simon (1973)]. A problem is ill-structured if it lacks definition in some sense, eg a clearly specified goal. However, Simon argues that the ill-structured/well-structured distinction lacks objective meaning. The significance of the problem space concept is that all problems are ill-structured until they are given meaning and structure by a particular individual through the internal representation of the problem space. This argument is important for understanding the value of the information processing paradigm to studying behaviour in complex and uncertain task environments and is the basis for identifying regularities in human problem solving behaviour.

The problem solving and decision making behaviour of an individual can be viewed as a path through their perceived problem space. Essentially, the particular problem space used by an individual determines what information is available and how it can be processed. The behaviour pattern of the subject can be seen in terms of a sequence of knowledge states, each of which represents the subject's total knowledge about a problem at any point in time. These knowledge states are related to each other by operators, which represent the information processing behaviour of the individual. As we shall explain more fully below, operators can be viewed as macroscopic representations of eip's. In sum, the behaviour of an information processing system (IPS) is simply the execution of a sequence of eip's. However, it is the macroscopic representation of eip's which allows an overall picture of individual behaviour to be observed in the form of decision making strategies (ie. sets of decision rules).

Information Processing Systems

An important aim of this section is to introduce PS models as one form of representing the behaviour of an IPS.

Before starting this task we shall briefly define the elements of an IPS. This provides an important understanding of the structure and design of PS models.

Newell and Simon (1972, p 20) define an IPS in terms of:

- a processor that controls the sequencing of eip's. The processor consists of:
  - (a) a set of basic eip's
  - (b) a STM that acts as a buffer for input/output knowledge states
  - (c) an interpreter or inference engine that determines the control sequence of eip's;
- effectors and reflectors that provide communication between the internal and external environment.
- a LTM (or data base) that contains symbol structures that are stored in the form of production rules, ie condition-action pairs. An information process is simply defined as an input-output relationship between a pair of symbol structures.

The link between this definition of an IPS and the description of humans and computers as symbol processors is important to the arguments of this chapter. In particular it underpins our view that PS models can be viewed as a theoretical language for developing computer simulation models of procedural rationality in economics. Many of the elements of Newell and Simon's definition of an IPS will take form in our description of the OPS production system language discussed in the next section. At this stage we simply wish to focus upon the concept of eip's and their relationship with the idea of production rules.

An important element of the IPS paradigm is the view that an individual's problem solving behaviour can be decomposed in terms of a set of basic information processing activities. Indeed, Newell and Simon (1972, p 29) identify seven primitive eip's:

- discrimination; the ability of the system to alter behaviour on the basis of the content of STM;
- test and comparison; the ability to be able to compare symbols and identify different symbol types;
- symbol creation; the ability to create new symbols;

- writing of symbol structures; the ability to add, change and delete symbol structures from memory;
- reading and writing externally; the ability to communicate symbol structures between the internal and external environment;
- designating symbol structures; the ability to ensure symbol structures do not become inaccessible;
- storing symbol structures; the ability to record symbol structures for later use.

These eip's are at the most basic level of information processing activity. From these it is possible to construct macroscopic operators that, in the context of a particular task, may provide a more meaningful description of an individual's behaviour. It is important that these eip's are observable at a sufficiently disaggregated level so as not to hide the procedural aspects of how problem solving is being carried out. Of course, at what level one chooses to model depends upon the purpose of the research and the level of detail at which information processing behaviour has been observed. For example, Bouwman (1978, 1983) has developed cognitive process models for a financial diagnostic task using operators that are more aggregated than Newell and Simon's basic eip's. Bouwman used information processing operators such as: compute a simple trend; compare with internal norm; explain; summarise and so on. While these operators could be decomposed into Newell and Simon's basic eip's, their meaning in the context of Bouwman's work related to the characteristics of the task environment facing subjects in his experimental work.

In sum, while Newell and Simon provide a sufficient set of basic eip's to model the full generality of information processing behaviour, they are likely to be considered too detailed for the purpose of procedural modelling outside the field of cognitive psychology. Task related operators are likely to provide a more meaningful interpretation of subject behaviour. This view is reinforced by recognition in AI and expert systems research that expertise is task specific [Hayes-Roth, Waterman and Lenat (1983)].

An important element of Newell and Simon's theory is the ability to capture the behaviour of an IPS in terms of a set of rules called a program. This program determines the sequence of eip's to be executed as the contents of STM change over time. The effect of eip's is captured through the production rules that reside in LTM. The matching of symbol structures in STM with the left hand side (LHS) conditions of production rules results in a particular eip sequence being activated (ie the right hand side (RHS) action of the rule). In sum, the program of rules provides us with a description of the information processes used during the solving of a problem. Such a program is known as a PS model and it is a formal approach adopted by cognitive psychologists for modelling information processing systems.

It should be clear from the discussion above that the adaptive nature of information processing systems is captured through the interaction of the short-term and long-term memories of the system. Indeed, there is no direct relationship between individual rules stored in LTM. This ability to process and manipulate symbols and symbol structures and, thereby, change the contents of human memory has enabled production systems to emerge as a formalism for the modelling of both human and computer intelligence. We shall now conclude this section with a discussion of PS models.

Production System Models

PS models have a long history in mathematics, linguistics, cognitive psychology and artificial intelligence. In the field of formal logic the work of Post (1943) is associated with the use of PS models as a general computational mechanism and in developing algebraic models of language. The research of Chomsky (1957) provides an illustration of the application of PS models for representing the differences between classes of languages. Following the work of Newell and Simon, PS's have become a formalism for describing information processing models in the cognitive psychology literature [see for example Klahr and Wallace (1976)].

PS's are rule-based models in which the control structure typically follows a simple recognise-act paradigm. A PS is simply a set of rules that describes what an individual does under what conditions and, therefore, captures the regularity in problem solving behaviour. There are three elements to a PS model [see Davis and King (1976) and Waterman and Hayes-Roth (1978)]:

- a set of production rules
- a data base
- an interpreter.

The similarity between this structure of PS models and the definition of an IPS given by Newell and Simon should be clear to see.

The PS model for a particular task is an information processing model of an individual's cognitive processes and expressed in a form capable of simulation as a computer program. The rules are of the general form:

<u>Conditions</u>		<u>Actions</u>
IF [C1, C2 . . . Cn]	THEN	[A1, A2 . . . An]

where C1 to Cn represent left hand side (LHS) conditions and A1 to An are right hand side (RHS) actions. The conditions or LHS of a production rule are symbols stored in the data base. Typically, these would be the conditions that exist at any time in the external environment. The data base corresponds to the STM of an IPS and for this reason its capacity to store symbol structures may be restricted in line with Miller's "magical number 7, plus or minus 2" [Miller (1956)]. The actions or RHS of a production rule generally result in the manipulation of the symbols stored in the data base (STM). In brief, production system execution involves scanning the LHS of each rule until a successful match is achieved with the contents of the data base. The firing of a rule is also known as rule instantiation and involves transforming the contents of the data base (STM or working memory) into a new problem space knowledge state. This sequence of matching conditions and firing rules is known as a recognise-act cycle and Figure 2.1 illustrates the basic execution process.

The third element of a PS is the interpreter or inference engine. This has direct correspondence to our use of the term in relation to the processor described in the definition of an IPS and provides the control structure for the recognise-act cycles. An important role of the interpreter is conflict-resolution - the process of determining which satisfied rule is to be fired when the LHS conditions of more than one rule match the contents of the data base. Another important and related role is providing the mechanisms for pattern matching. Different interpreters can impose different control structures on the recognise-act cycle. We shall demonstrate one such control structure in our discussion of the OPS4 interpreter in the next section.

Figure 2.1 The Recognise - Act Cycle for a Production System Model

Data Base :		C5, C1, C3		
		Condition		Action
Production Rules:	P1:	C1 and C2	---->	A1
	P2:	C3	---->	A2
	P3:	C1 and C3	---->	A3
	P4:	C4	---->	A4
	P5:	C5	---->	A5
Pattern Match				
Conflict Set:	P2:	C3	---->	A2
	P3:	C1 and C3	---->	A3
	P5:	C5	---->	A5
Conflict Resolution				
Rule Firing:	P2:	C3	---->	A2

The architecture of PS models corresponds closely to the previous description of an IPS. As Newell and Simon (1972, p892) summarise:

> "the production system was one of those happy events . . . that historians of science often talk about: a rather well-prepared formulation, sitting in wait for a scientific mission".

The explicit assumption that an IPS is organised as a PS is central to Newell and Simon's theory of human behaviour. The basis for this representation is argued on a number of grounds, though as they acknowledge, there is no proof as to the correctness of their belief. Some important features of PS models are:

- the modularity of PS rules as independent components of behaviour allows for the ease of creating and deleting rules. This is important for the modelling of adaptive and learning behaviour. In sum, production rules in LTM are related only through the data base (STM);

- PS's can display the nature of the cognitive processes that characterise human behaviour. For example, the dynamic nature of the data base corresponds closely to STM as the collection of information an individual is aware of at a particular point in time. This is important for understanding the role of protocol analysis described in the following chapter. Similarly, PS's offer a possible model of LTM;

- as a modelling framework PS's are not limited by the standard flow of control that characterises the conventional use of hierarchically organised programming languages , eg BASIC, Fortran;

- the recognise-act framework of PS's is sufficiently flexible to capture important elements and findings of stimulus-response psychology.

Newell and Simon pioneered the early application of PS's for cognitive modelling in the task domains of chess and cryptarithmetic. There have also been applications of PS modelling techniques for the development of performance orientated models. These knowledge based expert systems have been extensively discussed in the AI literature [see for example Winston (1984)]. The most well-known system is MYCIN, a PS model developed to provide consultative advice on the diagnosis and therapy of infectious diseases [see Shortliffe (1976)]. Another example is DENDRAL, a system designed to examine spectoscopic analysis of an unknown molecule and predict the molecular structures that could account for that particular analysis [see Lindsay et al (1980)].

There are two distinct classes of PS models in the literature [Davis, Buchanan and Shortliffe (1977)]. First, the application of PS's to cognitive modelling. Much of this research is based on Newell and Simon's work that views PSs as a theory of human behaviour. The purpose here is to simulate the behaviour of an individual with a minimal set of production rules. The production rules capture the regularity in an individual's information processing behaviour. In this use of PSs the researcher is concerned to try and reproduce all aspects of an individual's behaviour.

A second class of PS models is concerned with developing performance orientated models (ie. expert systems). They can be classified as 'impure' PS models which simply use rules to represent knowledge about a particular task domain. Similarity between actual human behaviour and the behaviour of the system is not important. The field of expert systems adopts this perspective in the application of PS models though, as we noted above, other forms of knowledge representation are also used in experts systems modelling. The production rules of a knowledge based expert system will typically be constructed from observing the behaviour of several experts in a particular task domain. No attempt is made to build a cognitive model of a particular individual but simply to develop a system that displays competent behaviour comparable (and hopefully better) than that of a human expert. An important aspect of an expert system model is its ability to reason and explain its behaviour.

In this research we are concerned with the use of pure PS models for developing models of procedural rationality. However, it needs to be recognised that the building of pure PS models may also have a number of spin-offs with regards developing expert systems. For example, in the process of developing a pure PS model the researcher will typically gain an insight into the nature of problem solving expertise and judgement for a particular task. In the field of business decision making, where so little is understood about management decision making processes, exploratory research in building pure PS models is likely to benefit the longer term development of expert systems.

In the next section we shall illustrate the use of PS models for simulating adaptive firm behaviour. However, first we shall briefly examine the role of PS models as a theoretical language for underpinning the use of simulation for developing behavioural process models in economics.

The close link between the information processing paradigm of human problem solving and the concern of behavioural economists with procedural rationality has been highlighted above. PS's have emerged as a methodology for modelling procedural rationality because their structure corresponds closely to the elements of human information processing theory. Moreover, the ease of translation of PS models into computer programs has reinforced their value in cognitive modelling. Within Newell and Simon's theory of human problem solving regularities in behaviour emerge through the creation of heuristic decision rules (production rules) that reflect the particular expertise, skills and goals of the decision maker. Different decision making strategies can be viewed as a self-contained collection of decision rules. Moreover, decision strategies can adapt and change over time.

The condition-action structure of production rules captures the adaptive nature of human behaviour. Which particular sequence of rules fires depends upon the environmental conditions that are perceived and stored in the data base at any point in time. The set of production rules (or program) guides the problem solving behaviour of the model and represents the problem space search activity that drives an individual decision maker to achieve a goal state. The limited set of production rules that describe the behaviour of an IPS highlight the significance of bounded rationality. The modularity of PS models provides a flexible framework within which adaptive behaviour can be modelled by the addition of new productions to the rule base.

The operators (information processing activities) that form the RHS actions of production rules are made up of a set of eip's. The work of Huber (1980) and Johnson and Payne (1985) provides a good illustration of the development of Newell and Simon's theory regarding the decomposition of heuristic choice strategies into a set of basic eip's. For the behavioural economist, the concept of a heuristic decision rule or strategy is likely to be a more meaningful representation of behaviour than the use eip's. However, the concept of an eip is significant for a number of reasons.

The information processing activities implied by Newell and Simon's basic eip's correspond closely to the symbol processing capabilities of computers. The ability of computers to read, write, compare and move symbols in memory can be translated in terms of the previous discussion of the role of eip's in information processing theory. One consequence of this is the ease with which PS models can be represented in the form of computer simulation models. This argument underpins the use of computer simulation as a theoretical language for PS models and follows from the symbol processing similarity of humans and computers. Of course, it is still recognised in the AI and cognitive psychology literatures that humans can still do things which computers can not.

The concept of eip's is also of value in terms of providing an underpinning for the interpretation of a set of decision rules as a model of human behaviour. In brief, decision rules can be thought of as sequences of information processing activities which are applied as an individual moves from one knowledge state to another in a problem space. This perspective might also be helpful for developing measures of decision making performance eg. measuring the information processing effort implied by different combinations of eip's (decision strategies).

In applying the PS framework of modelling, behavioural economists face a number of difficulties and problems. First, there exists a range of different PS methodologies in the literature. Simon (1979b) presents a discussion of some different approaches that have been taken to PS architecture in information processing research. Some important issues are concerned with the specification of conflict resolution strategies, algorithms for pattern matching and the level of detail at which knowledge state operators should be specified. Many of these issues relate to the control structure that resides in the PS interpreter and, despite extensive discussion in the AI and cognitive psychology literatures, there has not emerged a consensus on the design structure of PS models. A similar problem exists with regards the programming languages that have been used to model PS's. Indeed, from outside the fields of artificial intelligence and cognitive psychology it is difficult not to view this problem as reflecting differences in programming style between researchers. Important experimental research into the cognitive psychology of economic agents is beginning to generate the kind of evidence that will allow the future development of PS interpreters specifically for modelling economic behaviour. This is likely to be an important direction for future research.

A second difficulty in developing PS models is the identification and representation of production rules. This is an issue that is pertinent to behavioural research in general and we address the problem in the next chapter. One approach is to incorporate hypothetical rules based on the output of theoretical models, eg the expected value rule. The work of Johnson and Payne (1985) provides an illustration of this approach. However, following our earlier discussion, an important characteristic of behavioural research is the elicitation of production rules from the direct observation of behaviour. In the cognitive psychology field PS modelling is associated with the analysis of verbal protocols collected while observing human problem solving behaviour. Protocol analysis provides a framework of analysis for extracting production rules from recordings of verbal thought processes. The methods of protocol analysis are introduced in the next chapter. Importantly it is a technique that supports the PS framework of modelling discussed in this chapter.

A development of the previous point is that it must be possible for the behavioural researcher to be able to observe and write such judgemental rules. This requires that decision makers are able to report their knowledge and experiences in a form that allows the researcher to express it as rules. It is unlikely, therefore, that every task domain will support the use of PS rules as a means of modelling human behaviour. We explore this issue in the next chapter but there are some obvious points worth making at this stage. For example, trivial tasks that are highly formalised are unsuitable for PS modelling [Davis, Buchanan and Shortliffe (1977)]. Equally, tasks should not be so complex and ill-structured as to deny some level of formalism; since subjects would be unable to bring expertise or skill to the problem and regular patterns in behaviour would be difficult to observe.

This completes our discussion of the nature of PS models. PS's have an architecture which, in general terms, corresponds closely to the elements of information processing models of behaviour. However, information processing theory emphasises the adaptive nature of decision making. As Simon [(1979b), p371] argues:

"Production systems also show great promise for modelling learning processes, for it is not hard to construct adaptive production systems that are capable of generating new productions and adding these to the system."

We demonstrate this point in the next section and use this as an illustration of the application of PS simulation modelling to economics.

2.5 PRODUCTION SYSTEM MODELS: AN APPLICATION TO LEARNING

Adaptive Production Systems and the OPS4 Environment

The discussion in this section is based upon a relatively simple simulation model developed in Rae and Reynolds (1983). The adaptive PS model presented in this section is of a firm making pricing and output decisions in a duopolistic environment. We describe the behaviour of the firm in terms of a changing set of decision rules which reflect the dynamic nature of the market conditions in the simulation model.

PS models provide a particularly powerful framework for the modelling of learning behaviour in economics. Within HIP theory individual decision makers are viewed as having a collection of production rules (condition-action pairs) that reside in long term memory (LTM). These rules have been formed as a result of their past experience in a particular task domain. For some task domains it is conceivable that the content of LTM remains static, reflecting the simple and unchanging nature of the environment. However, many real world decision making tasks are not of this nature and in these circumstances we can view the PS rule base as being dynamic.

For the modelling of learning behaviour we need a framework that allows for the creation of new symbol structures (ie the RHS and LHS elements of production rules) and their storage in LTM. In this way the behaviour of an IPS includes its ability to add, modify and delete rules from LTM. Learning in this context can be associated with the rate of change of the rule base and the ability of the system to create appropriate rules in response to knowledge states for which the PS model has no previous experience (ie no production rules currently exist in the rule base).

An early example of the feasibility of modelling learning using PS's can be found in Waterman (1970, 1974). Waterman's work was concerned with the development of adaptive PS models for learning to play the game of poker skilfully. The important feature of PS models is that production rules represent independent components of behaviour and it is this modularity that makes the creation and deletion of rules from LTM straightforward. Given the structure of production rules, there are a number of possibilities for different types of rule adaptation and we can view the impact of learning as taking place in three principal ways:

- create new rules
- delete existing rules
- modify existing rules.

Moreover, the modification of existing rules covers a variety of different types of learning. For example, modification could include the changing of only LHS conditions - either totally or partially. Similarly, learning could be restricted to modifying only RHS actions. The potential for exploring a variety of different learning mechanisms opens up the opportunity for much interesting work beyond that described below. We shall discuss possible future developments at the end of this section.

Modelling learning within a PS framework simply requires that there are production rules with RHS actions that are not restricted to modifying the contents of working memory. In essence, it must be possible for the PS to remove elements from working memory and assemble them into production rules which can then be added to the existing rule base. McDermott and Forgy (1978) have stressed the important role of the PS interpreter for ensuring both the sensitivity and stability of the system in self modification. There are numerous conflict resolution strategies that have been used to guide a PS's learning ability, eg priority ordering, special case rules, recency rules and so on. Moreover, a variety of PS languages have been developed for the purpose of modelling cognitive behaviour and, as each has generally been built around a different control structure, they all have different capabilities in terms of self-modification. Some well-known examples of PS languages are PSG [Newell and McDermott (1975)]; ACT [Anderson (1976)]; and OPS [Forgy (1979)].

The model described below was developed using the OPS production system language developed by Forgy at Carnegie-Mellon University, Pittsburgh USA. We shall now briefly describe some important features of the OPS PS language.

This description of OPS is based on a version known as OPS4 which was obtained from Carnegie-Mellon University and implemented at the University of York (UK) on a DEC-10 system. OPS was developed as a PS interpreter for modelling human behaviour and cognitive processes. The framework for translating and firing production rules in OPS is a forward chaining system (ie antecedent driven) with the rules expressed in a simple IF-THEN format. Rules are stored in 'production memory' (this performs a similar function to LTM described above) and the data (symbols) against which production rules are matched is held in 'working memory' (equivalent to the previous description of STM). The inference engine for OPS follows the familiar recognise-act cycle and provides the control mechanism for pattern matching and conflict resolution in the firing of production rules.

OPS4 is implemented in MACLISP, a dialect of LISP. For the purpose of modelling with OPS it is necessary to obtain a good working knowledge of LISP - particularly the nature of LISP data types and the handling of strings. We shall not describe further the syntax of either LISP or OPS. The interested reader should consult Winston and Horn (1984) for a thorough discussion of LISP programming techniques. Forgy (1979) provides a detailed account of the OPS production system language.

The basic advantage of languages like LISP (and also PROLOG) for AI and cognitive modelling is the facility to write programs that can easily manipulate logical expressions and lists. This provides a number of advantages over languages like BASIC and FORTRAN for developing symbolic computer programs. In particular, the structure of LISP code is identical for both functions and data so that data symbol structures can be programs and vice versa. Production rules can be simply viewed as lists of symbol structures which can generate new symbol structures to be placed in either production or working memory. In the former case we have rules that are capable of generating new rules. This facility of LISP to treat data and program code as lists of symbols has been the basis for research in developing computer programs that are capable of generating the code of other computer programs.

While languages such as LISP and PROLOG have dominated AI research, it is clear that PS models can be given equivalent form in a number of different programming languages. A good illustration of this point can be found in James (1984) where the application of AI techniques for the development of expert systems is illustrated using the BASIC programming language. Another example is the expert system shell Leonardo that has been developed by Creative Logic (UK) and written in Fortran. However, a notable deficiency of these conventional language based PS frameworks is their inability to model learning.

The OPS4 interpreter incorporates two functions through which a PS model can modify the contents of PS memory. These two functions are <BUILD> and <EXCISE> (all function calls in OPS are represented in angular brackets). The <BUILD> function takes one or two arguments and will typically include a production name and a list which evaluates to a production rule that is compiled and added to production memory. The <EXCISE> function takes any number of arguments which evaluates to production names that are removed from production memory. Both the <BUILD> and <EXCISE> functions are central to our model of firm learning behaviour described below.

Finally, it is useful to describe the conflict resolution strategies that are built into OPS4. These determine which instantiated rules from any conflict set will be fired. Given the modularity of production rules and the fact that they reside in production memory in an unordered fashion, conflict resolution is an important part of the OPS4 control structure. An important feature of OPS4 is the tags kept on the age of working memory elements and production rules. This allows the interpreter to monitor the most recent elements that have been added or reasserted to working memory. The basic algorithm in OPS4 is to make the PS attend the most recent data in working memory and give preference to productions that are more specific with regard to the LHS of the rules. To sum, Forgy's OPS4 interpreter chooses which rule to fire by applying in order the following five conflict resolution rules:

(a) order conflict set instantiations on the basis of the age of working memory elements; if no rule dominates then -

(b) order remaining rules on the basis of the number of condition elements contained in a production rule's LHS. Production rules with a greater number of elements dominate;

(c) if no dominant rule results from (b), then rules are ordered on the basis of the number of constant symbols contained in a production rule's LHS;

(d) should no rule dominate after (c), then the production rule most recently added to production memory dominates;

(e) finally, the failure to identify a dominant rule to fire from (a) - (d) results in the interpreter selecting an arbitrary rule to fire.

It is not difficult to see how PS languages developed to model firm behaviour might incorporate conflict resolution strategies that reflect cultural, political and organisational factors in their control structure.

A Production System Model of Firm Learning Behaviour

The PS simulation model described below was developed using the OPS4 production system language and contained three basic elements:

(a) Dynamic Market Environment: the model simulates the pricing and output behaviour of an entrant firm in a duopolistic market environment. The market environment is dynamic and changes over the 400 period cycle of the simulation.

The entrant firm is competing against three other firms which are operating a price cartel. All firms in the industry produce a single homogeneous product and the new entrant does not have any advantage or disadvantage in terms of cost and technology relative to the firms in the cartel. In sum, there is no possibility for product differentiation in the model or for firms to exploit differences in cost structure. Given the oligopolistic nature of the market environment these are aspects of corporate behaviour that could usefully be incorporated in further development of the basic model. The dynamic nature of the market environment is captured through the uncertainty surrounding the behaviour of the cartel and the nature of market demand.

The function representing market demand is a logistic curve and its specific form captures the effect of both the product life cycle concept and the impact of consumer price expectations on market demand. Specifically, total market demand goes through three broad phases: a product development phase; a growth phase; and a product maturity phase. There was no market decline phase incorporated in this particular simulation model. Consumer price expectations were captured by shifts in the logistic curve depending on whether firms in the industry priced at below, above or equal to the expectations of consumers. For the purpose of this model, the price expectations of consumers declined over the length of the product life cycle. This seems plausible and implies that high price strategies might be sustainable in the growth phase of the life cycle by being successful in terms of achieving market share and satisfactory profits. In contrast, the mature phase of the life cycle would suggest stable or even declining price strategies being the 'norm' for firms operating in the industry. While we would expect this to be the case, the entrant firm has no a priori knowledge of what pricing strategy rules are likely to be successful in particular market conditions.

The pricing behaviour of the cartel is modelled as being reactive and non-aggressive. This simply involved adjusting the previous period's price according to whether the cartel's market share in the previous period had increased, decreased or remained constant. This was a mechanistic pricing strategy that did not allow for the possibility of the cartel trying to anticipate the pricing and output strategy of the entrant firm or for collusion. Equally, the entrant firm's behaviour was not modelled with any assumed knowledge of the behaviour of the cartel.

In sum, market share for the entrant firm was a function of total market demand, level of production, the number of firms in the industry and the price strategy of the entrant firm relative to that of the cartel. If the entrant firm and cartel priced equally, market share would be identical for all firms in the industry. While this is valid for the simple conditions incorporated in the present model, it is clearly a gross over-simplification of oligopolistic market conditions in reality.

(b) Accounting and Performance Information System: both the entrant firm and the cartel faced a complex and uncertain market environment and there was relatively little feedback information. For the illustrative purpose of this simulation model, the information elements that provided feedback to both the cartel and the entrant firm were restricted to:

- profit performance
- market share
- market price data
- cost and production data
- stock levels

These knowledge elements essentially provide the structure to the problem space 'perceived' by the firms in the industry. It also reflected upon the assumed objectives of a satisfactory level of profits and the maintenance of market share. While the detail is not crucial to our discussion here, it needs to be stressed that the specification of these knowledge elements (together with defining what possible decision strategies can be made) has the effect of restricting the type of learning that can be modelled. For example, we have limited (quite deliberately) the set of possible knowledge elements that form the LHS conditions and RHS actions of production rules. Clearly, there is scope for developing much richer models of learning behaviour than that presented here.

(c) Decision Rules: the entrant firm was required to make pricing and output decisions for each period of the 400 period simulation run. Production rules for output decisions were 'given' to the entrant firm. Failure to match production with demand resulted in the entrant firm incurring stockholding costs or loss of market share. Output was simply increased, decreased or held constant with the objective of maintaining a 10% buffer stock in relation to the previous period's level of sales.

The main focus of the simulation model presented in Rae and Reynolds was upon the learning behaviour of the entrant firm with regards pricing strategy. On entering the industry, the entrant firm had no experience as to the likely success of different pricing strategies (described below). The entrant firm is required to learn and adapt its behaviour to changing environmental conditions. The nature and extent of any learning behaviour would be reflected in changes to the firm's rule base. Clearly, in a highly dynamic and uncertain market environment we would expect the rule base to change regularly as the firm adapts its behaviour. In contrast, an unchanging market environment would be characterised by a relatively stable rule base.

For illustrative purposes structure was placed upon the form of learning by the entrant firm. However, this could be relaxed in a more complex model. The possible price strategies of the entrant firm were limited to:

- increase price by 10%
- hold price constant
- decrease price by 10%.

While the role for standard pricing rules in business is well established in behavioural research, the choice of the 10 per cent rule in this case is not based on direct observation. Clearly, it would be very straightforward to increase the range of possible price changes that could be considered by the entrant firm. This simply has the effect of expanding the set of possible RHS actions that can be used to define production rules. Moreover, the present model could be extended to allow for the entrant firm to learn an appropriate percentage rule to apply in particular market conditions.

With regard to the LHS condition elements that the entrant firm considered in forming pricing strategy production rules, we again simplified the range of possibilities. For this purpose the entrant firm evaluated a pricing strategy in terms of its impact on the level of sales. In this sense, the model defines which elements of the firm's environment are relevant to determining its behaviour. An interesting development of the basic model would be for the entrant firm to learn which knowledge elements should form the LHS conditions of production rules. In the present model it is the current price and sales conditions and their relationship to previous conditions which form the basis of the LHS conditions of production rules.

From Figure 2.2 below we can see there are nine possible combinations of environmental conditions for which the entrant firm can develop pricing strategies. Together with the three different pricing strategies (RHS elements) there are in total 27 possible production rules that could be developed by the entrant firm. However, given the unlikely circumstances of market sales ever remaining constant in a period, there were only 18 different production rules likely to be developed. As we shall see below in discussing the results from the simulation run, only 15 of these rules were actually developed during the 400 period simulation.

Figure 2.2 Possible LHS Condition Elements of Production Rules

		Knowledge Element	
		Pricing Policy	Change in Sales
LHS	1	INCREASE	INCREASE
	2	INCREASE	DECREASE
	3	INCREASE	CONSTANT
	4	DECREASE	INCREASE
	5	DECREASE	DECREASE
	6	DECREASE	CONSTANT
	7	CONSTANT	INCREASE
	8	CONSTANT	DECREASE
	9	CONSTANT	CONSTANT

The LHS conditions presented in Figure 2.2 are the basis for the entrant firm recognising the current "state of the world" and developing an appropriate response in terms of pricing strategy. Initially, the entrant firm has no experience or indication as to the likely success of any of the pricing strategies and in consequence is assumed to behave randomly. This is a rather simplistic view and is adopted to highlight the discovery aspect of the entrant firm's behaviour.

In applying a price strategy to a new environmental situation, a price rule is established which is stored in production memory using the OPS4 <BUILD> function. This new rule will then be retained in production memory providing that when it is fired it achieves the entrant firm's objectives of maintaining or increasing sales and a satisfactory level of profit. If the application of a price strategy rule is unsuccessful (a reduction in sales) on three consecutive firings, it is then removed from production memory by the <EXCISE> function in OPS4. The excised rule is then replaced with an alternative price strategy rule for these particular environmental conditions. While this is a simple learning mechanism it serves to illustrate the use of the PS framework for modelling adaptive behaviour.

An example of the basic structure of the pricing strategy production rules developed by the entrant firm is given below:

(G279 Pd 154)

IF

PRICE LAST PERIOD = CONSTANT; AND
SALES = DECLINED

THEN

PRICE THIS PERIOD = CONSTANT

All rules that were generated in the simulation run were of this format: G 279 is the rule identifier; Pd 154, the period in which the rule was built; the remaining information is the familiar LHS conditions and RHS actions of the rule.

Early in the simulation run new LHS conditions were experienced and this resulted in the creation of new production rules. Only one price strategy was employed by the entrant firm for a given set of LHS conditions. As unsuccessful rules were excised from the rule base, new rules with the same LHS conditions were generated but with a different RHS action. The PS model for the entrant firm had a 'memory' in the sense that if a particular RHS action (strategy) was unsuccessful, it was replaced with one of the remaining strategies that had not been tried for that set of LHS conditions. If all three alternative price strategies had previously been tried then the cycle starts again with a random selection. A more sophisticated mechanism could have easily been incorporated; for example, allowing the entrant firm to generalise upon its past experience and develop a smaller rule base of more general and successful rules.

From the previous discussion it should be clear that at any one time six production rules were held in production memory by the entrant firm. Moreover, given the dynamic nature of the market there was the possibility of previously excised rules being re-introduced into the entrant firm's rule base. No rule, therefore, was permanently excised from the rule base. This seems reasonable given that strategies are likely to be successful under different environmental conditions and at different points in time.

Finally, it needs to be stressed that the entrant firm did not have any a priori notion of what was a good or bad pricing strategy under particular market conditions. The firm had to discover this through experience. Rules that survived for long periods of time and were fired successfully under different market conditions could in a sense be viewed as being robust rules. However, the incorporation of a greater range of possible strategies available to the entrant firm would have allowed more meaningful inferences to be made on the nature of good and bad pricing strategies.

A Production System Model of Firm Learning Behaviour: Results

The output from the simulation model described above provided a number of different insights into the behaviour of the entrant firm. Detail can be found in Rae and Reynolds (1983). In this section we shall limit our discussion to the behaviour of the entrant firm's rule base and how this changed over the simulation period.

Given the description of the model, it was expected that learning (adaptation of the rule base) would reflect the level of uncertainty in the market environment. This was indeed the case over the 400 period simulation with the rate of change in the rule base declining as market conditions stabilised. In total, the entrant firm built some 38 production rules during the simulation run with 32 of these being excised at some point from the rule base. The random elements of market demand and the cartel's pricing strategy ensured that the entrant firm changed its rule base throughout the simulation. The rule base changed at a constant rate for the second, third and fourth one hundred period blocks - 8 rules per one hundred periods. As we expected, the entrant firm had to adapt and learn at a rapid rate in the first one hundred decision periods. This was the period when market conditions were at their most dynamic. During this stage a total of 14 rules were built in an attempt to find rules that produced satisfactory levels of market share and profits. Figure 2.3 provides a summary of the price strategy production rules that were built by the entrant firm during the simulation. This figure also provides insight into the frequency with which particular rules were fired and the length of time they resided in the rule base. There were in total fifteen types (different LHS conditions) of price strategy rule built by the entrant firm.

Figure 2.3 Production Rule Firings During Learning Model Simulation Run

LHS Conditions		RHS Action	No of Times Rule Fired	No of Periods Rule Survived
Price Change	Sales Change	Price Strategy		
CONSTANT	INCREASE	INCREASE	11	65
CONSTANT	CONSTANT	CONSTANT	11	28
CONSTANT	INCREASE	DECREASE	67	301
CONSTANT	DECREASE	INCREASE	6	27
CONSTANT	DECREASE	CONSTANT	57	225
CONSTANT	DECREASE	DECREASE	44	127
DECREASE	INCREASE	INCREASE	6	24
DECREASE	INCREASE	CONSTANT	56	254
DECREASE	INCREASE	DECREASE	43	125
DECREASE	DECREASE	CONSTANT	6	354
DECREASE	DECREASE	INCREASE	6	6
DECREASE	DECREASE	CONSTANT	18	136
DECREASE	DECREASE	DECREASE	62	247
INCREASE	INCREASE	INCREASE	6	275
INCREASE	INCREASE	DECREASE	1	118

From Figure 2.3 we can gain an insight into the pricing strategies that were more robust for the entrant firm given market conditions and the simple learning mechanism incorporated in the model. This could be done using a number of different measures, eg the length of time the rules for a particular price strategy survived in production memory or the number of periods a particular price strategy rule fired. For example, 54.5% of rules fired were for decreasing price and 38.5% for rules that held price constant. Only 7% of rules fired resulted in increases in price.

In considering the pricing strategy rules fired by the entrant firm it can also be seen that two sets of market conditions appeared to determine the strategic behaviour of the firm:

Market Condition	Number of Rules Different Built
Price Constant/Sales Increase	13
Price Decrease/Sales Increase	9
Price Constant/Sales Decrease	6
Price Decrease/Sales Decrease	7
Price Decrease/Sales Decrease	1
Price Increase/Sales Increase	2

In terms of RHS actions some 14 rules were built for decrease price; 14 rules for hold price constant and 10 rules for price increase strategies.

Despite the very simple trial and error learning strategy incorporated in this simulation model, the behaviour of the entrant firm appears intuitively quite reasonable. The significance of pattern recognition and feedback in identifying satisfactory decision rules is clearly illustrated by examining the match between LHS conditions and RHS actions in the rules built by the entrant firm. Not surprisingly, increasing price was the least successful strategy. This is reflected in both the short period of time for which price increase rules resided in memory and in terms of the rules left in the rule base at the end of the simulation. One half were for decreasing price and the remainder for holding price constant. Given the nature of the product life cycle, this is exactly the type of behaviour we would have expected the entrant firm to discover.

The results from the simulation model of the entrant firm's behaviour are not surprising and they do not yield any novel insight into actual decision making behaviour. However, the discussion above does provide an illustration of the richness of a PS modelling framework for behavioural research. For example, if the nature of the market environment or the behaviour of the cartel had been different, we might expect the adaptive behaviour of the entrant firm to change, eg converge towards a different set of relatively successful rules. PS models of this type may prove useful for discovering the robustness of particular strategies for a variety of different environmental conditions.

There are a number of directions in which the PS model described above could be extended. For example, we have taken a rather limited perspective of the nature of the learning mechanism assumed for the entrant firm. We restricted the range of knowledge elements that formed the LHS conditions of production rules and, therefore, determined the behaviour of the firm. A more complex model might have incorporated learning mechanisms for determining which elements of the environment should be scanned each period. This is an important feature of firm behaviour in the real world and highlights that good decision making strategies are not simply about RHS actions but are also concerned with identifying the relevant environmental variables to monitor. The ability to discriminate between various environmental stimuli is an important aspect of problem perception.

Similarly, the RHS actions of the entrant firm were restricted to simply increasing or decreasing price by 10% or holding price constant. The set of price change strategies could have been expanded, as could the range of decision strategies in general. For example, the entrant firm might have been modelled to learn about an appropriate price adjustment factor in different market conditions rather than simply apply the standard 10% rule. We could also extend the range of strategies to include other marketing mix variables eg. advertising expenditure.

A more ambitious development, and one that seems quite feasible within a PS framework, is the exploration of how corporate strategy develops within firms. There are a number of interesting features of PS models that make such research possible. In the context of oligopolistic markets this would allow the behavioural economist to explore important issues regarding market processes and structure. For example, the modelling of the adaptive behaviour of several firms could be achieved by 'dividing' the working and production memory within an OPS4 type environment. This opens up the possibility for modelling rivalrous behaviour where competing firms are not only adapting to a changing market environment but also to each other. The PS framework could also open up the opportunity for studying organisational behaviour. Departments or groups within an organisation could be modelled as separate production systems and conflict resolution could be incorporated to reflect the various cultural and power relationships in the organisation.

The adaptive PS framework may also provide the opportunity to investigate good and bad strategic decision making behaviour within firms. An important theme in the business policy and corporate strategy literature is the need for firms to adapt to changing environmental conditions. There is extensive anecdotal and case evidence that provides examples of the good and bad implementation of corporate strategy. With the PS modelling framework presented in this chapter we could examine this area in a number of interesting ways. For example, bad corporate decisions could be related to both the structure of production rules, the adaptive nature of the rule base and the control structure implicit in the interpreter. Differences in problem perception could be reflected in the content and form of the elements that make up the LHS and RHS of production rules. We shall use this feature of PS models to consider problem perception much more explicitly in later chapters of this thesis.

The failure of firms to adapt to changing environmental decisions can be captured through a static rule base, ie when learning stops or an adaptive mechanism that is deficient relative to other firms in the industry. For example, we might associate experience and skill with the ability of firms to generate more robust and general rules rather than a rule for every set of circumstances experienced. In the simple entrant model this was not done. However, a more complex model might incorporate rule generalisation as one mechanism for representing how firms capture experience in a relatively small rule base.

In sum, PS models provide the scope for investigating a host of economic phenomena that are conventionally excluded from orthodox economic modelling, eg competitive market strategies; industry and market evolution; corporate mistakes and so on. We do not claim that these issues cannot be examined using models developed within alternative frameworks. However, PS models and their link with information processing theory provide a very rich modelling framework (as we have demonstrated with respect to learning) for studying procedural aspects of decision making in economics.

2.6 CONCLUSION

In this chapter we have examined the implications of moving from the substantively rational framework of neoclassical economics to adopting the procedurally rational framework of behavioural economics. We have argued that there are two related issues of concern in behavioural research. First, computer simulation has emerged in the literature as a language for representing behavioural process models in economics. Despite the early use of computer simulation in behavioural research its role as a theoretical language for behavioural economics has not been fully developed.

Drawing upon information processing theory we have introduced PS's as a framework for developing models of procedural rationality. We have illustrated the flexibility of PS models for studying important behavioural phenomena, eg learning. PS's provide an underpinning for computer simulation as a theoretical language for representing behavioural process models in economics.

A second and related issue concerns the need to observe actual decision making behaviour. This is important if we are to discuss how individuals use and process information in decision making. However, the structure and content of PS models suggests the need for detailed behavioural data (ie. to observe production rules). How are we to collect such data? Under what conditions are economists able to observe behaviour in such detail? We address these issues in the next chapter and examine the combined role of protocol analysis and laboratory experiments in economic research.

CHAPTER 3

OBSERVING ECONOMIC BEHAVIOUR: THE ROLE OF PROTOCOL ANALYSIS AND LABORATORY EXPERIMENTS

3.1 INTRODUCTION

In the previous chapter we introduced the information processing paradigm of human behaviour as underpinning the role of PS's as a theoretical language for modelling procedural rationality. An important element of a PS model is the set of production rules that describe an individual's behaviour in a particular task domain. If models of procedural rationality are to have behavioural content we need to be able to derive a set of production rules from observing the problem solving behaviour of actual decision makers.

The need to study human decision processes is central to the behavioural research programme in economics. The early work of Cyert and March (1963) emphasised the importance of studying actual decision processes as a basis for providing empirical content to behavioural models. More recently Gilad and Kaish (1986, p xix) have argued that:

> "Economic theory should concentrate on and be able to explain real observed behaviour. This shift in emphasis to what actually happens rather than the logical conditions necessary for things to happen unites behavioural economists in a quest for a stronger descriptive base to economics".

Similarly, Winter (1986, p 152) in discussing the research programme on the behavioural theory of the firm, argues that one of the most significant characteristics of this area of inquiry is:

> " "asking businessmen what they do", that is, finding out how things are done by asking those who are closely involved in doing it".

In this chapter we examine the difficulties and problems associated with building PS models by deriving production rules from the direct observation of actual decision processes. Two particular and related problems are of central concern. First, the need to model human decision processes within a PS framework requires a high density of behavioural data. In addition to a method for collecting such data, we require a structured approach to its analysis. The output of such an analysis should be an information processing model of subject behaviour that can be represented in the form of a PS model and simulated on a computer. In the next section we shall introduce the technique of protocol analysis and examine its relationship with PS modelling. The link between the information processing paradigm and protocol analysis in cognitive research is central to the arguments developed in this and the previous chapter. We also examine the limitations of protocol analysis and consider the necessary conditions for the validity of verbal protocols as behavioural data.

A second problem faces all behavioural researchers concerned with observing actual decision making processes. That is, under what circumstances should 'real' behaviour be observed? For example, in studying firm behaviour there are a number of possibilities: structured interviews of management; scrutiny of internal documents and memoranda; questionnaire and survey research; case study analysis; and the 'unobtrusive' observation of actual management behaviour in the laboratory or the field. Clearly, behavioural research will progress by the use of alternative approaches to observing behaviour and no single method can be said to dominate any other in all circumstances. However, in what sense are some of the methods noted above concerned with the direct observation of actual behaviour? To what extent are they able to provide the process detail necessary for developing PS models? Is simply asking businessmen what they do sufficient for developing the type of information processing models of human behaviour that we described in the previous chapter?

After introducing the technique of protocol analysis we link its role with the use of laboratory experiments in economics. The precedent for this relationship can be found in the cognitive psychology literature. Specifically, we argue that the conditions validating verbal protocols as behavioural data are more likely to be satisfied within the controlled environment of a laboratory setting. While laboratory experiments have their limitations, they also provide an important vehicle for the unobtrusive observation of actual behaviour. In sum, an important theme in this thesis is to bring together PS models, protocol analysis and laboratory experiments as an approach to developing models of procedural rationality in economics.

3.2 PROTOCOL ANALYSIS AND ITS RELATIONSHIP WITH PS MODELLING

The focus upon procedural rationality in behavioural research requires the use of techniques to aid the study and modelling of human decision processes. Verbal protocol analysis is one example of a range of process tracing techniques that are concerned with identifying the information processing regularities in decision making behaviour. Other examples include recording eye movements during problem solving [eg Russo and Rosen (1975)] and explicit information search techniques such as using information display boards [eg Payne (1976)]. Verbal protocol data can either be collected concurrently during the actual performance of a task [eg Newell and Simon (1972)] or retrospectively after the task has been completed [eg Nisbett and Wilson (1977)]. In the research described in later chapters we have, following the arguments of Ericsson and Simon (1984), made use of concurrent verbal protocols.

Protocol analysis has been used extensively in cognitive psychology research and it is a methodology that is associated with Newell and Simon's information processing theory of human behaviour. The collection of verbal protocols requires asking a subject whose behaviour is being observed to 'think aloud' during the performance of a task. No attempt should be made to direct the verbal data to be produced by a subject. For example, it is inappropriate to ask a subject to explain or theorise upon his/her actions. The researcher should provide brief and simple instructions asking decision makers to verbalise whatever thoughts emerge during problem solving. Typically, these verbal thoughts are tape recorded for subsequent analysis and provide the basis for building information processing models of behaviour.

While the application of verbal protocol analysis has largely been restricted to areas of cognitive psychology, artificial intelligence and expert systems, there have also been recent examples of its use in the business and management literature [see for example, Bouwman (1985); Bouwman, Frishkoff and Frishkoff (1987); Schweiger (1983); and Isenberg (1986)]. For example, the study by Isenberg (1986) involved 12 general managers from large US corporations thinking aloud while solving a short business case study. This and other studies provide strong support for the use of protocol analysis as an approach to understanding the information processing activities of decision makers performing complex and ill-structured tasks [Bouwman, Frishkoff and Frishkoff (1987)]. Protocol analysis is generally acknowledged as a resource intensive and time consuming activity. However, it is arguably the best available technique for making a detailed observation and study of human decision processes. In contrast to other techniques employed in behavioural research (eg regression models), protocol analysis provides a high density of process information for the development of behavioural simulation models.

Protocol analysis is a technique that has been the source of much criticism and confusion in the literature. Of notable concern is the possible effect that verbalisation has on a subject's performance during a task. Moreover, are human experts able to provide a complete record of the information processing activities they perform during a task? In addition, the researcher faces the difficulty of trying to ensure objectivity in the subsequent coding and analysis of verbal protocols. Before considering these issues in detail, we shall briefly outline the various steps of protocol analysis. However, it needs to be noted that protocol analysis is a non-standard technique and difficulties on how to proceed face the researcher using the technique for the first time. The work of Waterman and Newell (1971) and Newell and Simon (1972) provide the reference points for our description of protocol analysis. Good recent examples of the application of these basic ideas can be found in Bouwman (1985) and Bouwman, Frishkoff and Frishkoff (1987).

The exposition of protocol analysis here is closely linked with Newell and Simon's theory of human problem solving introduced in the last chapter. Problem solving is viewed as a path - a series of inter-connected knowledge states - through a problem space. A problem space is defined as the subject's internal representation of a particular task. Verbal protocols collected during problem solving can be used to study the information processing behaviour of a subject. Bouwman (1985) suggests that protocol analysis can be used at a number of different levels:

(i) Scanning the protocol for simple anecdotal evidence about behaviour. This can provide a broad overview of problem solving that could support other methods of analysis [see for example, Hey (1981)].

(ii) Scoring the frequency of use of certain types of information or activities. An analysis of this type provides an insight into the important processing activities of decision making behaviour [see for example, Bouwman, Frishkoff and Frishkoff (1987)].

(iii) Global modelling of the decision making process. This involves putting some initial structure to the knowledge state sequences that characterise behaviour. Analysis of this type will involve the researcher conducting a detailed coding of the protocol. Insight into detailed decision making strategies will begin to emerge [see for example, Stephens (1980)].

(iv) PS model/computer simulation. As the work of Bouwman (1985) demonstrates, this is the most detailed level of protocol analysis and requires a complete as possible study of the decision making process. The description of protocol analysis below lends itself to this level of analysis. PS modelling of this type is particularly useful for conducting exploratory research, eg contrasting differences in decision making strategies between subjects; hypothesis testing; development of intelligent computer programs (eg expert systems).

Protocol analysis ia an iterative and searching process that demands considerable research time. The work of Ericsson and Simon (1984) provides a good overview of the psychological underpinnings of the technique. As codes of practice develop, it is likely that automation of protocol analysis will follow. Indeed, early attempts at this can be found in the literature [see for example, Waterman and Newell (1971) and Bhaskar and Simon (1977)]. The following steps outline the generally accepted approach to protocol analysis:

Step 1: **Analysis of the Transcribed Protocol Into Thought Units**

The first step is to take a complete transcript of the verbal protocol from the tape recording. This can, of course, be carried out at different levels of detail by complementing the analysis with timing information, syntactic information and so on. It is to be expected that the literal translation of a tape, certainly for a complicated task, will appear confusing and disjointed on first examination. For example, the grammar structure may be incomplete and it might be difficult to determine whether particular statements were made as questions or facts. Unfortunately, hours of study of the transcribed tape will typically be required before detailed analysis along the lines described in the following chapters can start.

The prime purpose of analysing the protocol is to place a structure on the information processing behaviour of a subject. We are, therefore, looking for regularity and patterns in a subject's verbal comments. Bouwman (1983, p 655) has summarised:

> "Protocol analysis is a time-consuming search for a workable compromise between, on the one hand, eliminating non-relevant information, thereby increasing the accessibility of the remaining information and, on the other hand, retaining and structuring as much information as possible to avoid discarding information which is essential for a proper understanding of the underlying thought process".

A useful initial step is to break the transcribed protocol into "thought units" or "topic elements" - discrete steps that represent a single idea used by a subject during decision making. The purpose here is to facilitate the assessment of what information a subject is heeding at a particular point in time during decision making and how it was being processed. Some writers [see for example, Bouwman (1983)] suggest that the analyst can also 'clean up' and edit the full protocol at this stage to remove any irrelevant comments by a subject. This, however, should be done very carefully.

There is clearly scope for the analyst to place his/her own interpretation on what constitutes a thought unit or topic statement. This element of subjectivity is of concern and one solution is the use of an independent analyst. However, in simple and well-structured tasks it is unlikely that there will be a need for independent analysis. Of course, the ultimate test of any protocol analysis will be the ability of the PS model to faithfully capture the behaviour of an individual subject.

Step 2: **Protocol Coding and Problem Space Specification**

Once the protocol has been broken up into thought units it is then possible to code each topic statement in terms of the elements that make up the subject's perceived problem space. We have seen in Chapter 2 that the concept of a problem space is central to Newell and Simon's information processing theory and involves specifying the knowledge elements and operators that define a subject's perception of a particular task. Knowledge elements simply represent some state of knowledge in the problem space and state what the subject can know during problem solving. Operators correspond closely to the concept of an eip introduced in the previous chapter. Operators take existing states of knowledge as inputs and produce new states of knowledge as output. Essentially, operators capture the information processing behaviour of subjects and, conceptually, function incrementally - adding, deleting or modifying knowledge states during problem solving.

The coding of thought units in terms of knowledge elements and operators can be done in a grammar-like way using Backnus-Normal Form (BNF) notation [Newell and Simon (1972)]. In Chapter 5 we illustrate this representation and introduce the BNF form of notation.

The particular coding scheme used by the researcher will depend upon the structure of the decision making task and the purpose of the particular research [Payne, Braunstein and Carroll (1978)]. Once again the interpretation of the researcher is likely to be important in determining the choice of codes and the use of an independent analyst is recommended to resolve ambiguity and increase the external validity of the protocol analysis. For simple and well-structured tasks the specification of knowledge elements and operators is straightforward and can be done with confidence as to its objectivity. Indeed, in these circumstances there are likely to be only small differences between the problem space and the task environment representation of a problem.

An important issue in the coding of problem space operators is the level of 'granularity' used. In the previous chapter we noted that information processing activities are theoretically decomposable in terms of Newell and Simon's eip's. To a large extent the level of the operator specification will reflect the nature of the task and the degree of detail captured in the verbal protocol. Also of relevance are the particular research objectives since different levels of operator coding capture different aspects of decision making behaviour. For example, the analysis of verbal protocols from the perspective of a cognitive psychologist is more likely to be characterised by detailed information processing codes, probably disaggregated to the level of eip's. Whatever level of detail is adopted, it is important to stress that operators can usefully be described in terms of knowledge inputs and knowledge outputs. Hence, a natural form for their representation is the use of production rules.

Step 3: **Problem Behaviour Graph (PBG)**

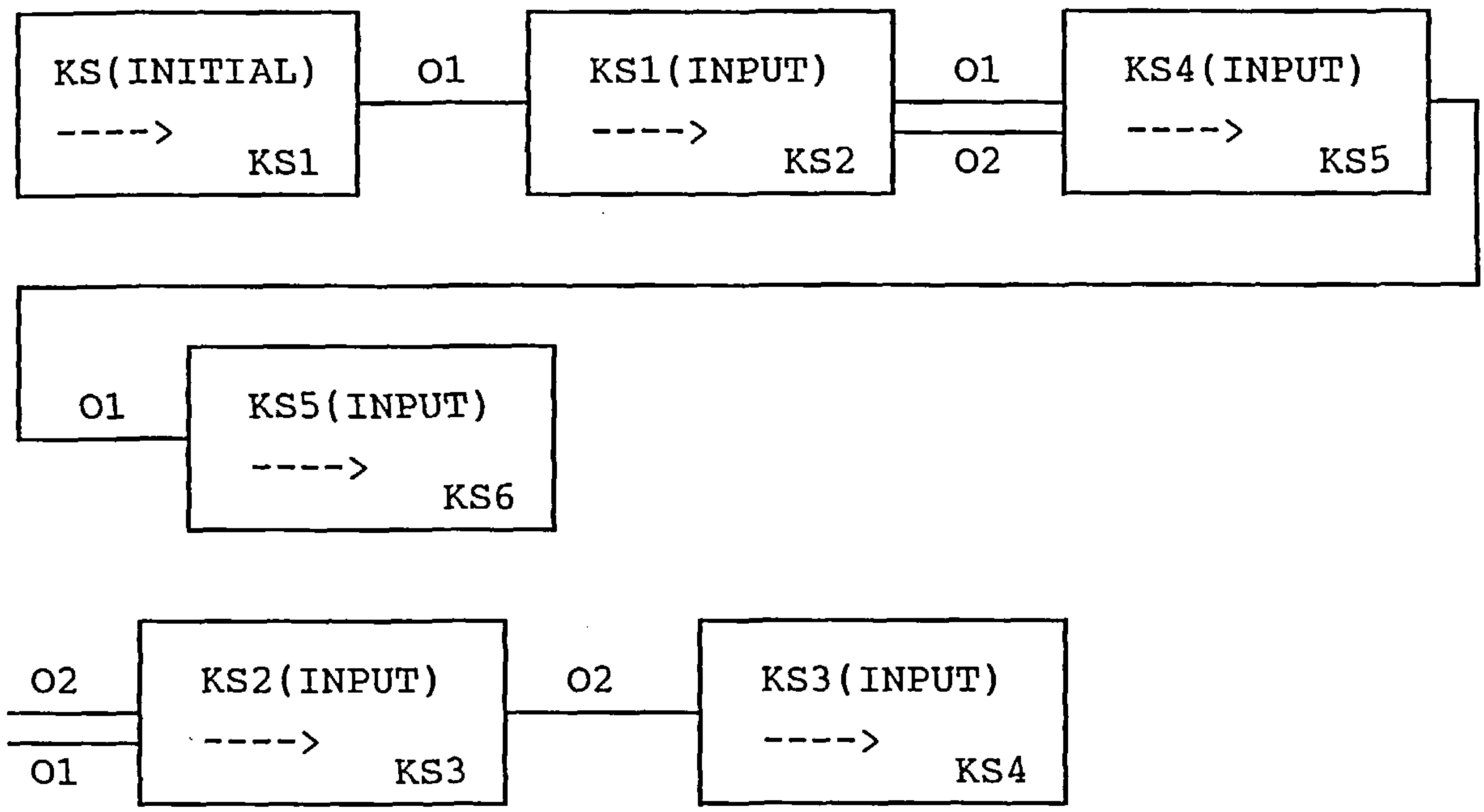
The PBG describes the trajectory of the subject's behaviour through the problem space. It can be viewed as a flow chart that provides a summary of a subject's information processing activities. In complex decision making tasks the PBG provides valuable insight into the frequency and sequencing of knowledge state operators (defined in the problem space) used during problem solving.

The notation and architecture of PBG's has generally followed the work of Newell and Simon and is illustrated below in Figure 3.1.

Each node of the PBG represents a state of knowledge achieved by a subject during problem solving. In Figure 3.1 KS1 . . . KS6 define different knowledge states. A branch connecting knowledge state nodes represents the application of an operator to a previous knowledge state (input) and results in a new knowledge state (output). In Figure 3.1 we have defined two problem space operators 01 and 02. The flow of the diagram is from left to right and downwards, reflecting the decision making process of the subject over time.

The graph in Figure 3.1 is divided up in terms of the operators defined in the problem space. While this is not conventional in the literature, we have found it a useful way of examining the protocol for recurring patterns within each operator code, eg for examining the specific combination of knowledge elements that are input to an operator. A break in a particular operator sequence is illustrated by a double branch with the previously fired operator identified below the second branch. It should also be noted that in presenting PBG's it is often necessary to use abbreviated notation to aid the clarity of the diagram since all of a subject's accumulated knowledge cannot be summarised in each node of the graph.

Figure 3.1 Problem Behaviour Graph



In sum, the PBG is a useful vehicle for summarising the behaviour pattern of a subject that emerges from the coding of protocols. At this stage the structure of a subject's information processing behaviour should begin to emerge and the exercise of constructing PBG's provides the analyst with a great deal of information about the content of the production rules that appear to have been used by a subject. Despite the simplistic images that may appear to result from constructing PBG's, their development is a very valuable part of protocol analysis.

Step 4: **Production System Model**

The PBG does not provide a structured logic that is capable of simulation in a computer program and the final step to this representation is the development of a PS model. This involves developing situation-action (if-then) rules that link knowledge state inputs and outputs via the operators specified in the problem space and summarised in the PBG. The aim is to develop a set of production rules that fully describes the information processing behaviour of a subject. The construction of production rules fundamentally depends upon being able to observe repetition in subject behaviour. As Newell and Simon (1972, p 191) argue:

> ". . . if each situation called forth a unique process, then we could never verify that the proposed process was in fact the one used".

Given the inability of decision makers to be substantively rational, the emergence of regular patterns in behaviour (heuristic decision rules) is central to the IPS view of behaviour. Heiner (1983, 1985) has also put forward this view as an explanation of the origins of predictable behaviour in complex and uncertain environments.

The discussion above also emphasises that PS's are a natural form of representing the behaviour of an IPS. The coding of verbal protocols and the development of PBG's underpins the view that we can model human decision processes in terms of a set of correspondences between knowledge states and the actions that follow (ie production rules).

The actual form the PS model takes will depend upon the objective of the research and the availability of modelling languages. In the previous chapter we illustrated the development of a PS model using the PS language OPS4. Of particular interest there was the modelling of learning behaviour and hence the need for a LISP based language capable of transforming data symbol structures into program symbol structures (ie creation of new production rules). Where the adaptive nature of PS models is not the focus of research, the use of expert system shells and conventional languages like BASIC, FORTRAN and PASCAL could be used. For example, in the experimental work reported later in this thesis our concern was with building PS models to capture subject task performance in a complex and uncertain environment.

In sum, a PS model involves the detailed specification of problem space operators in the form of production rules and, if necessary, an ordering of the productions for resolving conflict in rule instantiation.

Step 5: **Production System Model Trace**

A final phase of protocol analysis is to trace the behaviour of the PS model in terms of its ability to generate knowledge states and apply operators while simulating subject behaviour. This allows the researcher to address the following important questions: How much does the model explain? What is the predictive content of the model?

To date, the application of PS modelling and protocol analysis has largely been restricted to well-defined and rather simple decision making tasks. See for example, the work of Clarkson (1962); Payne, Braunstein and Carroll (1978) and Bouwman (1983) and the discussion in Bouwman, Frishkoff and Frishkoff(1987). Moreover, the criteria for validating such models are not well formulated.

Payne, Braunstein and Carroll (1978) suggest three different tests of the validity of behavioural process models:

(i) Does the model generate the type of behaviour of interest and that was observed from the protocol? This has been labelled a "sufficiency criterion" [Bouwman, Frishkoff and Frishkoff (1987)].

(ii) How powerful is the model in terms of being able to match (predict) the final decisions made by a subject? This criterion focuses upon the ability of the model to simulate decision outcomes.

(iii) Does the model generate a subject's behaviour in a similar behavioural process to that followed by the subject? This is a much stronger process criterion and demands of the model builder the necessity for understanding behaviour and not just simply being able to describe it.

The first criterion is much weaker than (ii) and (iii). It is conceivable that behavioural models could be developed to satisfy this criterion without the use of detailed information processing data eg. the statistical analysis of decision output data. A similar argument could be made with regards the second criterion. Moreover, Payne, Braunstein and Carroll's predictive criterion is somewhat weaker then the predictive criterion applied in orthodox economics.

However, the third (process) criterion is much stronger than any behavioural criteria by which substantively rational models in neoclassical economics are tested. The use of decision output data is likely to be an inadequate basis for developing models to meet this criterion. There are a number of possible ways the process criterion could be applied. For example, the PS model could produce a simulated protocol so that the reasoning of the model could be compared with the reasoning displayed by an actual subject in his/her verbal protocol. We could test for the frequency and sequencing of problem space operators by comparing the PBG produced by the PS model with the actual PBG's of the subject.

It is also possible to develop a fourth criterion:

(iv) Does the model predict the behaviour of the subject in a similar (but different) set of conditions and/or the behaviour of other subjects?

This fourth criterion corresponds more closely to the notion of prediction in orthodox economics. However, just as the third criterion may be inappropriate for testing orthodox economic models, this fourth criterion could also be inappropriate when testing behavioural process models. Clearly this will depend upon the circumstances in which problem solving behaviour is being observed. It is also important to recognise that behavioural process models may provide different types of predictions. For example, in highly complex and uncertain decision making tasks behavioural process models may provide insight into differences in behaviour between subjects and provide a taxonomy of 'good' and 'bad' decision making strategies for a particular task. The prediction of optimal choices in these circumstances is unlikely to provide an insight into actual decision making behaviour.

Limitations of Protocol Analysis

To complete our discussion in this section we shall consider some of the methodological concerns that have been expressed about the validity of verbal protocols as behavioural data. To a large extent the discussion reflects the debate between Nisbett and Wilson (1977) and Ericsson and Simon (1980). For a complete review of the issues surrounding the role of protocol analysis see Ericsson and Simon (1984).

The criticisms of verbal protocol analysis are essentially threefold. First, it is argued that individuals have no direct access to their higher mental processes and often have no conscious awareness of what they are doing. As Nisbett and Wilson (1977, 233) argue:

> "People often cannot report accurately on the effects of particular stimuli on higher order, inference-based responses. Indeed, sometimes they cannot report on the existence of their responses, and sometimes cannot even report that an inferential process of any kind has occurred."

Nisbett and Wilson's conclusion is drawn from an extensive review of research studies that have used verbal protocol analysis. Given the inability of direct introspective awareness, Nisbett and Wilson go on to consider the possible source of an individual's verbal report. They provide a number of suggestions. For example, verbal reports may be based upon an a priori theory about the connection between stimulus and response or simply a description of what an individual believes their mental processes to be. In these circumstances, the extent to which such a verbal report is accurate can only be by chance or because of the incidental and correct application of an a priori theory. In either event, we can question the use of verbal protocols as behavioural data.

Nisbett and Wilson's paper prompted a response from several writers sympathetic to the use of verbal protocol analysis; see for example, Smith and Miller (1978); Ericsson and Simon (1980; 1984).

The arguments of Ericsson and Simon are particularly important for providing an understanding of when the use of verbal protocol analysis is likely to be successful and valid. Ericsson and Simon argue that individuals, in response to the instruction to think aloud, will verbalise information that is stored in STM. The important argument in Ericsson and Simon's thesis is that only the most recently heeded information in STM is available for further information processing (ie generation of verbal reports). This conclusion follows from the limited information processing capacity of STM proposed by Miller (1956).

While the details of Ericsson and Simon's argument focus upon the understanding of memory, attention and recognition provided by human information processing theory, their conclusion is quite simple. They provide a theoretical justification for the validity of verbal reports as data. Given a limited set of conditions the process of verbalisation produces information that is actually stored in STM and can be revealed without interfering with other information processing activities. In these circumstances Ericsson and Simon argue that verbal data is a valid basis for understanding the information processing characteristics of a subject's other (non-verbal) behaviour.

Ericsson and Simon (1980) also challenged Nisbett and

Wilson's interpretation of the research results from studies using protocol analysis. The majority of the studies reviewed by Nisbett and Wilson involved the use of retrospective protocols or required subjects to report on information that would not normally be heeded while performing a particular task (and hence not stored in STM). In contrast to concurrent protocols, retrospective reports require a subject to verbalise their thoughts after completion of the task. There are two difficulties.

First, the time lag between task performance and verbal recall may result in not all the relevant information being retained in STM. Moreover, as Newell and Simon's theory of human problem solving suggest, retrieval of information from LTM is fallible and often results in recollection of inappropriate information. Second, the nature of retrospective probing is suspect. For example, the posing of questions that require a subject to provide an interpretation of his/her behaviour rather than simply describe what was done or requesting the reporting of information that was never heeded in the task.

In sum, the accuracy with which subjects can produce verbal reports of their behaviour depends upon the experimental conditions in which the reports are elicited. The use of inadequate procedures for conducting verbal protocol analysis will clearly produce verbal data that is highly suspect. However, given certain experimental conditions (outlined below), it is argued that information held in STM will be available for recall by a subject. Within the framework of human information processing theory, the discussion in the previous chapter regarding the interplay between STM and LTM is very important for validating the use of verbal protocols. The LHS and RHS symbol structures that characterise production rules should be "observable" (when fired) through the verbal reports that recall the contents of STM during the performance of a task. Effectively, the verbal protocol should reveal a map of the various knowledge states that characterise a subject's problem space and their path through that space during problem solving. These knowledge states represent inputs and outputs to problem space operators. Of course, Ericsson and Simon acknowledge that even if their conditions for the validity of verbal protocols are satisfied, the verbal protocol report may be incomplete. This might be due to the inability of subjects to access their thoughts or becuase information that was heeded to (and, therefore, in STM) was simply not reported.

A second methodological criticism of verbal protocol analysis is that the process of verbalisation interferes with task performance. This effect has two potential and possibly related sources. First, there is the behavioural motivation of subjects who may react to the process of observation. There may, of course, be no deliberate intention to change behaviour patterns but simply the physiological reaction to operating in a controlled environment. In contrast, there could be a deliberate attempt to change behaviour, eg enhance performance or mislead researchers as to real behaviour patterns. It is, of course, not possible to eliminate the presence of such effects when observing actual behaviour, particularly in an organisational context. However, this is a problem that confronts all research concerned with studying actual behaviour and is not restricted to the technique of protocol analysis.

A second source of interference has its origins in the limited information processing capacity of STM and is particularly relevant to our discussion of the use of protocols. Does the process of verbal reporting inhibit the processing capacity of STM and, therefore, alter the behaviour of a subject? With the use of concurrent protocols, information processing theory suggests that verbalisation will not alter the underlying thought processes given certain conditions. As Ericsson and Simon (1980, p226) conclude:

> "When the subjects articulate information directly that is already available to them, the model predicts that thinking aloud will not change the course and structure of the cognitive processes".

Ericsson and Simon provide evidence of a number of studies that have explicitly studied the effects of verbalising on task performance; see for example, Karpf (1973) and Carroll and Payne (1977). Their sample of studies supports the view that information processing theory predicts verbalisation does not affect decision processes.

A third criticism of protocol analysis concerns the subjectivity of the coding and modelling process. This is an acknowledged difficulty given the current state of the art of protocol analysis. However, we prefer to view protocol analysis as a technique that attempts to minimise the impact of the researcher's own subjective interpretation of subject behaviour. The acceptance of this role of protocol analysis would be enhanced greatly by researchers providing a detailed description and discussion of the particular protocol analysis techniques used in a study. Combined with the protocol transcripts such a discussion would allow others to assess the reasonableness and validity of the particular approach taken and allow a similar research procedure to be followed in future work.

Another obvious way to improve the external validity of protocol analysis is through automation and/or the use of independent analysts. Given the time and resource cost of protocol analysis, both these alternatives may seem unattractive to the individual researcher. The work of Newell and Waterman (1971) and Bhaskar and Simon (1977) provide examples of attempts to automate and semi-automate the coding of protocols. Bouwman, Frishkoff and Frishkoff (1987) illustrate the value of using an independent analyst when coding protocols. As the methodology of protocol analysis matures it is likely that some of the problems of automating protocol coding will be overcome (eg coding of ill-structured tasks) and enhance the acceptability of such automatic coding packages. Two major benefits will follow: first, it will increase the objectivity of coding; and, second, it will reduce the research cost of employing verbal protocol analysis.

In responding to these methodological criticisms of protocol analysis, Ericsson and Simon (1980) identify a number of conditions that need to be met for concurrent verbal protocols to be a valid source of behavioural data. These conditions, it is argued, ensure that subjects are able to give verbal reports that are not epiphenomenal and do not change the cognitive processes that are demanded of a subject in a particular task. They were also an important consideration in the design of the laboratory experiment described in the following chapter:

(1) Instructions given to subjects should be clear, simple and eliminate possible ambiguities in the task. Subjects should be asked to 'think aloud' and not theorise or explain their behaviour.

(2) Ericsson and Simon argue that the information to be verbalised should be that which would normally be heeded during the performance of the task. Asking subjects to report information that is not central to a task may distort information processing behaviour.

(3) Cognitive overload (eg excessive information processing) may result in subjects providing incomplete verbal protocols.

(4) Given the limited capacity of STM, it is important there are no significant time gaps between cognitive processing (task performance) and verbalisation. The limitations of recall from LTM are likely to result in incomplete verbal reports when retrospective protocols are collected.

(5) High familiarity with a task may result in the cognitive processes required for a task being automatic, eg repetitive decisions. In this case, STM may not be in active use and verbal protocols will be very sketchy and of limited value.

(6) The re-working of task related information (eg via written reports or visual stimuli) will result in a slowing down of task performance and may substantially influence cognitive behaviour.

The conditions highlighted by Ericsson and Simon emphasise the need for the researcher to consider carefully the experimental circumstances in which behaviour is observed. Within the framework of human information processing theory, the reliability and validity of verbal protocols depends upon the structure of the task performed by subjects and the circumstances in which their behaviour is observed. This requires that the researcher has some element of control in the way human decision processes are observed. It is against this background that we discuss the role of laboratory experimentation in the next section. We are not suggesting that protocol analysis and laboratory experimentation are not of value as independent methods of research. However, their combined use for the study and modelling of human decision processes can be viewed as an important direction for future behavioural research. Finally, it should be noted that other data (eg. decision output data) about how a subject performs a task is also likely to be available in addition to protocol data. However, protocols have particular relevance to the discovery of LHS and RHS elements of production rules that describe a subject's information processing behaviour.

3.3 THE ROLE OF LABORATORY EXPERIMENTATION IN BEHAVIOURAL RESEARCH

In this section we complete the discussion of this chapter by briefly considering the role of experiments in economic research. One of the main reasons why we have developed a laboratory experiment to study human decision processes in this research should be clear from the previous discussion. The methodological development of protocol analysis has resulted in a clearer understanding of the necessary conditions for verbal protocols to produce valid behavioural data. The laboratory setting allows the behavioural researcher greater opportunity for creating a problem solving situation that satisfies these conditions [Ericsson and Simon (1984)]. There are also, of course, more pragmatic reasons for the use of a laboratory setting. These reflect upon the difficulties of observing the behaviour of economic agents (particularly firms) in practice.

Whilst economics cannot be regarded as an experimental science, there has been a notable increase in the use of experiments in behavioural research [Gilad and Kaish (1986)]. The survey work by Plott (1982), Smith (1979;1982) and more recently Forsythe (1986) provides a useful insight into the variety of research studies in economics that have used experiments for generating behavioural data. We shall not review this material here; the references quoted in the three survey papers above provide an extensive overview of the existing literature. Further, there is a good review of the use of laboratory experiments in economics in Roth (1987). Instead, we focus upon the reasons for using an experimental setting in this research and some of the methodological problems that this presented.

The experimental economics literature is varied and is largely concerned with the use of experiments to study market processes as well as aspects of individual choice behaviour. Some good examples of the use of experimental research in the study of market processes can be found in the two edited volumes by Smith (1979; 1982). Much of this work [see for example, Smith (1976; 1982a); Plott and Sunder (1982) and Plott (1982)] has involved the creation of small-scale microeconomic environments (eg experimental markets) for studying the relationship between the preferences of individual economic actors and the market and institutional parameters within which choice takes place. One of the important results from this research has been the identification of a number of conditions [see for example, Wilde (1981) and Smith (1982a)] that are sufficient for validating a laboratory experiment in terms of a controlled and well-defined microeconomic environment.

Experimental research on individual choice behaviour has a strong psychological base [see for example, the work of Tversky and Kahneman (1974) and Grether and Plott (1979)]. One important direction for this kind of research has been the study of the way in which individuals process information when faced with complexity and uncertainty. For example, Schoemaker (1982) provides a good review of some of the experimental research that has focused upon the study of individual behaviour to test the descriptive validity of the axioms of SEU theory.

Our use of experiments in this research is not concerned with the study of experimental markets or the testing of a specific behavioural assumption, eg Bayes rule. However, in common with previous experimental research in economics, we are using a laboratory setting to provide the appropriate conditions for the controlled study of phenomena relevant to this research, ie human decision processes. The investigation of human problem solving behaviour at the level of detailed information processing activity is usually carried out in laboratory settings [Simon et al (1987)] and often involves the use of the technique of protocol analysis. Typically, this requires studying the behaviour of a small number of subjects for a relatively short period of time - about one hour. Good examples of this kind of experimental work outside the discipline of economics can be found in Newell and Simon (1972); Payne, Braunstein and Carroll (1978); Bouwman (1983) and Isenberg (1986).

In this thesis we return to the more complete cycle of behavioural research by emphasising the need for the direct observation of decision making processes. The concern with the need to study what goes on inside the black box presents a number of difficult research problems. For example, in what circumstances can actual behaviour be observed? The problems of observing behaviour has hindered the development of behavioural research in economics, particularly with regards the study of firm behaviour. A careful search of the literature does provide some recent illustrations of the in-depth study of decision processes in the tradition of behavioural research [see for example, Earl (1984) and Bromily (1985)]. However, in general, behavioural research has tended to be theoretical, building upon the early behavioural relationships of Cyert and March and Simon [see for example, Nelson and Winter (1982)].

Given our previous discussion of PS modelling and protocol analysis, we are essentially faced with the alternative of studying behaviour in a 'real world' setting or an experimental setting. The use of questionnaires, primary company data, structured interviews or case studies will not provide the richness and density of behavioural data for developing PS models that is required within the information processing paradigm. Moreover, our earlier discussion suggests that the conditions required for validating verbal protocols as behavioural data are unlikely to be met in a real world setting. This is not to say that verbal protocol analysis in these circumstances is of no value but simply that the approach is unlikely to result in anything more than the analysis of tape recordings of structured interviews. That said, the development of many expert system models has progressed in this way.

There are, however, reasons other than the use of protocol analysis for conducting the detailed observation of behaviour in a laboratory setting. A central aim of field research is to allow the unobtrusive observation of behaviour so that it remains 'natural' and is not influenced by the process of observation. In the context of studying the strategic decision making behaviour of firms it is difficult to see how the conditions for such unobtrusive observation are likely to be satisfied in practice. There are a number of obvious reasons for this.

A major problem is the availability and cost of access to the study of actual decision making processes in firms. Field studies are time consuming and require a high level of co-operation from a company's senior management. Typically, this would involve the researcher spending a considerable number of months 'on site'. This may or may not coincide with the occurrence of the process or phenomena that is the focus of the research. The business and management literature is characterised by a considerable lack of detailed observational data in the area of strategic decision making. What data is available [see for example Mintzberg et al (1976)] is highly aggregated or largely anecdotal. This is not surprising given the sensitivity surrounding a company's corporate strategy and the fact that such observation requires the co-operation of individuals whose prime concern is with making strategic decisions. The study by Bromily (1985) provides an example of a recent behavioural field study concerned with the modelling the capital investment decisions in firms.

Even if it were possible to obtain the co-operation and agreement of management to such research, there remains substantial practical difficulties in observing the detailed aspects of a firm's strategic decision making process. For example, consider a major investment decision such as a new product launch or a corporate takeover - good examples of strategic decisions. To observe such behaviour is likely to be prohibitively expensive, involving the need to study behaviour over lengthy periods of time and possibly at a variety of levels in the organisation. The generation of observer created artefacts cannot be ruled out and it becomes questionable whether observing behaviour in a 'natural' setting is possible. Moreover, in these circumstances it is difficult to see how such observation would contribute to the direct study of decision processes rather than observing the outcome of decision processes. Furthermore, the use of techniques of retrospective probing of management are likely to be subject to all the problems we noted earlier with regards protocol analysis.

Camerer (1985) has discussed the role of field study research in the business policy and management literatures and has criticised its contribution in terms of developing general theories of business behaviour. Camerer argues that field study observation has resulted in ambiguous concepts, checklists on business practice and anecdotal case evidence that does not appear to have any theoretical underpinnings. However, Camerer's concern with the problems of field research can be contrasted with the views of those who support the use of field studies in management research [see for example, Mintzberg (1977)]. Earl's study of corporate mistakes demonstrates that it is possible from evidence collected in field studies to identify broad patterns of behaviour that characterise organisation decision processes [Earl (1984)].

Direct field study is unlikely to be appropriate for developing behavioural process models within the PS modelling framework we have previously described. In studying human decision processes using the technique of protocol analysis, the necessary conditions for validating verbal protocols as data require the researcher to exert control over the design and structure of the task to be performed by subjects. Laboratory experiments provide the researcher with the opportunity for the controlled measurement of behaviour [Festinger (1953)]. The stated advantage of laboratory experiments is widely agreed to be that the laboratory ensures that "adequate control can be maintained and accurate measurement of relevant variables guaranteed" [Wilde (1981, p138)]. Despite this widely acclaimed purpose of laboratory experiments, it is only possible to achieve an approximation to this degree of control given the currently available techniques for conducting experiments in the social sciences.

Laboratory experiments can vary in design, complexity and structure and their exact form depends upon the purpose of the particular research study and the ingenuity of the experimenter. In economics there is no theory of how to conduct laboratory experiments and Smith (1982, p 923) has argued: ". . . learning to run experiments is like learning to play the piano - at some point you have to start practising". While there may be an element of truth in this view, the work of Wilde (1981), Smith (1982a) and

Plott (1982) provides good examples of where a number of precepts have been established for validating the use of laboratory experiments in economic research. In the previous section we established some important principles that have guided the design and use of experiments for this research into the study and modelling of human decision processes.

The critique of laboratory experimentation is contained in a well-established body of literature on research methods in the social sciences [see for example, Simon and Burstein (1985)]. Their arguments apply equally to the use of experiments in economics [see the discussion in Plott (1982)]. The major criticism of the use of laboratory experiments is that they are artificial and their results are not representative of the real world [Anshen and Guth (1983)]. It is argued that laboratory experiments, by their very nature, are an approximation to any real life situation and, therefore, one should only generalise findings to the real world with extreme caution [Chapanis (1967)]. As Mintzberg (1977, p93) argues in relation to the use of laboratory experiments for studying business behaviour:

> ". . . the very complexity of phenomena determines the organisation's behaviour . . . processes such as strategy formulation are characterised by the inherent complexity and dynamic nature of the environments in which they operate; re-creating these processes in artificially simplified environments in the laboratory eliminates the very characteristics that determine the organisation's responses".

This is an argument against experimentation in general and fails to acknowledge that the lack of realism represents a deliberate abstraction on the part of the researcher. As Festinger (1953, p 10) argues:

> "A laboratory experiment need not, and should not, be an attempt to duplicate a real life situation".

Clearly, if one wanted to observe behaviour in the full complexity of a real-life situation (with all the attendant difficulties noted above), it would eliminate the need to develop a laboratory experiment.

An important counter-argument to the artificiality of laboratory experiments is the distinction between mundane and experimental realism [see for example, Carlsmith et al (1976) and Henshel (1980)]. Mundane realism refers to the extent to which an experiment can be said to be realistic in terms of incorporating processes found in the real world. Experimental realism is concerned with the design and structure of an experiment and its impact on encouraging subjects to participate in the experiment for the purpose of observing 'natural' behaviour. Experimental realism is clearly important for any experiment and criticising an experiment for lack of mundane realism may be misleading. In this context, we can associate the conditions identified for validating the use of verbal protocol data with the requirements for achieving experimental realism.

An important implication of the previous discussion is that a high level of mundane realism is not necessary for a high level of experimental realism. This is clearly illustrated with reference to the experimental work in economics [see Plott (1982) and Forsythe (1986)]. Moreover, achieving high levels of mundane realism runs counter to the purpose of conducting experimentation and could be at the cost of reducing the generality of the results from the experiment. For example, one problem might be that subjects abbreviate and edit their behaviour because of perceived familiarity between the experiment and some real world task. The result is that behaviour could be characterised by 'overlearned rules' and appear 'smoothed' with much of the behavioural detail the experiment was designed to elicit being removed from direct observation. In the context of the previous discussion, verbal protocols would be disjointed and thin.

Henshel (1980) has argued that artificiality, in the sense of low mundane realism, may be deliberately maximised in experiments that are designed for the purpose of discovery and theory construction. Experiments used for verification and hypothesis testing may require a high level of mundane realism for the comparison of observed behaviour in the laboratory with that in a comparable 'real' world setting. Smith (1982a) makes a similar argument in providing a methodological classification of experiments in economics.

Given our earlier discussion on protocol analysis, it is apparent from the arguments above that realism (in a mundane sense) may be sacrificed in certain circumstances for the purpose of achieving visibility in the study of behaviour. Cambell (1957) emphasised this point by making a distinction between the internal and external validity of an experiment. For any experimental design it is likely that there will be a trade-off between internal and external validity. Internal validity refers to whether the experimental setting has a significant impact upon the behaviour of a subject, whilst external validity indicates the degree to which the experimental results can be generalised to other populations. While internal validity was an important consideration in the design of the experiment described in the next chapter, we are cautious in accepting the view expressed by some authors that internal validity is more important than external validity [see for example, Carlsmith et al (1976)].

A second problem in the use of laboratory experiments in economics to study firm behaviour is whether 'real world' managers behave in the same way as the subjects used in experiments [Plott (1982); Holt (1985)]. Typically, the subjects of experimental research in economics have been students. For example, Plott and Sunder (1982) used students from the Graduate School of Business in Chicago to study experimental security markets; and Holt (1985) used subjects from undergraduate economics classes at the University of Minnesota to investigate the consistent-conjectures hypothesis in oligopoly theory.

The convenience and low cost associated with employing student subjects makes their use attractive in academic research. However, to what extent are students 'real' economic agents? The evidence on this issue is limited and mixed. For example, Anderson and Murphy (1973) compared student and household subject groups in consumer choice experiments and concluded that students' response patterns did not accurately reflect those of other consumer classes. In contrast, an earlier study by Babb et al (1966) found no significant difference between the behaviour of students and businessmen during a business gaming exercise.

Plott (1982) argues that differences between classes of subjects ought not to be taken as a criticism of laboratory experimentation but as a need for more experimental research using different classes of subjects. In some task domains this may be a relatively straightforward task; however, our previous discussion has highlighted the difficulty of using actual business managers (particularly senior management) for experimental research. Moreover, it needs to be recognised that the academic community consists of a diverse set of individuals with a wide variety of backgrounds and experience. It is unlikely that the population of 'friendly' academic subjects available for a particular experiment consists solely of undergraduate students.

The careful selection of academic subjects for experimental research may also provide a number of advantages over the use of real economic agents (managers) to study firm behaviour:

(i) the cost of, and access to, appropriate subjects;

(ii) the possible increased need for mundane realism in an experimental design (at the cost of the experiment's internal validity);

(iii) the extensive skill and expertise of real subjects in a particular task domain may result in the observation of unexpected artefacts ie. a higher likelihood of observation bias;

(iv) non-academic subjects may lack the familiarity and sympathy with the objectives of academic research.

In sum, the decision regarding the choice of subjects requires a balancing of issues between the pragmatics of a particular experimental exercise and the objectives of the research. With regards the study of firm behaviour, the evidence from reviewing previous experimental research in economics suggests the use of corporate senior management is both impractical and raises difficulties concerning the trade-off between the internal and external validity of an experiment. At the other extreme, the use of undergraduate students to study business behaviour introduces serious doubt the external validity of the experimental results.

Finally, there are two procedural problems that face the researcher in using laboratory experiments. These concern the role of instructions and the provision of monetary payments (incentives) to subjects. Instructions serve two important roles [Plott (1982)]. First, instructions should be simple and unambiguous and, if necessary, be used to minimise the impact of artefacts created by the experimenter giving instructions to subjects as to what the experiment is intended to demonstrate. Fromkin and Streufort (1974) discuss this issue and argue the case for concealing the true purpose of an experimental study from subjects.

A second important use of experimental instructions is to enhance the external validity of an experiment and allow other researchers to follow similar experimental designs. Furthermore, we noted above that Ericsson and Simon (1980) advocate a specific role to experimental instructions as one of a set of necessary conditions to validate verbal protocols as behavioural data. In this context, instructions play a crucial role in establishing the internal validity of an experiment.

The issue of whether monetary payments are necessary in experimental research is still an open debate in the literature. There are clearly doubts about the motivation of subjects in experimental settings where there are no monetary rewards in proportion to subject task performance. This may be particularly important in experiments involving a lengthy period of subject observation. The result maybe subject fatigue or boredom and this could encourage random behaviour or the mechanical application of a particular pattern of behaviour as the subject dwells on things other than the experiment.

Whilst it can be argued that monetary payments provide incentives in an experimental setting, there appears to have been no rigorous empirical test of this issue. There has also been interesting experimental work in economics that has not involved monetary payments in a formal reward structure [see for example, Witt (1986)]. Moreover, inclusion of monetary rewards (eg in the form of a complex payment structure) could distort subject behaviour in a particular task by violating the Ericsson and Simon conditions noted earlier. Indeed, there seems to be no distinction in the literature between the significance of payments to subjects as a reward for participation in an experiment and payments linked to task performance during an experiment. Once again, as with other aspects of experimental design, the impact of incorporating monetary payments can be viewed in terms of its effect on both mundane and experimental realism. We shall comment further on this issue in discussing our experimental design in the next chapter.

3.4 CONCLUSION

This chapter has focused upon the implications of adopting the procedurally rational framework of behavioural economics, in particular the need to study human decision processes. The study of actual behaviour is an important element of the behavioural research program in economics and demands techniques for producing a high density of behavioural data.

A key element of PS models introduced in the previous chapter was the PS rule base which captures the decision making skill and expertise of an individual decision maker. Protocol analysis provides a methodology for eliciting and representing heuristic decision rules within a PS framework. Following the work of Newell and Simon, the combined use of PS models and protocol analysis has become an important approach to developing information processing models in the cognitive psychology literature.

Ericsson and Simon (1980, 1984) identified a number of necessary conditions to validate verbal reports as behavioural data in terms of accurately capturing a subject's information processing activity. We have argued that satisfying these conditions is closely associated with the study of human problem solving behaviour in laboratory settings. There are also other important reasons for the study of complex economic behaviour in experimental settings - particularly firm behaviour. These reasons relate to both methodological and practical issues that face behavioural researchers in studying actual decision making behaviour.

In the remainder of this thesis we shall explore more fully the application of the approach to behavioural research we have developed in this and the previous chapter.

CHAPTER 4

A STRATEGIC DECISION MAKING EXERCISE

4.1 INTRODUCTION

In this chapter we describe the design, structure and operation of a laboratory experiment developed for the purpose of studying and modelling human decision processes in a business decision making task domain. The experiment required subjects to make decisions for a hypothetical firm operating in a competitive and uncertain market environment. The task that confronted subjects during this exercise appeared complex and ill-structured and was developed in the form of a computer simulation model. Decisions were made over a number of consecutive periods before the exercise was terminated at some unknown future period by the computer. In total, ten subjects participated in the exercise and all had practical business experience. Two of the subjects were practising managers studying on an MBA programme and the remainder were academic staff at Sheffield Business School (UK). All the academic staff were actively involved in consultancy with local firms, advising on general business matters and financial and marketing strategy.

In the next section we review some of the issues relating to our experimental design and in particular, the decision to use a laboratory setting and our choice of task domain. We then provide a discussion of the structure and design of the experiment. This is followed by a brief outline of our experimental procedure. We also consider whether our experimental design satisfied the conditions necessary to validate the use of verbal protocols as behavioural data. These conditions were discussed in Chapter 3. Finally, we reflect on some limitations and problems of our experimental setting and suggest possible directions its development in future research.

4.2 RATIONALE FOR THE EXPERIMENTAL SETTING

The study of business behaviour is a particularly good illustration of where models of procedural rationality have an important role to play in economic research. In Chapter 2 we noted that the strategic decisions of firms are not easily analysed within the substantively rational framework of neoclassical economics. Strategic decisions, however, are an important determinant of corporate behaviour and, yet, the economics and management literatures reveal only a limited insight into the strategic decision making process within firms. For example, Black (1976) and Myers (1984) both criticise the theoretical and empirical research in the financial economics literature for failing to provide insight into how firms actually make dividend and financing decisions and account for how strategies can vary so widely between firms in the same industry.

In contrast, Simon (1980) has emphasised that we should expect to observe different (information processing) systems employing different strategies to perform the same task. This has important implications for decision making research; as Simon (1980, p42) argues:

> "I am not aware that any theorems have been proved about the uniqueness of good, or even best, strategies .....
>
> Hence, research on the performance of adaptive systems must take on a taxonomic, and even a sociological aspect. We have a great deal to learn about the variety of strategies, and we should neither disdain nor shirk the painstaking, sometimes pedestrian, task of describing that variety."

In the remainder of this thesis we contribute to what Simon has labelled the 'painstaking task' of studying and modelling decision making strategies. Our prime purpose is to explore more fully the value of the information processing methodology introduced in the previous chapters. We illustrate how decision making strategies can be represented in the form of information processing rules (ie. production rules). We identify these rules from observing the actual decisions of our subjects and by using the technique of verbal protocol analysis.

A second objective is to provide insight into the characteristics and nature of the particular decision strategies used by subjects in our experimental task. While our sample of subjects was relatively small and our experimental design limited the period of observation for any individual subject, we are able to draw some tentative conclusions about the issues raised by the kind of questions posed in Chapter 1. For example: What information was used during our experimental decision making task? Can we distinguish between good and bad decision making strategies? How are decision tasks perceived and structured?

In conducting the remainder of this research we were faced with two tasks. First, to determine the setting in which subject behaviour was to be observed (ie. laboratory or field); and, second, to select the task domain for which subject performance was to be studied. In Chapter 3 we presented a case for using laboratory experiments to conduct the type of detailed study of human decision processes required for developing models of procedural rationality.

The use of laboratory experiments in behavioural research can be viewed as an approach that occupies the 'middle ground' between the abstract and theoretical models of the neoclassical economist and the anecdotal use of case evidence and field research that characterises the management literature. In studying and modelling procedural rationality there is a need to go beyond simply describing the behaviour of specific industries or firms. To understand more about the 'how' and 'why' of decision making we require the controlled observation of actual behaviour in stylised task domains where multiple observation and simulation of behaviour is possible.

The adoption of a laboratory setting for this research reflects both the methodological framework discussed in

Chapters 2 and 3 and the practical problems associated with observing decision making processes in firms. However, in designing a laboratory experiment the researcher is faced with the difficulty of trying to ensure that the experimental task captures the essential nature of the decision making problem under investigation. Moreover, a sufficiently high degree of experimental realism is required to elicit the appropriate behavioural processes that are characteristic of the particular task being studied.

The design of any experimental setting will by necessity simplify the complexity and uncertainty that characterises a real world task. In using experiments to study business behaviour it is not possible, nor is it desirable, to replicate reality in all its detail. Indeed, this is an important argument for the use of the laboratory as a research setting. However, this also brings disadvantages since any particular experimental setting will present limitations and problems for the researcher with regard to the drawing of general inferences about human behaviour. This makes the design and running of experiments a very difficult exercise, particularly as problems often emerge after the experiment has been completed e.g. during protocol analysis. We shall discuss aspects of our experimental setting later in the chapter.

Given the exploratory nature of this research, the design of our experiment was not directed towards the testing of a specific behavioural hypothesis. Instead, our prime concern was with demonstrating the methodology introduced in Chapters 2 and 3 and exploring its role for studying strategic behaviour within firms. The focus on strategic behaviour followed from the importance of developing models of procedural rationality for studying behaviour in complex and uncertain task environments. Strategic decisions are characterised by ambiguity and ignorance and with firms adapting to dynamic market conditions (but not in some optimal sense). Firms develop 'reasonable' strategies in response to unexpected changes in market conditions and it is most unlikely that a single best strategy can be identified.

The characteristics and nature of strategic decisions are described fully in the business policy and corporate strategy literatures [see for example, Hofer and Schendel (1978) and Johnson and Scholes (1987)]. In Chapter 2 we noted the high degree of similarity between the description of strategic decisions in the business literature and the 'true' nature of uncertainty described by some economists [e.g. Shackle (1972); Loasby (1976)]. Arguably, the distinguishing feature of strategic decisions is the importance of managing a firm's competitive position [Porter (1980)]. This view reflects both the discussion in the management literature and the casual observation of firms in the 'real' world. For example, the use of relative measures of performance by corporate management e.g. market share, emphasise the importance attached by firms to their competitive position.

In designing the laboratory experiment for this research we attempted to capture some important characteristics of the strategic decision problems that face firms. For example, our decision exercise involved subjects managing a hypothetical firm for which there was uncertainty regarding market demand and the behaviour of a competitor firm. Thus, relative competitive position was an important aspect of the exercise that subjects could have considered when making decisions. We shall describe more fully the detailed design of our laboratory experiment in the next section.

A further consideration in determining the nature of the experimental task to be performed by subjects was our use of protocol analysis. Protocol analysis provides a high density of behavioural data and involves a detailed study of individual information processing behaviour. We were, therefore, limited as to the length of time we could realistically expect subjects to seriously participate in our decision making exercise. Research in the cognitive psychology literature using the technique of protocol analysis has generally involved the study of behaviour in decision making tasks for about one hour [Simon et al (1987)]. This factor needs to be balanced against the importance of observing repetition in information processing behaviour when analysing protocols. In sum, we required a decision making task that allowed subjects to make a number of consecutive decisions in a relatively short period of time.

Considering the issues above, it was important to develop an experimental task that was generic to a number of businesses but was also independent of the circumstances that apply to a particular firm or industry in practice. Thus, subjects were not required to recall specific information about an industry or market environment but could simply respond to the circumstances that develop in the simulated experimental setting. Inevitably, this involves reducing the degree of mundane realism captured in the experiment.

The pricing and product decisions of firms was chosen as a task domain that we believed would allow us to achieve the experimental conditions required for this research. Corporate pricing and product strategy is central to management decision making in most firms and is an area of firm behaviour that is studied extensively in the economics literature. The strategic significance of pricing and product decisions is underpinned by uncertainty regarding market demand and the policies of competing firms.

The basic structure of an experimental design of the type described below can be established fairly quickly. However, the detailed aspects of building and refining an experimental setting are costly in terms of time and effort. In the case of complex simulation tasks these costs are likely to be unavoidable if a high level of experimental realism is to be achieved. In addition to the problem of the trade-off between experimental and mundane realism, the researcher faces the difficult issue of when should model refinement stop and experimentation begin? The laboratory experiment described in the next section was developed over several months before a final version of the model emerged. It seems an important objective that experiments of this type are portable so as to allow their use by others in further research.

An important aspect of designing our experiment was testing the simulation model in trial runs with subjects who were not to be used in the experiment proper. The testing of the simulation model provided important feedback, particularly about the perceived nature of the experiment by subjects and the form in which information was presented on the computer screen. Over a long period of development it becomes difficult for the researcher to view the experiment from the perspective of the 'novice' subject. Of course it is not possible to optimally design an exercise of this type and it remains a difficult problem to identify how further improvements could be made without actually running the experiment extensively. The only way to minimise these types of problems is through more extensive pre-experimental testing. This, however, is a resource and time intensive activity and involves the use of valuable and willing subjects.

In hindsight it should not be surprising that we can find aspects of our experimental design where further development and improvement could be made. However, it is difficult to quantify what impact such improvements might have had on our final analysis and results. Ultimately, the researcher needs to judge when development work must stop and it is only by experience in research of this type that we will improve our judgement on these issues in the future. What is important is for individual researchers to discuss fully the details of the specific experimental setting used in a research study. In this way it will be possible for others to improve and develop previous work. In the next section we provide a detailed description of our laboratory experiment.

4.3 DESCRIPTION OF THE LABORATORY EXPERIMENT

This section is important for understanding the discussion of the next three chapters where we analyse and interpret our subjects' decision making behaviour. With over 3000 lines of program code the simulation exercise is complex and we shall not describe the fine detail of its design. Instead, we restrict our discussion to providing a broad overview of its constituent parts.

The reader may find it useful to read the instructions distributed to subjects participating in the experiment before reading the detail of this section. These instructions can be found in the Appendix to this chapter. The basic structure of the experiment reflects the discussion in the previous section and for development purposes the simulation was broken down into four modules:

(a) market environment module
(b) competitor firm's strategy module
(c) subject's decision making module
(d) accounting information and performance module

Modules (c) and (d) formed the basis of the exercise as viewed by the subjects, whilst modules (a) and (b) represented the simulation model of the market environment and the behaviour of the competitor firm.

(a) Market Environment Module:

To capture the richness of strategic product/market decisions, the market environment for our laboratory experiment was developed around the Lancastrian framework of consumer demand [see Lancaster (1971)]. The Lancastrian model of consumer behaviour is based on the premise that goods are valued for the attributes they possess and that differentiated products are essentially different packages of attributes.

Lancaster's model provided an appropriate framework for operationalising the notion of competing products in our laboratory setting. Within this framework it was also relatively straightforward to incorporate the possibility of launching new products and withdrawing products from the market ie. developing a product\portfolio strategy. For the purposes of this experiment we restricted the simulation to where consumers' utility was assumed to be a function of two characteristics. These were defined as C1 (characteristic 1) and C2 (characteristic 2).

Subjects were not asked to assume that the product market simulated in the experiment related to a particular consumer or industrial market with which they were familiar e.g. the consumer 'white goods' market. The reason for this was to increase the likelihood of satisfying the Ericsson and Simon conditions for validating verbal protocols as behavioural data. It was important that subjects responded to the specific information cues generated by the simulation exercise. This was an attempt to avoid subjects displaying automatic responses to particular environmental conditions or using their past experience of particular market conditions.

Clearly, there is scope for experiments which are designed and fine-tuned to a particular market environment, e.g. for studying the success of particular 'industrial recipes' [see Grinyer and Spender (1979)]. However, the design of such experiments would involve a substantially longer period of development than is feasible for the purposes of this research. The generic environmental setting adopted here is appropriate for the exploratory research in this thesis and reflects both pragmatic reasons and the need to meet the conditions for the valid use of protocol data.

Sales and market share achieved by subjects in any period was determined by a number of factors. The distribution of consumer expenditure depended upon the prices of all competing products and their relative mix of the two characteristics C1 and C2. Within the Lancastrian framework it is straightforward to relate the demand for any product to its consumption technology (ie its mix of C1 and C2) and its price in relation to other products on the market. In brief, each product can be represented as a 'strategy point' in characteristic space. The simulation model simply allocated consumer expenditure amongst competing products by 'plotting' each product on the market in characteristic space (strategy space). The model then 'constructs' the efficiency frontier given the price and characteristic mix for each product. Each product's position (strategy point) in relation to the efficiency frontier determined its level of consumer demand for the period.

Subjects were not provided with any explicit information about the Lancastrian model of consumer behaviour. Given the background of all but one subject it was unlikely that subjects would have had an appreciation of the model underlying consumer demand in the experiment. Indeed, this is supported by evidence in the protocol data that we analyse in the following chapters. Subjects were informed that the relative mix of C2 to C1 for each product determined how consumers perceived 'similar' products in the market and that it was possible to imitate products already on the market by launching a new product with an identical mix of C1 and C2.

Subjects were also informed that consumers in the market had perfect knowledge. Thus, consumer expenditure was allocated amongst the various products cost-effectively to obtain the desired amounts of characteristics (C1 and C2) according to aggregate consumer preferences. The structure of the Lancastrian model defines a maximum price for which a product can be located on the efficiency frontier and be demanded by consumers. Given the significance of relative prices in this framework, it was important for subjects to monitor the price levels of products available on the market in any period and the degree of similarity between products in terms of their mix of C1 and C2.

Finally, the level of sales for a product on the market depended upon the total level of consumer expenditure in any period and its distribution in terms of preferences for the characteristics C1 and C2. A further element of uncertainty regarding demand was introduced by assuming that the market followed a product life cycle. Around this long-term trend (the product life cycle), consumer demand in any period also shifted randomly.

At the start of the exercise subjects were faced with a product market that had gone through the introductory phase of the life cycle and the decision periods simulated in the experiment proper covered the growth and maturity phases of the life cycle. All participants of the exercise were familiar with the product life cycle concept, though no information regarding the parameters of the cycle were revealed to subjects before the exercise. Moreover, there was no opportunity for subjects to conduct market research other than indirectly by feedback from the market environment. In sum, it was very difficult for subjects to identify any detailed trend in market demand from period to period. However, most subjects were able to perceive the broad trend of growth in market demand from the notes distributed prior to the exercise and the data generated during the simulation.

It is not difficult to see how the basic Lancastrian model adopted for this exercise could be modified and made more complex by introducing additional product characteristics, alternative consumer preference distributions and allowing a broader range of marketing mix decision variables to be included (e.g. advertising). More sophisticated models could be developed by simulating particular market environments or industries, though there is always a trade-off in an experiment of this type between its degree of complexity and the perception of this complexity by subjects. Evidence from our subjects' protocols suggests that they found market demand relationships very difficult to predict. Moreover, experimental realism could be substantially reduced if relationships in the exercise became so complex as to discourage subjects from attempting to explore and understand the nature of these relationships during decision making. In this situation, random behaviour may result and reduce the value of any protocol data collected.

In sum, the relationships we have simulated in our experiment between demand, price and product characteristics are complex at a technical level, but relatively simple at a conceptual level. This was an important consideration in trying to enhance the degree of experimental realism in our laboratory setting.

(b) Competitor Firm's Strategy Module:

An important aspect of any firm's corporate strategy is the monitoring and response to the decisions of its competitors. In the design of our laboratory exercise we captured this aspect of strategic decision making by simulating the behaviour of a single rival firm. The behaviour of the competitor firm was kept deliberately simple and unsophisticated. In particular, the competitor firm's strategies were reactive with no attempt to anticipate subject behaviour.

In modelling the strategic pricing and product behaviour of the rival firm it was important that its decision rules did not take advantage of information relating to the design of the experiment that would not be available to the novice subject facing the exercise for the first time. This was a difficult task, though the trial runs of the experiment did provide some useful parameters for how sophisticated our modelling of the competitor firm's strategy needed to be. In simulating the rival firm's behaviour the objective was to both maximise the degree of experimental realism and provide a mechanism for stimulating active decision making on the part of subjects. Moreover, it should be noted that the competitor firm's rule base included a variety of pricing and product strategies and as a result a number of different market structures evolved during the running of our experiment with different subjects (see the discussion in Chapter 6).

It is important to note that the decisions of the competitor firm were determined simultaneously in each period with the decisions made by the subject. There were no communication mechanisms that allowed the competitor firm and subject to 'inform' each other about their strategies (ie. no possibility of collusion). Thus, the competitor firm could only "observe" the decisions taken by the subject after the performance and results data had been generated for the period. This is identical to the situation with which we presented subjects in our experiment. In sum, the competitor firm's decisions were modelled on the basis of its historical relative performance and after consideration of its own previous decisions and those of the subject.

The use of straightforward rules to model the competitor firm's behaviour reflected our concern that subjects should not perceive that the competitor firm had a strategic advantage. However, the mechanistic rules of the competitor firm did result in some subjects [see for example the protocol of subject S7 in Chapter 5] perceiving a degree of rigidity in the behaviour of the competitor firm, particularly, in the later stages of the exercise. This was evident when one or two subjects attempted to develop more sophisticated strategies e.g. anticipating competitor moves or suggesting the possibility of collusive behaviour. These are limitations in our experimental design that need to be recognised when interpreting the behaviour of our subjects.

The competitor strategy module can be sub-divided into three elements:

(i) Product Withdrawal Strategy

With regard to the product withdrawal strategy of the rival firm the focus was upon monitoring the market share and profitability for each product in its portfolio. The basic decision rules were that the competitor never withdrew totally from the market in any period and could not withdraw more than two products from its portfolio in any period. These conditions were also imposed upon each subject during the experiment. These conditions impose constraints on the nature of the strategic behaviour that we could study in our experimental setting. For example, there was no opportunity for the rival firm or the subject to enter new markets.

The rules for selecting products to withdraw were straightforward. A product would be withdrawn if it had no market share for two periods and/or the operating profit for the product had been negative for three periods. In the event of conflict, the length of time a product had been part of the competitor firm's portfolio was the criterion for determining which product would be withdrawn. More sophisticated strategies could have been modelled. However, we believe that for the relatively small number of decision periods for which subjects were to participate in the exercise, it was unlikely that complex tactical strategies, e.g. loss-leading, would be developed. Indeed, this proved to be the case for the majority of subjects.

(ii) New Product Strategy

The competitor firm's new product strategy was more sophisticated though it still faced the same constraints as those imposed on subjects in the experiment. In essence, new product strategy was driven by market share objectives and the identification of "strategic gaps" in the market. The competitor firm's strategy was dynamic and this made it difficult for subjects to forecast exactly what the competitor might do in any period. This is an important aspect of competitive market strategy in practice. Incorporating this aspect was straightforward and involved changing certain "trigger points" (see bleow) for different periods in the exercise. A similar approach was used in modelling the pricing strategy of the competitor. As we shall discuss later, there was a tendency for the competitor firm to become more aggressive in the later periods of the simulation.

The decision to launch a new product by the competitor firm was triggered by the following factors:

(1) relative market share
(2) presence of "strategic gaps" in the market
(3) "static" market share below a certain target level

As we have noted above, (1) refers to the notion that the rival firm employed targets for market share which changed during the exercise in response to a particular subject's pricing and product strategy. For example, the competitor firm was programmed to incrementally increase its target market share towards a maximum of 70% during the exercise. The rival would not launch any new products if it "dominated" the market according to the target share that had been set for a particular period.

In addition to its target market share objective, the competitor firm was also modelled to identify the presence of "strategic gaps" in the market. A "strategic gap" was defined in terms of differences in characteristic mix between products that were available on the market in the previous period. Essentially, this involved 'measuring' the distance between the 'strategy points' that represented products available on the market. These gaps were viewed in relation to the total level of market demand in the previous period. This was not a sophisticated decision rule but was based on the expectation that subjects would also develop new product strategies by giving consideration to the similarity of products marketed in the previous period (ie by reference to the C2/C1 ratio).

As we shall see in the following chapter some subjects also adopted generic strategies that reflected this type of thinking. The rival launched new products in market segments which provided the largest potential for gaining market share. There is a large body of research in the marketing and business strategy literatures which highlights the importance of market share in determining successful business strategies [see for example the work on the PIMS data base e.g. Buzzel et al (1975)].

As with our subjects, the rival was exposed to the risks of random movements in market demand, shifts in consumer preferences, as well as the possibility that a subject may also launch a new product onto the market for similar reasons. A simple rule was assumed for the competitor firm. A new product would not be launched if the potential market share for the product was estimated to be less than 25%. This estimate was crudely based on product sales in the previous period. One further refinement in the competitor firm's new product strategy was to limit the gaps considered for product launch to those market segments in which the subject had a product. The competitor firm would not launch a new product that competed directly with one of its own products. This is similar to the 'pincer' strategy used by subject S7 and described in Chapter 5.

Finally, if the competitor firm's market share fell below 40% and remained static for two consecutive periods then its product strategy became highly aggressive. This was a positive strategy aimed at attempting to improve market share. In these circumstances, the competitor firm launched a new product that imitated a successful product in the subject's product portfolio. This strategy was rarely activated and was included to provide a realistic response by the rival to the emergence of successful products introduced by subjects. This was a strategy that was also adopted by a number of our 'successful' subjects [see the discussion in Chapter 6].

When launching a product the competitor firm pursued an aggressive strategy when defining the consumption technology for a new product. The mix of C1 and C2 for a new product was chosen to make it competitive with products marketed by the subject and, as we have noted above, in extreme cases the competitor firm would actually imitate a successful product of the subject. This aspect of the rival's product strategy was not modelled using information on the distribution of consumer preferences for the purpose of determining an optimal mix of characteristics for a new product [see Baumol (1967)]. The strategy simply reflected information about total demand and the characteristic mix of competing products on the market last period.

In sum, the rule of thumb employed by the competitor firm was simply to launch products that were more likely to compete with a product of the subject in a particular market segment rather than any of its own products. Once again, the degree of aggressiveness assumed of the rival firm increased with the time period of the exercise. This reflected the expected increase in significance of market share in influencing strategic decision making during the later stages of the product life cycle.

(iii) Pricing Strategy

The price strategy of the competitor firm was not modelled to be optimal in any sense, but reflected what appear to be reasonable rules of thumb given the cost and market conditions incorporated in the experiment. As the cost conditions were identical for both the subject and the competitor firm, it was the dynamic conditions regarding market demand and subject behaviour which led to changes in the competitor firm's pricing decisions. The price decisions of the competitor firm were modelled to reflect three key sources of information:

(1) variable cost of the product
(2) market share of the product
(3) the subject firm's pricing strategy

New products were launched and priced according to the variable cost of the product and the price mark-up strategy used by the subject in previous periods. No products were priced at below variable cost as this would result in operating losses and increase the probability of bankruptcy (the probability of this, though, was very low). However, the competitor firm priced its products competitively subject to minimum target levels for price mark-up. Once again, the level of these target mark-ups for new products varied according to market conditions.

With regard to the pricing of products which were already on the market, the competitor firm set prices using its target levels for market share and its objectives regarding profits. It was, thus, possible for the competitor firm to increase, decrease or hold constant product prices depending on whether a product's market share for the previous period had fallen within an acceptable target range. This combination of cost-based, competitor-based and market-based pricing seems intuitively reasonable. It also reflects our expectations with regard to the behaviour of the subjects in our experiment. As the discussion in Chapter 6 will demonstrate, a similar classification of pricing rules emerged from studying our subjects' behaviour.

(c) Subject's Decision Making Module:

An important consideration in designing the subject's decision making module was the development of an effective and efficient interface between the subject and the simulation environment. The nature of the subject's contact with the computer simulated environment was vital for ensuring that we could satisfy the necessary conditions identified by Ericsson and Simon (1980). Our concern was to provide an unobtrusive mechanism for recording the decisions of each subject and also reporting their performance relative to the rival firm on a period by period basis. Clearly, it was important that the procedural aspects of communicating with the computer had a minimal influence on subject behaviour.

In addition to providing an interface between the subject and the decision making environment, this module played an important part in the experimental setting by providing a degree of control and structure to the way subjects performed the decision making task. Specifically, certain constraints were imposed on our subjects' pricing and product decisions. These were outlined in the instructions distributed to subjects prior to running the experiment.

The overriding concern in designing this module was to ensure that the procedures followed by subjects when entering their decisions for each period were straightforward and free of ambiguity. Within reason, a number of error checking facilities were introduced to prevent simple key stroke mistakes. We also provided the opportunity for subjects to revise their strategy at various stages in the process of entering their decisions onto the computer e.g. where a subject may have had "second thoughts" about a particular strategy or have simply typed a figure wrongly. There is no evidence from the protocols of our subjects that they experienced any difficulties in this respect.

Subjects were allowed, at various stages in the exercise, to review historical market data relating to the previous period. There was no facility for recalling data beyond the last decision making period. This was largely to avoid any problems created by a subject attempting to conduct excessive historical analysis. This reflects one of the conditions identified by Ericsson and Simon (1980) in terms of eliminating the possibility of cognitive overload. Subjects could have kept their own written records. However, no subject attempted to do this. Moreover, given the dynamic nature of the market environment, historical data was of relatively little value for decision making purposes beyond representing a history of performance to date. The majority of subjects appear to have appreciated this point in their decision making.

Performance data presented to subjects at the end of each period included information relating to the current decision period as well as a historical summary of performance to date. Subjects were not provided with a 'hard copy' of this information. They were advised that they could, if they wished, record any key variables they considered important for decision making. One or two subjects commented on the inability to refer back to detailed performance data beyond the previous period. However, we do appear to have avoided problems that might have been created by subjects having too much information and spending excessive amounts of time trying to establish meaningless relationships (through the re-working of data) implicit in the computer model. This satisfies one of the conditions of Ericsson and Simon in terms of avoiding subjects having to rework large volumes of data. In brief, we attempted to design and structure this exercise so as to eliminate the need for subjects to perform any additional information processing activity beyond that required as part of the decision making task.

In summary, we have attempted in this laboratory experiment to strike a balance between the information and data provided by the computer model and the analysis that was required and expected of subjects. If too much guidance had been given as to the type of analysis expected of subjects, this may have imposed a structure on their decision making behaviour, the observation of which was the very purpose of this exercise. This issue was very difficult to judge and it is apparent that the mix of experimentally generated information to that produced by individual subjects did vary from one subject to another. Hopefully, the analysis in the next three chapters will support our interpretation that we do appear to have captured in our subjects' verbal reports the essential elements of problem formulation and decision making that characterised the structure of our experimental setting.

(d) Accounting Information and Performance Module:

The final module of our experimental simulation captures the important accounting relationships that generated performance data. These relationships determine the impact of the decisions taken by the subject and competitor firm and the current state of the market environment on the financial performance of both the subject and the rival firm. The more detailed aspects of these relationships are described in the notes distributed to the subjects prior to the exercise (see the appendix to this chapter).

The interpretation of financial performance data was an important aspect of our experimental design since it provided valuable insight into the knowledge state structures perceived by subjects in their problem space. In turn, these knowledge state structures form the input and output elements that define the problem space operators. The accounting relationships incorporated in the exercise were simple and reasonably transparent and followed widely accepted business conventions. This was important for the purpose of increasing experimental realism and also for ensuring that subjects had the confidence to use the performance information as a basis for their decisions.

The accounting and cost relationships were identical for both the hypothetical firm managed by the subject and the competitor firm. Initial financial position statements for the competitor firm and subject were provided in the notes distributed to subjects prior to starting the exercise. These initial statements referred to three periods prior to the start of the exercise proper and served two main purposes. First, to give subjects a feel for the exercise and provide them with a sample of the type of information generated during the exercise. Second, to provide subjects with a brief history of the market environment in which they were to make decisions. For example, this information showed that the competitor firm had recently introduced a new product which had been successful. Importantly, these initial statements also provided subjects with an insight into how market demand was growing.

It can be seen from these initial results that the competitor firm has a marginally advantageous position. Marketing two products against the subject's single product, the rival had achieved a slightly better performance in terms of market share, profitability and return on capital employed (ROCE). In part, the reason for presenting this scenario to subjects was to increase their awareness about the changing nature of the market environment and stimulate active decision making behaviour from participants early in the experiment. In addition, it highlighted the harshness of the market environment that followed from our adoption of the Lancastrian framework for modelling consumer demand.

This harshness in the market environment was an important consideration in the design of our experimental setting. While we have modelled a market environment that might be regarded as over-sensitive to changes in decision strategies - it is a feature, we believe, that enhanced experimental realism. Given the necessity of running the exercise over a short period of time, it was important that subjects could observe clearly the impact of their decisions on their own performance and the performance of the competitor firm. This does not mean that subjects were able to identify clear and unambiguous relationships. Comments in the protocol data discussed in the next two chapters clearly demonstrate that this was not the case. However, the high sensitivity of market relationships to the decisions taken by subjects and the rival firm did assist in ensuring subjects provided a rich amount of behavioural detail in their verbal reports - despite the short period of observation.

The financial performance data reported to subjects during the exercise included a variety of performance measures e.g. ROCE, market share, profitability and so on. Many of these variables are related and highlight the complex issue of measuring business performance in practice. While subjects studied the full range of performance measures there was a strong tendency to focus upon profitability and market share. These two measures dominate the assessment of business performance in practice. While other performance variables were commented on by subjects their significance in terms of their influence on decision making is difficult to determine from the protocol data.

Subjects were not briefed to pursue a particular objective in the exercise and there were no financial incentives or rewards linked to particular performance variables. This reflects our discussion in the previous chapter regarding the specification of objectives as part of the task of defining a problem space. As we observe in practice, firms pursue a variety of objectives the emphasis on which change with market conditions. Clearly, different strategies are developed for pursuing different objectives.

Given the background and experience of our subjects, all were aware as to the significance of the various performance measures included in the exercise. With the exception of share price movements, subjects could have easily calculated and checked the performance results reported at the end of each period. No attempt was made to do this and it would appear that subjects interpreted the performance information at face value. Indeed, there was only one occurrence of a subject expressing concern in their protocol about whether the computer had 'miscalculated' a set of financial results. In this instance it was a subject who was 'disappointed' about the result of a particular set of decisions.

An earlier design of the exercise had presented performance results for the competitor and subject in the form of simplified profit and loss and balance sheet statements. However, trial runs suggested that subjects found too much information being presented for interpretation and this was reflected in the amount of time these subjects spent on this phase of the decision making process. Further comments received during the exercise proper suggested that some subjects found difficulty in interpreting the financial data and there was evidence from the protocols to suggest subjects did not fully use all the available information provided at the end of each decision period. It is difficult to determine whether this was through lack of understanding or represented a deliberate cognitive mechanism to limit the amount of information attended.

In sum, while performance evaluation is an important element of the decision making process, we did not want this activity to dominate the decision making behaviour of subjects in our exercise. The detailed financial relationships in the exercise were kept deliberately simple so that subjects did not see the financial data as coming from some "black box". The instructions provided subjects with an intuitive feel for the financial relationships in the simulation model and emphasised that they did not need to understand their full detail, but simply use and interpret the information in a conventional manner.

4.4 EXPERIMENTAL PROCEDURE AND THE VALIDITY OF VERBAL REPORTS

In this section we outline the operation of the experiment and discuss whether we are likely to have satisfied the conditions specified by Ericsson and Simon (1980) for validating the use of protocol analysis.

The basic structure of our experimental procedure was as follows:

(1) Distribute a set of instructions and a description of our decision making task to all subjects. This was done at least 10 days prior to running the experiment. To the best of our knowledge there was no contact between subjects on the matter of the experiment.

(2) Subjects were provided with an opportunity immediately prior to starting the exercise proper to clarify any issues relating to experimental procedure.

(3) A 'training period' was included in the simulation which allowed subjects to become familiar with how the exercise operated. The training part of the exercise could be repeated with the base data being the same for each training period.

(4) Subjects then participated in the exercise proper. Thinking aloud protocols were collected for each subject. The exercise was terminated randomly by the computer between the sixth and eighth period of decision making.

Given our discussion in the previous chapter, there are two issues regarding our experimental procedure that are worthy of further comment.

Choice of Subjects

The first concerns the selection of subjects. Clearly, the availability and choice of subjects has an important influence upon experimental design and also the nature of the behaviour that the experiment can be used to investigate. The focus of behavioural research on procedural rationality requires the detailed observation of information processing behaviour. The study of firm behaviour by asking business managers what they do poses a number of difficulties [Winter (1986)]. The need for a high density of behavioural data limits the circumstances under which such data is likely to be collected. In advocating the combined use of an experimental setting with the methodology of protocol analysis, it was necessary to give consideration to the type of subjects employed in our research. While access and availability of subjects was an important issue it was not the prime determinant in our choice of subjects.

The concern with experimental realism and the need to satisfy the conditions for validating the use of verbal protocols suggested the need for a compromise in the choice of subjects. It was also important that the inferences we would be able to draw about the strategic behaviour of our subjects would have broad application to actual business practice. Our choice of subjects reflected these factors. Selecting ten subjects from Sheffield Business School (UK), we were able to use individuals with practical business experience (both past and present) while at the same time ensuring that our experimental setting was perceived to have a high degree of experimental realism.

Given the mixture of practical business experience and an academic background, the majority of our subjects appeared to adapt to the structure of the exercise with relative ease. Not surprisingly, a number of subjects found the process of thinking aloud difficult. However, there is no evidence to suggest that this influenced their actual decision making behaviour. At most, the aspect of giving verbal reports appears to have occasionally slowed down the behaviour of our subjects and/or possibly resulted in a less than complete verbal report of their decision making behaviour.

Monetary Payments to Subjects

A second important issue in our experimental design concerned the payment of subjects. Once again, there are a number of conflicting issues here. The main reason for not incorporating monetary payments as part of our experimental design was to avoid defining the objectives to be pursued by subjects. Linking a monetary reward to market share or profitability would have influenced the behaviour of our subjects in a way that does not appear to characterise the strategic behaviour of firms in practice. In the context of mundane realism we are, of course, open to the criticism of what motivates subjects in our laboratory experiment. However, given the nature of our decision making task, it is unlikely that a realistic reward structure (in a mundane sense) could have been developed for this particular experimental setting.

A second reason for not including monetary rewards as part of our experimental design was to avoid this becoming the focal point of attention during decision making. Given the range of performance variables included in the simulation, any reward scheme would necessarily be complex and could move a subject's attention away from more strategically significant variables, e.g. the behaviour of the competitor firm. While it might be argued that some profit sharing schemes have such a role in practice, it was not an issue that was of concern in this research.

What was of concern was whether the absences or presence of a monetary reward scheme would fundamentally influence the degree of experimental realism achieved in our laboratory experiment. On this issue we believe that our choice of subjects was an important factor in minimising any detrimental impact from not including monetary payments as part of our experimental design. Indeed, we were pleasantly surprised at (and very grateful for) the enthusiasm and commitment displayed by all of the subjects who participated in our experiment. While it was expected that the experiment would run on average for about one hour per subject, two subjects took considerably longer. One subject took just over two hours and another one hour and forty minutes. Many subjects found the exercise stimulating and the absence of monetary payment does not appear to have been a major limitation.

The Validity of Verbal Reports - Satisfying the Ericsson and Simon Conditions:

We shall now complete the discussion in this section by briefly relating the design and operation of our laboratory experiment to the conditions outlined in Chapter 3 for validating the use of concurrent verbal protocols. As we have argued, one of the reasons for adopting a laboratory setting was to validate the use of protocol analysis as a technique for developing models of procedural rationality within the information processing paradigm. We consider each of Ericsson and Simon's conditions described in Chapter 3.

(a) Instructions to subjects:

As we have described, subjects were provided with a clear set of instructions regarding the experimental task. While these were unavoidably long, they were also comprehensive so as to eliminate any possible ambiguities and misunderstandings. In addition to these written instructions, subjects also had the opportunity to ask questions before the exercise and complete a number of test runs before making any decisions in the exercise proper.

Importantly, our instructions to subjects simply asked them to "think aloud" and not theorise or explain their actions. The reason for this was to ensure that a subject's focus of attention was directed towards the task per se rather than any requirements included in the set of instructions distributed beforehand.

(b) Information that is verbalised should be that which is heeded during the task:

If subjects are asked to produce information that is not normally available while performing a task, then the information processing paradigm predicts that this could bias cognitive behaviour [Newell and Simon (1972)]. In designing our experiment we have deliberately made all information clearly available to subjects on the display screen of the computer. No specific request was made to subjects for reporting particular items of information - heeded or otherwise. Moreover, there was no obvious necessity for subjects to re-work information generated by the simulation model.

It should, however, be noted that some subjects did comment about information that was not available for use in decision making. For example, market research data; the opportunity for developing strategies not included in the design of the experiment, e.g. takeover and collusion. This provides the researcher with an insight into information that subjects would normally perceive to be available for consideration in a given decision making situation. These comments, however, were few in number and largely restricted to the later periods of the exercise.

(c) Cognitive overload:

An important consideration in designing our laboratory experiment was to avoid the possibility of introducing cognitive overload by design limitations in our experimental procedure. For example, asking subjects to do more than simply produce a verbal report of their behaviour could result in information processing activities not directly associated with the decision making task. If subjects had been asked to report in a written form this may well have had this effect.

The need for subjects to enter their decisions into the computer is an example of the type of act that could generate cognitive overload. It is difficult to measure the effect on behaviour of subjects keying in their decisions. The occasional comment by some of our subjects suggested difficulty in "finding a particular key" or "deleting a wrong entry". However, the stylised nature of our experimental design did limit the amount of key stroking required of subjects. If there had been more widespread comment about the difficulty of using the computer it might have raised questions about its possible effect on subject behaviour.

(d) Concurrent rather than retrospective reports:

Given the limited capacity of STM and the difficulty of recalling information from LTM, it is concurrent rather than retrospective reports that provide valid behavioural data. As is clear from our discussion above, there was no reason to anticipate time gaps between the occurrence of an information process and its verbal reporting by a subject. Verbal reports were concurrent.

(e) Automation of task behaviour:

Tasks with which subjects are very familiar may result in highly automated performance. In these instances the protocols become sketchy and provide very few statements about the information inputs and outputs of production rules. As the analysis in the next three chapters reveals, this does not appear to have been a serious problem with our experimental setting and for very obvious reasons. While all our subjects had knowledge and expertise of our experimental task domain, their familiarity with the particular form and pattern of information stimuli was limited. This partly reflected the stylised form in which the experiment was designed. In brief, they were not actively involved on a day to day basis with a decision making task that was structured in the same form as our laboratory experiment.

Clearly, as familiarity with the task increased in later periods of the exercise, there is evidence that some subjects' protocols became shorter. However, the dynamic and complex nature of our experimental task reduced the extent to which decisions made by subjects became automatic as a result of practice and familiarity. This also reflected the limited time period over which behaviour was observed.

(f) Re-working of task related information:

We have partly addressed this aspect of our experimental design already. Our experiment presented subjects with information in a clear and concise manner through the medium of the computer display screen. Variables central to the decision making task, e.g. market share, were presented in a form that did not require calculation. However, it is most unlikely that our experimental design was complete in this respect. For example, there is evidence of one or two subjects in the earlier periods of the exercise recording information because of what appears to be unfamiliarity with the screen displays (despite the trial periods). Another subject 'checked' figures in one of the early periods to confirm his interpretation of features in the exercise.

Again, it is difficult to assess whether these instances of subjects re-working information were significant. Their lack of occurrence suggests they may not have been important. From the protocols it appears, if anything, to have simply resulted in a slowing down task performance.

In sum, it appears that our strategic decision making exercise broadly satisfies the conditions identified by Ericsson and Simon. This, however, does not guarantee complete verbal reports in all circumstances. We are, nonetheless, confident that we substantially reduced the impact of poor experimental conditions on invalidating the verbal reports collected during the running of our experiment. There are, of course, other aspects of our experimental design that create difficulties in interpreting the behaviour of our subjects. We examine these issues in the next section.

4.5 LIMITATIONS AND PROBLEMS OF OUR EXPERIMENTAL DESIGN

To complete the discussion in this chapter we consider some of the limitations and problems of our experimental setting. The discussion in this section is important for two reasons. First, the issues we examine have significance for our interpretation of subject behaviour in the next three chapters. Second, we identify aspects of our experimental setting that could be developed and improved by further research.

We focus upon two particular problems. The first concerns the nature of the competitive relationships incorporated in our experimental design. The second highlights a limitation concerned with the number of decision periods for which we are able to observe subject behaviour.

An important feature of our experimental setting, as with real world oligopolistic markets, is the interdependence between competitor firms. The result of any decision made by a subject depended upon the decisions made by the rival. Uncertainty regarding the pricing and product strategy of the rival presented subjects with a very difficult task of trying to predict the competitor firm's behaviour. This is a feature of oligopolistic markets that has been the source of extensive research in the economics literature.

The description of our decision making experiment above highlighted its focus upon the introductory and growth phases of the product life cycle. In these conditions it has been assumed that neither the subject nor the rival had extensive knowledge regarding the strategic behaviour of each other. For example, the competitor firm was modelled as a reactive firm which adopted 'aggressive' or 'friendly' tactics in response to the decisions made by our subjects. There was, as we noted, a tendency for the competitor firm to become more aggressive as the product life cycle moved towards the maturity phase.

While these behavioural assumptions regarding the interdependence between firms in an oligopolistic market are reasonable, they are also limited in terms of the strategic and competitive behaviour they imply. As Chapter 6 demonstrates, a number of different market structures emerged from running our experiment; however, the emphasis upon aggressive market behaviour is illustrated strongly in the protocols. Moreover, while there are instances of subjects attempting to conjecture the likely response of the competitor firm to a particular decision, the majority of our subjects developed reactive strategies to the rival.

The comments above highlight both the limitations of our experimental design and possible directions for future research. For example, incorporating a variety of different reaction patterns for the competitor firm would be an interesting extension of the present experimental setting. This could usefully be developed to include signalling mechanisms for indicating aggressive or friendly strategic tactics. In either case it suggests there may be a need for a longer period of observing subject behaviour than that used in the present study. This, however, introduces a number of difficulties given the research methodology we have adopted.

Another aspect of oligopolistic interdependence absent from our laboratory experiment was collusion. There was no explicit opportunity for communication between the competitor firm and the subject. Part of the difficulty arises from the competitor firm not being 'live' and, hence, any response to friendly signals initiated by a subject would be delayed because of the need for the rival to interpret market signals. Also the relatively few observation periods limited the scope for identifying friendly and aggressive tactics. This problem was compounded further by the fact that the competitor firm and subject made decisions simultaneously.

In sum, despite the nature of our experimental exercise characterising a non-zero sum game situation, the role for collusion was limited. Tacit collusion, while feasible, was unlikely to emerge in the conditions of our experimental setting. In fact, the competitive and uncertain nature of the market and the aggressive characteristics of the competitor firm presented subjects with a situation closely resembling that of the Prisoner's Dilemma [Luce and Raiffa (1957)]. That said, there were instances in our experimental runs where subject and competitor firm behaviour were not characterised by aggressive price cutting strategies and low profit levels. However, uncertainty about the behaviour of the competitor firm and the inability to effectively communicate co-operative behaviour tended to encourage aggressive behaviour on the behalf of our subjects.

Of course, market environments do exist that display similar characteristics to the scenario presented to subjects in our experiment. For example, the UK travel industry is a particularly good illustration of where during the 1980's a strategic gaming situation developed that resulted in aggressive pricing and product strategies being implemented by firms. Despite the repetitive nature of this 'game' situation and the opportunity for studying the behaviour of other firms, strategically timed aggressiveness has paid off for firms in the industry.

An important development of our experimental setting would be to construct a 'live' gaming situation in which subjects competed against each other. Indeed, the basic structure of our laboratory experiment would lend itself to a straightforward adaptation for this purpose. For example, networking two microcomputers would allow the creation of a duopolistic market situation with a 'live' subject replacing the competitor firm's strategy module described above. The scope for a more thorough investigation of oligopolistic interdependence between firms and its effect on strategic behaviour in this experimental setting should be apparent.

A second limitation of our experimental setting concerns the length of time over which the experiment was allowed to run. From our discussion above it should be clear that the length of experimental run was influenced by a number of factors. The two most important were our use of protocol analysis and the nature the decision making task.

The detailed study of human decision making processes using the technique of verbal protocol analysis has generally involved the study of subject behaviour in experimental settings for relatively short periods of time [Simon et al (1987)]. Typically, this has involved observing subject behaviour for highly structured tasks or problems. Examples of studies using protocol analysis outside the field of cognitive psychology lend support to this view. See for example, the work of Payne, Braunstein and Carroll (1978), Bouwman (1983) and Isenberg (1986). Bouwman provides a full description of his experimental method in which 16 subjects were each given four financial diagnostic cases for evaluation. All the cases were hypothetical and the experiment required subjects to provide verbal reports as they considered each case for between 10 and 15 minutes.

The possibility of studying subject behaviour in a series of independent observation sessions is clearly one approach of extending the length of experimental run. However, the opportunity for this type of observation also depends on the type of task to be performed. For example, in the studies quoted above [Payne et al, Bouwman and Isenberg] subjects were presented with a series of independent cases as their decision making task. The continuous observation of an evolving decision making strategy was not of concern in these particular studies. Moreover, the structure of these experimental tasks made it feasible to observe subjects at a later period in time (though this was not done). However, for this research our strategic decision making exercise does not lend itself to this type of extended observation. There would be a number of difficulties in interpreting subject behaviour if our experimental procedure had involved subjects 'continuing' the decision making exercise at some later point in time.

One possibility for extending the present research to allow a longer period of subject observation would be to observe a subject in a variety of different competitive and market conditions. In this research we have chosen to focus upon studying a number of different subjects given our interest in contrasting the strategies of different decision makers. In either case it highlights that the use of protocol analysis has generally resulted in researchers restricting the sample size of observation [Isenberg (1986)]. This reflects both the high cost of coding and transcribing protocols and the volume of behavioural data that is produced from collecting just a small number of protocol transcripts. Inevitably, the richness of detail captured from a small sample of verbal reports is at the cost of being able to make broad generalisations about behaviour.

In sum, previous uses of protocol analysis for studying decision making behaviour has largely been restricted to task domains that have been well-structured. Typically, these tasks have been viewed as a series of independent cases to be performed by a subject. The application of protocol analysis to ill-structured tasks where information is extensive and often ambiguous and decision making is a continuous process is not widely reported in the literature [Bouwman, Frishkoff and Frishkoff (1987)]. In moving in this direction our strategic decision making experiment necessarily involves a limited period of observation. This problem is not unique to this particular application of protocol analysis as a review of the previously quoted studies will reveal. However, it does nonetheless raise some difficulties about our interpretation of subject behaviour in the next three chapters.

Two particular problems raised by the length of run of our experiment warrant further comment. First, it limited the number of decision periods over which subject behaviour could be observed. Second, given the dynamic nature of the competitive and market environment in our experimental setting, there is the possibility that behaviour patterns would change if the exercise were allowed to continue for further periods.

The limited number of observations highlights two issues. First, concern over whether there were a sufficient number of decision periods to observe regularities in information processing behaviour. Second, the limited range of conditions under which behaviour was observed. The first issue will ultimately be reflected in our ability to be able to identify a limited set of production rules capable of simulating a subject's behaviour. While regular patterns of behaviour are important for identifying such rules, their behavioural validity is not established by the statistical significance of their occurrence. The second issue has already been commented on above and reflects the limitation of the present study in terms of observing subject behaviour for a restrictive set of market and competitive conditions.

To some extent these latter issues reflect the almost inevitable consequence of the need for the behavioural economist to study detailed human information processing behaviour. The methodology outlined in the previous chapters calls for a more extensive research programme into studying the behaviour of a variety of subjects in a range of different task domains. Broad generalisations about economic behaviour are unlikely to emerge as a consequence of any single study using the research methods described in Chapters 2 and 3. However, as behavioural research studies are developed and extended then qualified generalisations will emerge from describing the variety of strategies that characterise behaviour in complex and uncertain task domains [Simon (1980)].

A second problem raised by the length of our experimental run is the possibility that we were unable to observe the emergence of complete decision strategies. For example, statements in one subject's protocol (described in Chapter 6) provides evidence of a shift in strategy from reacting to the rival firm to attempting to anticipate competitor moves. This change in strategy occurred towards the end of the exercise possibly reflects the subject's increasing experience and familiarity with the task. However, the inability to observe the operation of this anticipatory mechanism on more than one occasion provided insufficient detail in the subject's protocol for this aspect of behaviour to be modelled in the form of production rules.

Given the structure of our experimental decision making task, there was no natural termination point when the observation of subject behaviour should stop. The nature of our research method and the practicalities of running an experiment of this type required constraining the period of observation. In this respect observation in this type of behavioural research is always likely to be incomplete. It remains to be assessed in the following chapters whether our study of individual decision processes provides valuable insight into the phenomena that were the main purpose for observing behaviour in our particular experimental setting. In sum, our limited period of observation is an acknowledged weakness of the present research but one that is likely to face researchers who conduct similar experimental research focused on studying real world decision making tasks - particularly the strategic behaviour of firms. This, however, is a characteristic of the type of task domains that are the focus of behavioural research in general and not just the limitations of our particular approach to behavioural research.

4.6 CONCLUSION

The behavioural focus of our methodology highlights the importance of studying actual behaviour. There are various ways we could have observed actual decision making behaviour for this research. At one extreme we could have studied professional managers doing their actual job and asked them to 'think aloud' as they made decisions. We have rejected this approach for a number of methodological and pragmatic reasons discussed in this and the previous chapters.

Instead we have designed an experimental decision making task. Inevitably, our experimental task is a simplification of a real business setting, though hopefully it captures some essential characteristics of strategic pricing and product problems facing many firms in practice. Given that we know very little about managerial decision making processes [Isenberg (1986)], it is inappropriate for an exploratory study to deal with the full complexity of a real world decision making task.

In designing an experimental setting that simplifies reality we are also reflecting the particular research methods employed in this thesis. The concern with studying behaviour at a highly detailed level reflects our application of the information processing paradigm to the study of behaviour in ill-structured tasks. A laboratory environment provides the opportunity for the researcher to minimise the effect of poor experimental conditions on validating the use of verbal reports. Early behavioural research using protocol analysis [see for example Clarkson (1962)] demonstrates the difficulties of isolating the task from its context when observing the behaviour of subjects in their real world setting.

The stylised nature of our experimental setting inevitably brings limitations in the way we can observe and study behaviour. Two particular problems of the present experimental setting are: the nature of the reactive behaviour assumed between our subjects and the simulated behaviour of the competitor firm; and also the limited number of decision periods for which behaviour was observed. It is important these problems are highlighted for the purpose of interpreting subject behaviour in the next three chapters.

This Appendix contains the instructions distributed to subjects prior to the start of our exercise. A sample set of performance data displayed to subjects at the end of each period of decision making is also included at the end of this Appendix.

(a) Subject Instructions:

A Business Decision Making Exercise

Introduction

I am most grateful for you agreeing to co-operate in this computer based decision making exercise. The exercise should take about one hour of your time and does not require you to have any computer skills. All that you are required to do is read this explanatory document in advance of the actual decision making exercise. There will also be an opportunity for you to ask questions before the exercise starts.

The exercise requires you to make decisions in a hypothetical business situation. In essence, you are asked to imagine yourself as a manager of a firm for which you are responsible for making pricing and new product decisions where there is uncertainty about future market demand. The exercise has not been designed to replicate reality (indeed, this would be impossible); however, it is intended to characterise in a simplified manner a decision making situation that faces many businesses in a variety of different industries and markets. It is also important to stress that I am not concerned with assessing your individual competence as a decision maker. The exercise has been designed such that there is no optimal way to behave and it is not possible to do anything silly or wrong!

The Exercise Procedure

For this exercise you will be required to sit in front of an IBM computer terminal and enter price and product decisions for a number of consecutive decision periods. The machine will terminate the exercise at some future period and it will record all your decisions for subsequent analysis. The purpose of this exercise is to analyse decision making processes using methods and techniques from the field of cognitive psychology.

In addition to observing what decisions you make, I would also find it helpful to find out why you have decided to make a particular decision. To this end, you will be provided with a tape recorder for the purpose of recording your spoken thoughts. You will be asked to "think aloud" as you are making your decisions. **This is possibly the most difficult part of the experiment.**

Please do not feel intimidated or inhibited by the presence of the tape recorder. You shall be in a room on your own and these recordings will be confidential. It is most important that you keep speaking during the exercise, even if you are only repeating the messages the computer is printing on the screen. Please try to relax and verbalise your thoughts in as natural a way as possible as a good tape recording of your spoken thoughts is probably the most valuable outcome of this exercise for my research.

As you make your decisions for each period the computer will simulate the market envirionment and report your financial results. There is one major competitor in the market and the outcome of your decisions will also depend upon the decisions made by the competitor firm. The decisions of the competitor firm are made at the same time as your own decisions and it does not have any additional information that is not available to you. In sum, decisions in this exercise will need to be made on the basis of past information and anticipated behaviour of the competitor firm and the market environment.

All the information presented to you during the exercise will be displayed on the computer screen. Please remember to verbalise your thoughts when interpreting this information. Pen, paper and a calculator are also provided should you wish to record important items of information or conduct any further analysis. The model does, however, provide a summary of your results at the end of each decision making period and this will allow you to compare your relative performance from one period to another and with the competitor firm.

During the operation of the exercise, the computer will provide instructions at all stages and there is no need for any technical knowledge regarding how to operate the computer terminal. Within reason, the exercise has been error-checked so that you cannot enter "unexpected" responses to questions. However, given the continuous nature of the decision making exercise, it would be impractical for me to have the machine check every single figure that you enter. It is, therefore, important that you enter your answers carefully and check them <u>before</u> pressing the <Return> key. If you want to change your answer to a question and you have <u>not</u> pressed the <Return> key, simply use the <Del> key to <u>move</u> the cursor back and overwrite your previous answer. Once you have entered the response to a question and pressed the <Return> key, the machine <u>only</u> checks for obvious errors, eg a price of £1,000 <u>for a</u> product that costs £7.50 to produce.

You will be provided with an opportunity to have a TEST RUN at the start of the exercise. This will allow you to gain familiarity with the exercise procedure and this can be repeated if you wish. There now follows a description of the scenario upon which the exercise is based. You will also find in the Appendix recent performance and market data which should be studied carefully before starting the exercise.

The Decision Making Exercise

As indicated earlier, this decision making exercise is not meant to represent any <u>particular</u> market environment, but has been designed with <u>the intent</u>ion of characterising a business situation that faces many firms developing product/market strategies. It is inevitable that an exercise of this type will lack elements of reality. Please do not become frustrated with this since it was necessary for me to structure the exercise in a manner that will help my subsequent analysis. That said, I have attempted to capture what I believe are realistic elements (albeit at a high level of generality) of the pricing and product decisions taken by firms in practice. However, it has been necessary to stylise aspects of the exercise so that you do not come with any pre-conceived ideas or past experiences which you believe are relevant to this particular decision problem.

Your role is to assume that you are managing a firm that produces and markets a consumer product. There is one major competitor in the market, a firm that currently produces and markets two products (one of which has been recently introduced to the market). The exercise distinguishes between products on the market in terms of their mix of two characteristics. It is not essential to define what these characteristics are, but if you find it helpful you may, for example, refer to them as "reliability" and "attractiveness" of the product. All the exercise is trying to do here is to enable the marketing of new products which are different with respect to their relative mix of the two characteristics compared with products already on the market.

Consumers' expenditure is influence by the mix of the two characteristics and the price of the product compared with competing products on the market. You do not have any information as to which of the two characteristics that consumers regard as most important. For the rest of this document, I shall simply refer to these two characteristics as "Characteristic 1" (C1) and "Characteristic 2" (C2). The mix of C1 and C2 for any product shall be described as its "consumption technology".

You have no information as to the likely behaviour of the competitor firm in the exercise and you can only observe past decisions in an attempt to judge the competitor's strategy. It is important to stress that the competitor firm is in an identical position regarding your decision making behaviour and does not have access to any additional information in helping it make decisions.

The products on the market are in the early stages of the 'product life cycle' and demand is uncertain. It is, therefore, not possible to forecast future demand with any accuracy and total market demand in a period can fluctuate randomly around any long term trend. In allocating their expenditure amongst competing products on the market, consumers examine the following information:

(i) The relative mix of the characteristics C1 and C2 for each product.

(ii) The price of each product.

(iii) The information in (i) and (ii) for all products available on the market in any period.

In sum, uncertainty regarding market demand is with regard to both the level and structure of consumer expenditure in any period. Consumers can be assumed to have perfect knowledge about all products available on the market in any period. As such, there is no role for advertising expenditure other than that which is implicit in the costs of launching new products onto the market. Consumers do not have any brand loyalty to particular products.

For each period of the exercise you will be required to make two decisions:

(a) Product Decisions

For each period you will be required to outline your strategy regarding the products you wish to introduce onto the market and also those products you wish to withdraw. You can of course leave your product portfolio unchanged if you wish. The 'rules' of the exercise are fairly straightforward:

(i) The maximum number of products that can be introduced or withdrawn in a period is two. This reflects the entry and exit costs in the industry. It should also be noted that you cannot withdraw from the market totally in any period. Each product has an identifying number eg. Product No. 1, and so on. At the start of the exercise the product your firm is marketing is identified as Product Number 2, while the competitor firm's products are 1 and 3. As new products are introduced onto the market they will be assigned a higher number and the product numbers of those products withdrawn will be eliminated from the exercise altogether so as to avoid confusion.

(ii) All new products launched must have their 'consumption technology' defined in terms of their mix of C1 and C2 - the two characteristics that influence consumer demand. For each new product you launch you will be asked to define the product in terms of so many 'units' of C1 and C2. All new products launched onto the market must have a postive amount of each characteristic. For convenience you will be asked to define each product in terms C1 and C2 using the scale 0.1 to 10.0. However, what is important is not the absolute amounts of C1 and C2 but their relative amounts. Finally, a new product must remain on the market for at least one period before it can be withdrawn.

(iii) In addition to defining the nature of the product, the mix of C1 and C2 also determines the cost structure of a product from the perspective of the firm. The relationship here is simple, since each unit of C1 and C2 adds £0.50 to the variable cost of the product. For example, the existing product for your firm (ie. Product Number 2) is defined in terms of 3.0 units of C1 and 3.0 units of C2, giving a variable cost per unit for Product 2 of £3.00. This cost structure is identical for the competitor firm and you will be reminded of the variable cost of each product at the time you make your pricing decisions.

It is important to stress that consumers are prepared to buy both expensive products (ie. high levels of C1 and C2) and inexpensive products (ie. low levels of C1 and C2). However, because of uncertainty regarding the level and structure of demand you have no information in the exercise about the distribution of expenditure amongst expensive and inexpensive products or the way this may change in the future.

(iv) In addition to variable costs, there are also fixed costs of production associated with each product of £750.00 per period. These are incurred no matter what the level of demand is for a product. There are no problems of holding stocks or capacity constraints since production for an individual product is always set equal to the level of demand.

(v) When making product and pricing decisions for any period you will have the opportunity to review product and market data for the previous period. For example when you start the exercise the following information will be shown on the screen:

MARKET DATA: LAST PERIOD

Prod.No.	C1	C2	C.Ratio	Price	Sales(Rev)
1	4.00	1.00	0.25	3.20	15300.67
*2	3.00	3.00	1.00	3.60	19088.08
3	1.00	5.00	5.00	3.75	15111.25

The figures above refer to the previous period and an * indicates your company's products. More detailed data relating to the state of the market is contained in the notes to the exercise.

Press RETURN to continue.

Similar information is available at various stages in the exercise. The columns C1 and C2 refer to the number of 'units' of C1 and C2 that defines the product and the Price and Sales (Rev) figures are in £'s. The C.Ratio column represents the ratio of units of characteristic 2 to units of characteristic 1 (ie C2/C1). This information is useful for comparing products since the closer the ratio for any two products the more similar they are perceived to be by consumers.

(vi) The launching of new products and the withdrawal of products from your firm's product portfolio has a financial impact upon the company. Product launch costs are £7500.00 per product and are treated as capital expenditure for accounting purposes. The 'salvage' value of withdrawing a product is £2500.00. These values are identical for the competitor firm and 'depreciation' charges only affect profitability in the period when a product is withdrawn. The costs of launching a new product are met out of 'cash balances. Investment in new products is still possible even if cash balances for the firm are negative though this implies an increase in the long-term liabilities of the firm.

(b) Pricing Decisions

After determining your product portfolio decisions for the period you will be asked to outline your pricing strategy for each product. The computer will remind you of the price you charged for the product last period (unless it is a new product) and also the variable cost per unit of the product (as determined by its mix of C1 and C2). You will be asked to confirm the price of each product so as to minimise the impact of error.

The price entered will be in £'s, though you do not need to enter the £ symbol. For example, if you enter 3.50, the computer will interpret this as £3.50. You will not be allowed to enter zero or negative prices.

Finally, please remember during decision making to 'think aloud' no matter how trivial your thoughts might seem.

Financial Performance and Results

After completing your product and pricing decision, the computer will simulate the impact of your actions, given the conditions in the market and the decisions taken by the competitor firm. It is important to stress that there is no objectively correct set of decisions to make during each period of the exercise. However, you should note that the exercise has been designed to encourage active decision making during the short period of time in which you participate, thereby allowing me to maximise the benefit of your help. As such, it is quite possible for either firm to dominate the market in any one period and this will be reflected in the reported financial results.

The Appendix to this note contains the "results" of the three previous periods, with Period 3 being the most recent (ie the last period). When you start the exercise proper, the computer will display information relating to this "last period", though for the purpose of the exercise your decision making activity will actually start from "Period 1". During the test run the model utilises the data for Period 3 contained in the Appendix.

The financial results are relatively straightforward to interpret and it is important that you 'think aloud' during your analysis and interpretation. Should you need to do any calculations, please use the pen, paper and calculator provided. It would be useful for you to 'talk through' any additional analysis that you carry out.

The financial results are broken down into two sections:

(a) Your firm's results; and

(b) The competitor firm's results.

For both your firm and the competitor you are provided with a summary of performance for the period and then a report which summarises performance to date. You will not be allowed to recall these result screens once you have pressed the <Return> key, so please interpret them carefully before moving on to the next screen display.

The results and performance information will also inform you of the products marketed in the period in terms of their characteristic mix and price. In addition, for the competitor firm, you will be informed of any new products launched - their characteristic mix and price, and also any products withdrawn from the market in the period.

The performance information reflects accounting relationships implicit in the exercise but it is not important that you understand these, except in very general terms. I shall now briefly explain the terms that will be used in the screen display of the results and performance data:

Sales Revenue: this simply refers to the number of units sold for each product multiplied by its price.

Share of Market Revenue: indicates the market share of your firm or the competitor firm in terms of market revenue. It is measured in percentage terms.

Operating Profit/Loss: this is calculated by deducting variable and fixed costs for each product from its sales revenue. The cost structure is identical for both firms.

Total Profit/Loss: this includes both operating profit/loss and an adjustment for interest and depreciation. Interest charges/receipts are 8 per cent of the cash balance. If you are carrying a positive cash balance you receive interest, and if you have a cash liability you will pay interest. Depreciation charges simply reflect the difference between the launch cost of a product and its 'salvage' value (ie £5000.00). Depreciation is set off against profit in the period a product is withdrawn.

Return on Capital Employed (ROCE): this refers to the total profit or loss for a period expressed as a percentage of capital employed. For simplicity, capital employed can be referred to as the sum of fixed assets and cash assets (or liabilities).

Cash Balance at End of Period: this depends upon the opening cash balance; profit/loss for the period and any new products or product withdrawals. Negative cash balances are allowed within the exercise (eg because of loss making products or excessive investment in new products). However, the exercise does allow for the possibility of bankruptcy if negative cash balances become excessive relative to the asset base of the company. The probability of bankruptcy, however, is extremely low.

Share Price: share price movements are also recorded for both companies. The relationship governing share price movements is complex (as it would be in practice) and is meant to reflect the stock market's assessment of the relative performance of both companies. In sum, share price behaviour can be assumed to reflect a firm's performance with respect to market share, profitability, return on capital employed, as well as random fluctuations in the stock market.

It is important to stress that the relationships which determine the values for the performance variables mentioned above are identical for both your firm and that of the competitor. It is not important that you understand these relationships in detail, but you should use and interpret the information during decision making.

The interpretation of your performance and that of your competitor is an important part of the exercise though you are not required to pursue a particular objective eg maximise profits. The variety of different performance variables discussed above are clearly not unrelated and are incorporated to allow the possibility of multi-objective decision making.

After interpreting the results for a period the exercise will then continue to the next period. You should not try to make decisions with a view to some terminal point in the exercise as the computer will stop the exercise at some randomly selected future period. It is envisaged that each period's decisions will take about five minutes or so - including the interpretation of the financial results. However, please take your time and complete the exercise at your own pace.

Summary

1 Read this document carefully in advance. Bring the document with you to the exercise in case you need to refer to it. There will be a five minute briefing period before the exercise starts to discuss any points of clarification.

2 The computer program explains things as it goes along and you will have the opportunity to carry out a test run before you start the exercise proper. You do not need any computing experience in order to participate.

3 Please make sure that the tape recorder is switched on at all times and that you talk aloud during the experiment - no matter how trivial some of your comments may seem to you. This is probably the most important aspect of the exercise.

4 Please take your time; I have attempted to provide certain types of information in a format which should not require excessive additional analysis. However, if you feel that further analysis of some information is necessary, please use the pen, paper and calculator provided. This analysis should be deliberate so please try to provide an explicit verbal account of what you do.

5 Thank you very much for your help. I hope you find the exercise 'enjoyable' and I shall inform you at a later date of the outcome of this research.

(b) Sample Performance Data

The following is a sample set of performance data as displayed to subjects at the end of each period on the computer screen:

COMPANY RESULTS :PERIOD 7

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
4	2.0	5.0	3.65	18310.	66832.02	1996.52
12	6.0	3.0	5.00	0.	.00	-750.00
13	3.0	7.0	5.20	0.	.00	-750.00

Total sales revenue for period : 66832.02

Total profit/loss (incl. int.& depcn) for period : -6653.04

Company share of market revenue for period(%) : 12.27

ROCE for period(%): -12.92

Cash balance of company at end of period : 28977.45

Share price at end of period : .50

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	36125.77	60.82	3881.15	7.16	1.46
2	.00	.00	-3361.10	-6.61	.91
3	.00	.00	620.01	1.20	.89
4	199406.50	64.97	8079.60	13.56	1.10
5	149338.70	37.71	503.20	.84	.76
6	70477.41	12.27	-1947.44	-3.35	.50
7	66832.02	12.27	-6653.04	-12.92	.50

Average profit/loss per period : 160.34

Average ROCE per period (%) : -.02

***COMPETITOR FIRM RESULTS: PERIOD 7 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.80	215203.40
3	1.00	5.00	3.30	79920.23
11	4.00	6.33	5.22	182544.40

Total sales revenue for the period : 477668.00

Total profit/loss (incl. int. & deprn.) for period : 41558.05

Competing firm's share of market revenue for period (%): 87.73

Competitor ROCE for period(%): 19.64

Cash balance of competitor at end of period : 189109.90

Competitor share price at end of period : 3.33

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	23274.24	39.18	6409.28	12.06	1.65
2	168300.00	100.00	19163.66	26.51	2.31
3	188100.00	100.00	21107.25	22.60	2.61
4	107493.50	35.03	16065.27	14.67	2.01
5	246661.30	62.29	20481.55	19.61	2.44
6	503722.60	87.73	40096.03	23.58	3.10
7	477668.00	87.73	41558.05	19.64	3.33

Average profit/loss per period : 23554.44

Average ROCE per period (%): 19.81

CHAPTER 5

A GLOBAL MODEL OF SUBJECT BEHAVIOUR IN OUR STRATEGIC DECISION MAKING EXPERIMENT

5.1 INTRODUCTION

The discussion in this chapter reflects two central themes. First, to explore more fully the concepts and techniques introduced in earlier chapters - particularly the technique of protocol analysis. Second, to outline the elements of a behavioural process model of subject behaviour for our experimental setting. This will form the basis for: (i) exploring the differences in behaviour between subjects, and (ii) developing a PS simulation model that captures the detailed information processing behaviour of an individual subject.

Concurrent verbal protocols typically generate high volumes of behavioural data and the researcher is faced with the possibility of analysing information processing behaviour at a number of different levels. In this chapter we restrict our protocol analysis to what Bouwman (1985) has called 'global modelling'. This represents a first attempt to examine the structure of the decision making processes that characterise the behaviour of our subjects. However, in analysing our protocol data at a particular level, we face the danger of neglecting the insight provided by alternative levels of analysis. For example, scanning a protocol transcript for anecdotal evidence of decision making activities that cannot be reduced to the form of detailed production rules may provide a valuable insight into the decision making process e.g. a subject's control strategies. We shall illustrate this point with examples from our analysis of subject S7's protocol later in this chapter.

The latter point highlights an important feature of protocol analysis as a research methodology. The ability to examine patterns and sequences in information processing behaviour demands repetition of decision making situations [Newell and Simon (1972), Bouwman (1985)]. However, repetition does not infer the presence of identical states of knowledge characterising the problem space over time. Indeed, given the nature of our experimental task, it is likely that subject behaviour will be observed for states of knowledge that are unique over the period of observation. Repetition thus refers to the nature of the decision processes that are identified as capturing subject behaviour and the circumstances under which they are evoked. In sum, production rules are based on observing general patterns in information processing behaviour and are not created by the 'ad hoc' fitting of rules to the facts (states of knowledge).

Process tracing methods raise a number of problems and difficulties for the researcher and in this chapter we attempt to present in as clear a manner as possible the procedure we have adopted in analysing subject S7's behaviour. For example, in identifying the knowledge elements and operator codes for S7 we have based our analysis upon the nature and structure of the decision making task presented to our subjects rather than the eip's of Newell and Simon's theory of human problem solving. This is valid given the premise that the task itself is viewed as the major determinant of observed behaviour [Newell and Simon (1972)]. Given the lack of comparable studies reported in the economics literature, we have developed the detailed aspects of our approach around the original work of Newell and Simon (1972) and also the research of Bouwman [see for example Bouwman (1983)].

In the next section we present a task analysis of our strategic decision making exercise. The purpose of this is to provide direction for our subsequent protocol analysis. It will generate, in broad terms, hypotheses regarding the knowledge elements and decision making processes (i.e. operators) that characterised our subjects' decision making behaviour [Bouwman, Frishkoff and Frishkoff (1987)]. An obvious basis for our task analysis is the normative and descriptive models of the strategic decision making process that can be found in the business policy and corporate strategy literatures.

In the following section we present a detailed discussion of subject S7's behaviour in terms of the general characteristics of his pricing and product strategies. We then specify the problem space for S7 and present a global PS model of his strategic decision making process. We also illustrate the construction and use of problem behaviour graphs (PBG).

Finally, we conclude the discussion of this chapter by considering some of the other significant findings that are revealed in our subject's protocol but which are not incorporated in our global model. This discussion emphasises the usefulness and limitations of protocol analysis as a methodology for studying various aspects of human decision processes. We also suggest a number of directions for further research.

5.2 THE DECISION MAKING EXERCISE: A TASK ANALYSIS

Newell and Simon's theory of human problem solving emphasises that both the structure of the task environment and the information processing characteristics of a subject determine problem solving behaviour. This is highlighted by the distinction between the concepts of a task environment and a problem space. Problem solving behaviour is viewed as a path through the problem space - the subject's internal representation of a particular task environment. It is to be expected that different subjects faced with the same external task environment will exhibit a common perspective with regards the demands of a particular task. This will be reflected in the way subjects represent the task environment internally in their perceived problem space. For example, the emergence of common knowledge elements and similar problem space operators.

Before analysing a subject's protocol the researcher needs to identify basic reference points regarding the nature of the knowledge structures and decision making processes that characterise a particular task domain. A useful preliminary to conducting protocol analysis is to present a task analysis of the experimental setting. Bouwman (1978) provides a good example of a task analysis for a financial diagnostic decision making exercise. The task analysis should assist the researcher in recognising patterns in human behaviour that are meaningful in terms of the general structure of the task that is being performed and the particular research objectives of a study.

A variety of empirical and theoretical studies in the business policy and corporate strategy literatures provide us with a basis for conducting a task analysis of our strategic decision making exercise. We shall not review this literature in any detail here. However, the normative and prescriptive models of the strategic decision making process developed in the literature have a number of common elements. For example, the early work of Pounds (1969) distinguished between two types of information processing activity in business decision making: problem finding and problem solving. A similar distinction is made between elements of the strategic decision making process in more recent literature; see for example, Mintzberg et al (1976), Harrison (1981), Leontiades (1982) and Johnson and Scholes (1987).

A widely used conceptual model in the business policy literature views the strategic decision making process in terms of the activities of: strategic analysis; strategic choice and strategic implementation. The latter two elements correspond to problem solving activities, while strategic analysis highlights the role of problem finding as a management activity. Good examples of the exposition of this model of corporate strategy can be found in Hofer and Schendel (1978) and Johnson and Scholes (1987).

This model of the strategic decision making process provides a useful framework for studying the decision making behaviour of subjects in our experimental setting. We can expect that knowledge structures and information processing operators that characterise the above activities should emerge in general terms from analysing the protocol data of a subject. This will provide the basis for defining our subject's problem space. Of course, in practice it is not always possible to distinguish between these elements of the strategic decision making process for the purpose of describing and analysing the behaviour of a firm. Similarly, in coding the protocol data of our subjects we can expect to observe 'jumps' in the application of particular problem space operators. As we shall discuss in Chapter 7, it may be very difficult for the analyst to account fully for the sequencing and application of operators.

In the management literature strategic analysis is largely viewed as being concerned with gaining an understanding of the strategic position of a firm in relation to its goals, resources and the environment (e.g. competition and market demand). This process clearly involves collecting and analysing information and developing an awareness of potential problems that require diagnosis. Finally, an important aspect of strategic analysis will be the emergence and specification of strategic goals.

Strategic choice and strategic implementation essentially correspond to the problem solving activities of the strategic decision making process. Strategic implementation is not a problematic issue in our experimental task. We did not structure our decision making exercise to capture the difficult aspects of putting strategy into practice. In reality, many of these problems arise from the organisational constraints that face companies and since the purpose of this decision making exercise was to focus upon individual decision making behaviour we shall not discuss the implementation aspects of strategy any further.

Strategic choice can be interpreted as the activities of identifying, evaluating and selecting strategies in response to the goals and problems identified from conducting a strategic analysis. The design and structure of our experiment had the effect of limiting the role of strategic choice by constraining our subjects to making pricing and product decisions. However, subjects were still faced with a variety of possible price and product strategies they could pursue. Chapter 6 examines in more detail the different generic strategies developed by our subjects.

The discussion above provides us with a very general framework for studying and modelling the strategic decision making process. We have also gained insight into what might be considered the elements of a procedurally rational model of subject behaviour for our experimental exercise. As it stands, the generality of this framework does not allow us to assess its feasibility or completeness for studying and modelling the decision making processes that characterise the behaviour of our subjects. We need to be able to operationalise this aggregated model in terms of more detailed information processing operators that reflected our particular experimental task. However, these operators cannot be specified a priori and must be the result of protocol analysis rather than its input.

Task analysis also provides a reference framework for the coding schema to be used when analysing verbal protocols. This is a problematic aspect of protocol analysis and has resulted in critics arguing that coding is 'ad hoc' and subjective [see for example, Svenson (1979)]. One possibility for overcoming this difficulty might be to link the set of codes used for analysing a protocol to Newell and Simon's elementary information processes (eip's). A theoretical underpinning for protocol analysis can be found in human information processing theory and eip codes appear a natural coding scheme when analysing protocols [Anderson (1984)].

One limitation of using eip's as a basis for coding protocols is that different research objectives may demand the use of different sets of codes [Bouwman (1984)]. It is important to stress that information processing behaviour can be described at a number of different levels. At a theoretical level all behaviour (from an IPS perspective) can be represented in terms of a basic set of eip's. However, this may not be an appropriate level for capturing the problematic aspects of information processing behaviour for a particular task. In sum, the coding scheme adopted by a researcher is a major determinant of the type of insight a protocol analysis will reveal about the decision making processes used by subjects for a particular task.

Bouwman, Frishkoff and Frishkoff (1987) present an alternative approach to protocol coding that is based on the task analysis of the experimental setting in which behaviour is to be observed. The nature of the decision making processes identified in the task analysis provides a useful basis for identifying problem space operators. Of course, different sets of codes (to the extent they can be identified in the protocol) simply provide a different view of the same decision making process. However, the prime concern of the researcher is to specify a set of codes that focus on those aspects of the decision making process that are central to the research objectives. For example, in this research we are particularly concerned with identifying operators that allow the study of different decision making strategies used by our various subjects.

In coding the protocol for subject S7 we identify a set of operator codes that reflect the discussion above about the nature of the strategic decision making process. However, our previous discussion emphasises that decision making can be viewed as taking place not just in one problem space but in a hierarchy of problem spaces - the lower order spaces representing information processes that more closely correspond to the elementary information processes (eip's) discussed in Chapter 3. These eip's in turn form the basis for defining more macroscopic operators. Too high a level of aggregation is likely to be problematic for the purpose of developing behavioural process models ie. the process 'disappears'. However, protocol analysis that is too disaggregated also has its problems. There is the danger of detailing sub-processes that are not problematic for the subject and as such do not add anything to the description of the subject's behaviour. Similarly, the application of a particular operator could have significance beyond some local aspect of a subject's behaviour and may require a higher level of aggregation for the purpose of studying a subject's decision making strategy (which of course, is the interest of our study).

In defining the operators for subject S7 our main purpose was to be able to identify the repetitive occurrence of particular decision processes in the subject's protocol and broadly determine their input and output elements. As we shall demonstrate, this does not imply that a single information process is associated with a particular operator; indeed, the operational specification of an operator for PS modelling purposes may require a set of production rules for representing sub-processes. These sub-processes refer to lower order problem spaces for S7 which we were unable to specify from the protocol data that was available.

For the purpose of developing a PS simulation model we require a hierarchy of production rules that define each of the global operators described below. These rules also give behavioural content to our subject 's decision making strategies. However, these low level rules are not always easily inferred from the protocol directly, hence the need for repeatedly being able to observe behaviour. Of course, their mispecification is the reason why we may observe differences between the PS trace and the actual behaviour of our subject. In generating a high density of process data, protocol analysis is typically concerned with the detailed observation of behaviour from a small sample of data. More aggregated methods of observation emphasise the use of large samples of data. This highlights the ethological nature of protocol analysis and contrasts with the more statistically orientated approaches to the study of human decision processes e.g. behavioural decision theory.

5.3 AN OVERVIEW OF SUBJECT S7's DECISION MAKING BEHAVIOUR

In this chapter we focus upon analysing the protocol transcript of a single subject - S7. In coding the protocol data for the subject we have adopted a level of aggregation that allows us to relate his decision making strategies to the elements of the strategic decision making process that were briefly described in our task analysis. The main purpose for doing this is to facilitate the comparison between the strategies of different subjects in the next chapter.

S7 was a good example of a subject who provided a detailed and comprehensive protocol of his decision making behaviour. For this reason much of the remaining discussion in this thesis will focus upon S7's behaviour. In this section we examine the nature of S7's pricing and product strategies. This discussion will rationalise the approach we have adopted to defining the knowledge elements and operators that specify S7's problem space.

The full protocol transcript for S7 is contained in Appendix I to this chapter. It is recommended that the reader review the protocol before continuing with the behavioural data contained in the protocol and the constraint of space, we are not able to present a full analysis of the whole protocol in this chapter.

Subject S7 was a senior member of academic staff at Sheffield Business School (UK) and had previously spent over ten years in industry. His previous management position had been as a general manager for UK manufacturing company. The subject also had extensive consultancy experience and regularly advised both medium sized public companies and small local firms on issues of marketing and corporate strategy. As we shall see in the next chapter, S7 performed relatively successfully in the development and implementation of his pricing and product strategies during the experiment. Appendix I also contains a brief summary of the trading and performance results for S7 and the competitor firm for the seven decision periods over which his behaviour was observed.

In developing a behavioural process model for S7 we follow a number of steps. Each step involves a different representation of the information processing behaviour of the subject. The sequence is as follows: (i) the audio tape; (ii) the lexical representation (usually in the form of thought units or topic statements); (iii) the problem space representation; (iv) the problem behaviour graph; (v) the production system model, and (vi) the production system trace. Protocol coding is an iterative process and definitions for the operator codes we have developed below are the result of a number of 'runs' through S7's protocol. Clearly, as the methodology of protocol analysis outside the cognitive domain develops, coding reliability and consistency as well as the efficiency of the coding process will be improved. Computer packages that can mechanically apply grammatical and linguistic rules to protocol transcripts are likely to be available in the longer term for this type of research.

In an attempt to increase the objectivity of our protocol analysis in this experiment we have used a second coder who independently coded the protocol of subject S7. This second coder was not, however, used to assist in the analysis of the protocols of other subjects whose behaviour we examine in Chapter 6. The use of an additional coder was particularly valuable for validating the reasonableness of our interpretation of S7's behaviour. Clearly, we could not expect our second coder to follow the long and iterative process we adopted in analysing the protocol. However, an important contribution of the additional coder was in helping to clarify any ambiguities in code definitions and also confirming the level at which information processing operators were to be defined.

The topic representation of S7's protocol is contained in Appendix I. This breaks down the transcribed protocol into 'thought units' that represent the subject dealing with a single action or a single piece of information. This is the first important step in putting structure to our subject's decision making behaviour and provides us with the basic units of analysis for developing the problem space of the subject. We reference these topic statements below in describing various aspects of S7's behaviour.

It should be noted that while each topic statement in S7's protocol has been assigned an operator code, the protocol extracts below illustrate examples of ambiguities and borderline cases in the coding of topic statements. In these instances topic statements do not neatly satisfy our definitions of the various operators described in the next section. Moreover, a number of topic statements provide only a limited insight into how we might specify a particular problem space operator for inclusion in our PS model. However, in deliberately assigning an operator code to each topic statement we are emphasising the importance of the researcher studying the full protocol. Ignoring topic statements that are not typical examples of information processing activities could reduce the researcher's access to the decision making processes and strategies used by a subject in a particular task. Equally, it would be misleading to suggest that the researcher can expect to find topic statements falling into neatly defined classes of operator codes. However, the refinement and fine-tuning of operator codes that result from a detailed protocol study should increase the consistency with which topic statements can be classified.

(i) Subject S7's Behaviour: General Overview

Subject S7's decision making behaviour was observed for for seven periods of our experimental simulation. Early statements by S7 suggest that he perceived the task as being ill-structured and this appears to be reflected in the rather tentative strategies he pursued in the first few periods. It also suggests that the presence of uncertainty had an impact upon S7's reasoning and control strategies as well as his specific decisions. This can be seen from the following extracts of S7's protocol:

PERIOD 1 <u>Topic Line 4</u>

So very high uncertainty ...at this stage of the exercise ... there are a lot of strategic questions at the moment that I clearly don't know the answer to ...

<u>Topic Lines 10 - 12</u>

Equally, I don't want to get into a price war or any other aggressive strategy early on...I think I will tend to go for a policy of collaboration rather than an all-out aggressive policy...though I realise I may have to change maybe as a result of his action ... or as a result of the total size of the market and its elasticity

The above extracts indicate S7's strategies were non-aggressive and exploratory in the early periods of the exercise. In contrast, by Periods 5 and 6 of the exercise S7 demonstrates greater knowledge of important market relationships and rival's strategy. This is reflected in the way S7 becomes more aggressive and directs his strategy towards pursuing well defined goals, notably increasing market share. The following extracts illustrate this point:

PERIOD 4 Topic Lines 180; 184 - 185

That is beginning to tell me something about the market here that there seems to be this pincer effect ... This pincer effect seems to refer to the c-ratios in this exercise and the absolute levels of the characteristics may not be as important... this was hinted in the case notes...but I've not exploited this so far. A slight change in strategy then ... I'll focus upon c-ratios more directly.

PERIOD 5 Topic Line 238

...well I've got the market share I wanted, that's all right ... exactly what I expected. I think I'm reading the signals right ...

There are other examples in S7's protocol to illustrate this point but all we wish to stress is that the exercise appears to have captured an important aspect of strategic behaviour - the subject attempting to cope with complexity and uncertainty. The significance of this can be found in reviewing the full protocol with there being clear evidence of the subject developing an incremental strategy (ie. adaptive behaviour). For example, in Period 5 the subject states:

PERIOD 5 Topic Line 220

...while my strategy appears to be a bit incremental...but there has been a clear policy that has emerged very easily...that is market share capturing and pricing penetration policy.

The above comments by S7 also suggest the possible emergence of unintended strategies with a shift from the non-aggressive stance that characterised behaviour in early periods of the exercise to a highly competitive pricing strategy in later periods. For example, in Period 4 S7 notes:

PERIOD 4 Topic Line 214

What has the competitor done? ... Yes, just as I thought... a pricing war on our hands. In a sense I've walked into this - I should not have shaded my prices up at the same time I expected him to shade his prices down.

From S7's protocol it is quite possible to identify in broad terms the nature of pricing and product strategies used by the subject. It is useful to describe these before presenting S7's problem space and global PS model in the next section. The reader may also find that the discussion in Chapter 4 of the rival firm's decision making module provides a useful base for interpreting the strategies followed by our subject. There is evidence of the subject and the competitor firm following similar strategies.

(ii) Subject S7's Product Strategy

(a) Product Withdrawal

S7 had a well defined and straightforward product withdrawal strategy. This was stated and summarised at various stages in the protocol. The following extract is a particularly clear exposition:

PERIOD 2 <u>Topic Lines 79 - 82</u>

I am not going to withdraw any products at this stage ... at £750 there is little point and they are worth that for market research ... ... so there may be a case for keeping products alive indefinitely ... although there is some money to be had back by releasing them. However, I've not got a cash flow problem so my overall strategy is not to kill products at all.

Unlike the competitor firm (and other subjects), S7 did not assess the performance of individual products for the purpose of deciding whether to withdraw them or keep them in his product portfolio. Once a product had been introduced it was kept in the portfolio and would only be withdrawn (or so it appears) if it had zero product sales or the subject was facing a cash/liquidity crisis. In brief, a product was always seen as having market research value.

(b) Product Introduction

S7 launched four new products during the course of the exercise and the subject's protocol reveals quite transparent trigger mechanisms that stimulated the introduction of new products. Two key mechanisms appear to have been:

(i) the existence of significant gaps in the market
(ii) the presence of successful competitor products

Both of these criteria can be viewed as being reasonable in the context of the design of our experiment. It will be recalled from Chapter 4 that similar criteria were used to model the new product strategy of the competitor firm. Examples of both these mechanisms being applied are quite explicit in S7's protocol. For example, the "market gap" criterion was applied in Period 1:

PERIOD 1 Topic Lines 13 - 14

... and I will try to avoid getting too close to his products which will be seen as an aggressive action ... and ... I will explore other areas of the market the competitor is not in ... ... and I think that will be my opening strategy.

The "successful competitor product" criterion was applied in Periods 4 and 7 and an extract from the protocol illustrates the subject's reasoning:

PERIOD 4 Topic Lines 221 - 223

Product 3 ... which is occupying the top end of the market ... it's doing OK. I've got two options here: (i) I can try and do more pincer movements on him or (ii) I can go to the extreme and go "under" him at one or other end of the market. I can either come in under Product 1 at less than .25 or I can come in over Product 3 with the 5 c-ratio.

As with the modelling of the competitor firm, the "market gap" strategy was essentially a non-aggressive strategy which was only applied by the subject early in the exercise. This strategy can be interpreted as representing attempts by the subject to identify niches in the market. In contrast, the launching of new products in later periods reflected a more aggressive strategy to acquire market share and ultimately dominate the market. This was reflected by the focus upon the nature of competing products marketed by the rival firm.

It is reasonably clear in the protocol how the subject identified successful competitor products. Explicit reference is made to a competing product's market share and this appears to be the basis upon which S7 launched new products in Periods 2 and 7. In Period 4 the product market share criterion was used again except that two competing products were identified as indicating potential market segments in which to launch a new product, ie. they were perceived to have similar market shares. A second criterion was then applied by the subject which compared the price mark-up of the two competing products. The product with the highest margin was used to identify the market segment in which to launch a new product as this would increase the likelihood of the new product being profitable.

Equally important in studying S7's product strategy is analysing the protocol when no new products were launched. In particular, it appears the subject viewed the impact of pricing and product decisions as being interdependent for the purpose of developing an overall strategy. In this respect, S7's strategy was more sophisticated than that modelled for the competitor firm. The following extracts from S7's protocol for Periods 2 and 3 provide good examples of the type of factors we need to take into consideration when defining the operator codes to model the subject's product strategy:

PERIOD 2 <u>Topic Lines 100 - 101</u>

... but Product 4, my expensive product, has sold nothing ... is that because of price or has my competitor done something there?

PERIOD 2 <u>Topic Lines 107 - 108; 111 - 113</u>

... Right ... OK ... my competitor hasn't launched any new products ... that's interesting ... what is hitting me is entirely price related ... but his Product 3 is doing very nicely. Yes, I've reversed my position completely, and yet all I've done ... well ... I've introduced the new product ... but essentially all I've done is change price.

PERIOD 3 <u>Topic Lines 119; 122 - 123</u>

... and I increasingly feel price is probably everything in the market ... I'm not going to introduce any new products ... since my competitor isn't ...

These extracts highlight the subject considering some broader issues in determining whether to launch a new product. For example, in the latter extract, the fact that the competitor had a successful product on the market was not sufficient to activate the launch of a new product. The subject perceived pricing strategy to be more important in this particular set of circumstances. Other significant facts regularly noted by the subject in his protocol that appear to have determined his product decisions were:

(a) the changing significance of price sensitivity in the market

(b) the existence of an unsuccessful product already competing with a successful product of the competitor

(c) an unsuccessful product (in terms of sales) had just been increased in price

(d) the competitor firm not launching any new products

A final aspect of S7's new product strategy was the assignment of c-ratio values to a new product. The choice of c-ratio appeared to reflect two factors. First, the subject considering how competitive the new product should be in relation to the "nearest" competitor product on the market. We have noted above that the c-ratio of the subject's new products became closer to those of the target product as the exercise progressed and reflected the increased aggressiveness of the subject. A second consideration was whether a new product was to be a "high value"; "mid-value" or "low value" product. This appeared to have significance in the early periods of the exercise and is clearly associated with 'market gap' type product strategies ie. a portfolio or niche perspective of product strategy.

Initially, the subject attempted to explore the relative success of high margin products for improving profitability and also for the purpose of developing a balanced portfolio. For example:

PERIOD 1 <u>Topic Line 17</u>

I think ... I'm going to try a top end of the market product ... a relatively high valued product ... compared with my existing product ...

However, as the exercise developed and the number of products on the market increased S7's perception of the importance of absolute amounts of C1 and C2 in defining a new product diminished. This also appears to reflect the recognition by S7 of the difficulties associated with assessing market demand. It also highlighted the growing significance of price competition for S7's strategy in the later stages of the exercise. For example, in Periods 4 and 7 it was the relative value of the c-ratio that dominated S7's choice of C1 and C2 when defining new products:

PERIOD 7 Topic Lines 291-292

I'll hit the competitor with a new product with a ratio of under .25 ... so I'll go in with 5:1 ... ... an extra unit of C1 characteristic ... to give a lower ratio ... ... He might go under me ... no he won't do that ... there is no reason to ... if anything he will go higher if he introduces a new product.

These extracts appear to emphasise S7's recognition that successfully locating a product in a market niche requires relatively few products on the market ie. greater opportunity for identifying market gaps. As the number of products on the market increased, S7 moved towards more aggressive pricing and product strategies ie. product differentiation in terms of characteristic mix becomes a difficult strategy to implement successfully. The appropriateness of these different strategies reflected the changing market conditions in our experimental simulation.

(iii) Subject S7's Pricing Strategy

The details of S7's pricing strategy are less transparent from the protocol than his new product strategy. To identify the nature of S7's pricing operators it was necessary to carefully study both the protocol and the actual pricing decisions made by the subject. However, taking the protocol as a whole, it can be seen that certain knowledge elements in S7's problem space are regularly the focus of attention when determining product prices. Once again we shall illustrate this with extracts from the protocol. The most important variables appear to have been:

(a) Product Cost: There are numerous examples in the protocol where the subject makes explicit reference to the variable cost of a product when determining its price for the period. For example:

PERIOD 1 Topic Lines 32 - 33

Variable cost for Product 4 is £6 ... it is a high value product ... and, therefore, it may stand a high mark-up.

PERIOD 7 Topic Lines 300 - 302

Product 8 ... variable cost £3.50 ... price last was ... £3.60 ... I'll sell at £3.55.

These comments suggest the use cost based pricing strategies by S7. However, the protocol extracts also indicate that these rules may not be straightforward. For example, the extract in Period 1 shows that the subject is employing some concept of 'product value' to indicate a level of price mark-up for a product.

(b) Product Sales Last Period: S7 closely monitored the performance of each product in terms of its market share in the previous period. Given the subject's policy of not withdrawing products, except in the event of a cash or liquidity crisis, there are numerous illustrations of price increase/decrease/hold decisions that appear to directly reflect a product's previous sales performance. For example:

PERIOD 1 Topic Lines 26 - 28

Variable cost for my product was £3 and the mark-up was 60p ... good sales on that .. I want to be cautious ... in fact, to avoid complicating issues I'm going to keep my price where it is ... £3.60

PERIOD 3 Topic Lines 131 - 133

Product 4 at £6.70 did disastrously ... let me ... my competitor's dropping his price ... I'm going to put that down to £6.40.

(c) Overall Pricing Strategy: On a number of occasions the subject made an overall statement of pricing strategy. This was then translated into price decisions for each individual product in his portfolio. Moreover, even where the subject does not make an explicit statement of general strategy, other comments and decisions imply S7 was following an overall pricing strategy. For example:

PERIOD 4 <u>Topic Lines 215 - 216</u>

... but there is a lot of sensitivity to price ... There is only one way I can go this period - my strategy is quite clear ... it won't do much for profitability but it will allow me to capture market share. So ... aggressive pricing is the only way out given I've walked right into this ...

PERIOD 7 <u>Topic Lines 289 - 290</u>

I'm going to keep all prices exactly where they are ... I've little room to drop them. I will drop them if I can ... I'll go for the throat and shade them down a little further.

To some extent the statement of an overall pricing strategy appears to reflect the broad strategic goals of the subject in terms of the relative importance of increasing market share and profitability. For example, in Period 4 the subject's strategy is focused upon increasing profitability and this is reflected in his attempt to increase prices on all his successful products marketed in the previous period. Similarly, in Period 7, as the extract above illustrates, the overall objective is to increase market share and despite a number of products achieving high market share in Period 6, the general strategy is to reduce prices.

(d) Competitor Pricing/Mark-Up Norm: A final significant variable that impacted upon S7's pricing decisions was the relative level of prices in the market. S7 quickly established the importance of price sensitivity in the exercise when there were a number of products on the market. It it is also clear from his protocol that S7 closely monitored the competitor firm's pricing strategy. For example:

PERIOD 1 <u>Topic Line 35 - 36</u>

... that will cover my costs ... yes, that doesn't seem too expensive in relation to products on the market last period ... that is probably under-pricing.

PERIOD 4 <u>Topic Lines 178 - 179</u>

His Product 7 is obviously squeezed ... because his pricing is by no means more outrageous there ... in fact it's low there ... but because I'm squeezing with Product 2 and Product 4 ... at a low price ... he is doing badly.

The importance of relative product pricing in this decision making exercise was emphasised in the last chapter. As the number of products on the market increased very keen pricing strategies would be required to successfully capture market share. S7 was particularly aggressive and his pricing strategy was a major factor in the emergence of very low margins for both the competitor firm and the subject towards the end of the experimental run.

Price margins were not the sole determinant of market share in this exercise. Differentiated products could profitably survive in the market providing price competition was not too aggressive and products were significantly different in terms of the C2/C1 ratio. However, S7's pricing strategy in Periods 5, 6 and 7 created wide differences in price between his products and those of the competitor firm. This eliminated any impact of shifting demand for the two product characteristics (C1 and C2) in determining market share. Only in Period 4 did the subject abandon his aggressive pricing policy and price his products marginally above those of the competitor firm in an attempt to increase profitability. However, at the beginning of Period 5, the subject comments:

PERIOD 5 <u>Topic Line 220 - 221</u>

... whilst my strategy appears to be a bit incremental ... but there has been a clear policy that has emerged very easily ... this is a market share capturing and pricing penetration policy. In a sense deviating from this last period was a mistake ... I should have stayed where I was ... I guess.

This statement is a reflection of the harshness of the market environment simulated in our experiment. A scenario of similar products and aggressive pricing limited the scope for both the rival and the subject to locate products in 'secure' market niches. In these circumstances product differentiation was a difficult strategy to implement successfully. However, this scenario did not emerge for all the subjects. There are examples of both the competitor firm and individual subjects marketing successful products located in 'large gaps' in the market.

One consequence of the aggressive product and pricing strategies developed by subject S7 was that the competitor firm became a "follower" rather than a "leader" in the market. This resulted in S7 being highly successful in Periods 5, 6 and 7. In sum, it paid for S7 to be aggressive providing he was more aggressive than the competitor firm. As was noted in the previous chapter, this suggests the emergence of characteristics similar to the Prisoner's Dilemma gaming situation in our experimental setting.

5.4 PROBLEM SPACE AND GLOBAL PS MODEL FOR SUBJECT S7

In this section we consider a more formalised representation of S7's information processing behaviour. We illustrate the stages of protocol analysis concerned with problem space definition and the use of Problem Behaviour Graphs (PBG). Finally, we shall develop a global PS model for S7.

(i) Problem Space for S7:

An important element of Newell and Simon's human information processing theory is that decision making takes place in a problem space. A problem space is defined as the subject's internal representation of a decision making task. The particular problem space used by a subject determines entirely what information is available and how it is to be processed during decision making (via the operators). Problem solving can thus be viewed as the search path followed by a subject through their perceived problem space as they 'move' from one knowledge state to another.

It is not possible to prove that actual decision making takes place in a particular problem space. However, Newell and Simon argue that the existence of a problem space is the major invariant of problem solving behaviour that holds across tasks and subjects. This perspective is fundamental to our research method. If we can define an individual's problem space for a particular task it is also possible to model a subject's decision making processes within a production system framework.

The previous argument emphasises that the ill-defined nature of our decision making exercise does not mean that subject behaviour cannot be modelled. In the previous section we described S7's behaviour and observed a structure to his information processing activities while performing our experimental task. In fact it was the very ability of S7 to work within a perceived problem space that had a high correlation with the actual requirements of the task (in some objective sense) and that enabled S7 to perform relatively successfully vis a vis the competitor firm. This, of course, is the very essence of human expertise. If the subject had been unable to place a structure on the task we would have observed random behaviour and this would have prevented our use of human information processing theory as a modelling framework. An important purpose of protocol analysis is to reveal a structure to a subject's verbal statements for the purpose of allowing the researcher to identify knowledge elements and operators that represent a subject's problem space.

Figure 5.1 summarises the problem space defined for S7. It was developed from analysing the full protocol contained in Appendix I. Following Newell and Simon we have adopted a notation known as Backus Normal Form (BNF) to present the problem space in a formal manner. BNF is a useful form of meta-notation for describing grammars of programming languages and allows a fairly straightforward representation of information about various classes of symbol expressions. We classify expressions by enclosing them in angular brackets "< >" - e.g. <letters>, where the identifier in the angular brackets is the name of the class. New identifiers can be assigned to classes of expression by using the assignment symbol ":: = " - e.g.

<small numbers> ::= <digit><digit>, where the class "small numbers" contains all expressions with two digits. Classes can also be defined that are arbitrary disjunctions by using the symbol "/" and which can be interpreted as meaning OR. For example, if we redefined the class of "small numbers" as:

<small numbers> ::= <digit>/<digit><digit>

We now have "small numbers" as referring to the class of expressions consisting of one or two digits. Finally, it is important to note that recursive definition can be admitted, thereby providing the system with capabilities of defining infinite classes.

It will be recalled from the discussion in Chapter 2 that a problem space represents the knowledge elements, goals and operators that define a subject's behaviour. Knowledge elements are the knowledge structures that the subject processes and are both the inputs and outputs of the operator elements. The operators are the transformation mechanisms that represent the information processing activity of the subject. For the purposes of this chapter we shall describe these operators externally in terms of the information they use as input and the information they produce as output. Our earlier discussion has provided some insight into how we might define these operators in terms of production rules for the purpose of PS modelling (see also the discussion in Chapter 6). Given our concern with global modelling in this chapter this will be sufficient for being able to identify when and where the operators occur in the protocol.

The interpretation of the knowledge elements in Figure 5.1 should be transparent given S7's protocol and our previous discussion of the experiment and the subject's behaviour. The operators require some explanation, though again, they should be reasonably clear from the protocol and the discussion in the previous section. The operators provide insight into both the information processing activity of

Figure 5.1 Problem Space for Subject S7 (BNF Notation)

Knowledge Elements

```
<period>::=  last/current/future
<company>::=  competitor/subject
<prod-id>::=  <digit>
<c1>::=  0.1/......../10.0
<c2>::=  0.1/......../10.0
<c-ratio>::=  <c2>:<c1>
<product type>::=  high value/mid-value/low value/
                   competing product
<product>::=  <prod-id> <c-ratio> <product type>
<portfolio>::=  [<product>]
<portfolio change>::=  -2/-1/0/1/2
<market sector>::=  top/middle/bottom
<competitive products>::= <company> <product attributes>
                          <company> <product attributes>
<product attributes>::=  <product>/<price>/<market sector>/
                         <competitive products>/fixed cost/
                         variable cost/mark-up
<price>::=  <digit-value>
<market data>::= total demand/product gap/price sensitivity/
                 market prices/product sales/<product>/
                 product life cycle
<strategic goal>::=  increase profit/increase market share/?
<price strategy>::=  price increase/price decrease/hold/
                     high mark-up/low mark-up/new/?/
                     competing product
<product strategy>::=  new product/withdraw product/no change/
                       product market gap/pincer movement
<strategy>::=  <price strategy>/<product strategy>/overall
<strategy type>::= aggressive/non-aggressive/?
<company strategy>::=  <company> <strategic goal>/<company>
                       <strategy> <strategy type>
<decision-1>::=  <company strategy> <portfolio change> <c-ratio>
                 <product strategy> <product type> <period>
<decision-2>::=  <company strategy> <portfolio> <price strategy>
                 <price> <period>
<decision>::=  <decision-1> <decision-2>
<performance  variables>::=  sales/market  share/profit/
                             share price/cash balance/unit sales/
                             operating profit/product sales
<company performance>::=  <company> <performance variables>/
                          <company> <product attributes>
<performance measures>::=  good/bad/increase/decrease/unchanged/
                           successful/unsuccessful/high/low/
                           /satisfactory/problem/noted/?
<performance assessment>::=  <company performance> <decision>
                             <performance measures>
                             <company strategy>
<strategy appraisal>::=  suitable/acceptable/feasible
<strategy assessment>::= <company strategy> <strategy appraisal>
                         <decision>
<strategic importance>::=  significant/noted/?/problem
<strategic assessment>::=  <expression> <strategic importance>
<task variable>::= [as defined above]
<assignment expression>::=  <task variable> <-- <task variable>
<expression>::=  <task variable>/<assignment expression>
<state expression>::=  <expression>/<expression> <tag>

<knowledge state>::= <state expression>/<knowledge state>
                     <state expression>
<strategic facts>::=  <performance assessment>
                      <strategic assessment>/<strategic facts>
                      <strategic  assessment>
                      <performance assessment>
<goal>::= get<decision>
<sub-goal>::=  get<expression>/check<expression>
<tag>::=  unclear/new/assumption
```

Operator Elements

DS/SA/DPPS/RATIO/DPS/PRICE/SV/PA/SF

Where:

DS = Determine Strategy
DPPS = Determine Product Strategy
DPS = Determine Price Strategy
PA = Performance Assessment
SA = Strategic Assessment
RATIO = Ratio
SV = Strategic Evaluation
SF = Strategic Facts

the subject as well as the inherent structure of the decision making task. We shall first describe each operator in turn before demonstrating the validity of our problem space definition by illustrating the construction of problem behaviour graphs (PBG) for the subject. Appendix I presents the topic representation of S7's protocol in terms of the operators defined in Figure 5.1. Each topic statement has been assigned one of the operators defined in S7's problem space in Figure 5.1

The specification of the problem space for S7 is the result of a detailed and iterative study of the subject's protocol. A useful technique is to group together topic statements for a particular operator for the purpose of identifying the knowledge elements that form its input and output. Ideally, the researcher should be able to establish an initial knowledge state; an information processing activity; and an output knowledge state for each topic statement in the subject's protocol.

It should also be noted that the problem space defined in Figure 5.1 is unlikely to represent the perceived problem space of S7 at every stage of the decision making process. Given the complexity of the task, S7's behaviour is likely to be characterised by a hierarchy of problem spaces. This captures the fact that our decision making experiment involved a variety of sub-problems e.g. evaluating performance; pricing a product and so on. The problem space in Figure 5.1 is a general problem space that reflects the range of knowledge elements and operators used by S7 during the full decision making episode for which his behaviour was observed.

The description of the operators below, together with the set of knowledge elements defined in the problem space, give an indication of how the LHS and RHS elements of production rules will eventually emerge from our analysis in Chapter 7.

DS: Determine Strategy. This is the activity of the subject determining the nature of his overall strategy and is repeatedly and consistently used throughout the whole protocol; see for example topic statements 6, 13 and 57 for Period 1 and 252 and 280 in Period 6. The input knowledge elements to this operator are: a company, a period and any accumulated strategic facts. It is of course the accumulated strategic facts that are the focus of the subject's protocol statements. The output is a current or future strategy for the rival or the subject. From the protocol it is clear that the output to the DPS operator generally takes two forms: (i) a strategic goal, e.g. market share or profitability and/or (ii) the assignment of a strategy type to a particular strategy, e.g. an aggressive pricing strategy.

S7 rarely provides a full summary of the particular set of strategic facts used in determining the output of the DS operator. Strategic facts are accumulated by the application of other operators, notably the SA and PA operators. For example, in Period 1 S7 attempts to accumulate significant facts early in the exercise about the environment and the performance of the competitor. Given high uncertainty and the fact that it is Period 1, the subject decides to adopt a non-aggressive strategy. This, in turn, is translated into both non-aggressive pricing and new product strategies.

SA: Strategic Assessment. Together with the PA operator, the SA operator was the most frequently used operator by S7. It represents the action of the subject identifying important facts in making price and product decisions or determining objectives. Unlike the PA operator, the SA operator is not concerned with the explicit assessment of subject or competitor performance. It is typically applied by the subject when trying to understand or place a structure to the competitive market environment. The input is any expression statement as defined in the problem space and the output is the assignment of a value in terms of strategic importance to that expression [ie. significant/noted/problem/?]. For example, in Period 1 the subject applies the SA operator in topic statement 3 in an attempt to assess the significance of price sensitivity in the market. In general, the SA operator provides valuable insight into the knowledge elements that S7 considered important during decision making.

The SA operator is a good example of where it is possible to identify what might be called more 'basic' operators being applied by the subject. For example, 'identifying a problem' or 'summarising a situation', or 'the comparison of two knowledge items'. There are two points to note here. First, these more basic processing activities are applied in other global operators as well (e.g. the PA operator) and generally appear to capture diagnostic aspects of the decision making process. Describing the subject's behaviour at this level does not, in our view, provide additional insight into the broader issues regarding the decision making strategies of our subject. It should also be noted that these basic operators are comparable with activity codes identified in other studies e.g. Bouwman (1978, 1983) and are approaching the level of eip's. The second point to note is that the inputs and outputs to these basic operators are captured in our definition of subject S7's problem space. It thus becomes a modelling issue as to what is the appropriate level of aggregation for representing S7's operators for the purpose of describing his perception of the problem solving task.

PA: Performance Assessment. The performance assessment operator represents the activity of the subject evaluating the success/failure of a particular strategy or decision. The evaluation is with reference to the performance variables incorporated in the exercise e.g. sales, market share, profit and so on. The inputs, therefore, are the particular strategy or decision and/or the value of the relevant performance variables. The output is an assignment expression that provides a performance measure and is noted for future decision making ie. it becomes a strategic fact. The PA operator has a similar role to the SA operator. Topic statements 60 through 63 for Period 1 illustrate the application of the PA operator.

S7 made no explicit statements to suggest the use of target levels for individual performance variables and the assessment of key variables such as market share was generally qualitative rather than quantitative e.g. 'increase/decrease/unchanged' and so on. The performance measures included in the problem space definition in Figure 5.1 attempt to capture the main assessment measures used by the subject in his protocol. Inevitably, we have had to be more linguistically rigid for modelling purposes than we can observe in the subject's own protocol. As with some of the other operators defining the PA operator requires a mechanism for relating the qualitative assessment of variables to the actual values of particular performance variables (ie. a set of production rules).

DPPS: Determine Product Portfolio Strategy. This operator is relatively straightforward given our discussion in the previous section. The input is a company strategy for the period and the accumulated strategic facts that are relevant to the decision of determining the subject's product strategy. S7 repeatedly applied the DPPS operator in some periods. The output of the operator is a decision whether to launch or withdraw products and, if so, how many, ie a value for the portfolio change knowledge element. The operator is also applied to determine the new product type, ie 'high value', 'mid-value', 'low value' or 'competing product'. Good examples of the DPPS operator can be found in topic statements 14 and 17 for Period 1 and statements 248 and 250 for Period 6.

RATIO: This operator captures the information processing behaviour of S7 in assigning values of C1 and C2 to a new product. As we discussed above, S7's actual assignment crucially depended upon the type of product being launched and the subject's product strategy for the period (determined by the DS and DPPS operators respectively). In later stages of the exercise the major determinant of new product c-ratios for S7 was the type of product strategy being pursued. There is also evidence in the protocol that the subject focused more explicitly on the c-ratio directly rather than the absolute values of C1 and C2 (which determine the product type) as his overall strategy became more aggressive.

In modelling the competitor firm, the equivalent of the RATIO operator only examined the product strategy knowledge element. This was the input for determining how "close" the new product's c-ratio would be to a product already marketed by the subject. As the exercise progressed, both the competitor firm and S7 became more aggressive by selecting c-ratios for new products that were very similar to the successful products of each other. Examples of the RATIO operator can be found in topic statements 19 and 22 for Period 1.

DPS: Determine Price Strategy. This operator is similar to the DPPS operator and captures the subject's activity of specifying a price strategy for a particular product. The inputs are the particular attributes of the product, a company strategy and the significant strategic facts that have been accumulated. The output of the DPS operator is a qualitative assignment of a particular price strategy to a product, e.g. price increase, price decrease and so on. This, in turn, forms the input to the PRICE operator which actually assigns a price value to each product in the subject's portfolio. There is evidence in the protocol that S7 (as did most other subjects) viewed the pricing decision in terms of these two steps. As with the competitor firm, key strategic facts in determining the price strategy for a particular product were the previous performance of the product in terms of market share, the price of competing products and the variable cost of the product. Good examples of the DPS operator being applied can be found in Period 1 in topic statements 28 and 33.

PRICE: This operator reflects S7's action of assigning a price value to each product in his product portfolio. The operator is more complex than appears from the protocol since the subject does not always explicitly comment about his decision to change a product price (ie the application of DPS). This highlights that S7's protocol transcript was not always complete as to the information processing activities of the subject. Insight into the nature of this operator required a careful examination of the actual pricing decisions of the subject as well as his protocol transcript. Topic statements 267 through 269 for Period 6 provide an illustration of S7 applying the PRICE operator.

SV: Strategic Evaluation. The SV operator captures the behaviour of the subject assessing the appropriateness of a particular strategy or decision. This assessment did not typically result in an explicit output but implied the subject relating a particular decision or strategy to: (i) the circumstances in the environment, (ii) the resource position of the firm, or (iii) the objectives of the subject. For this reason, the strategy appraisal knowledge elements that are output from the SV operator are defined in qualitative terms as: suitable (environment), acceptable (objectives) and feasible (resources).

As can be seen from the protocol, the SV operator is often applied after a particular decision has been made and rarely resulted in a change in strategy. In this sense we can actually question its significance in information processing terms and it suggests that the subject was simply commenting or confirming the rationale for a particular strategy. In this sense it might be viewed as having an important role in S7's reasoning method for coping with uncertainty in the exercise. The SV operator also provides useful insight into the importance of certain knowledge elements in determining particular strategies. Topic statements 21 and 29 for Period 1 provide examples of S7 applying the SV operator.

SF: Strategic Facts. The SF operator is a "housekeeping" operator that monitors all the significant facts that have been identified as a result of applying the SA and PA operators. This is an important operator that is implicit in the subjects' behaviour and it generates the input to the DS, DPPS, RATIO, DPS, and PRICE operators. For the purposes of simulating the behaviour of S7, the operator SF provides valuable insight into the specific combinations of task variables that are important to the subject's decision making activity (ie. the knowledge elements that form the LHS and RHS conditions of production rules). This emphasises that the subject does not sequentially assess the value of every single task variable but is in fact selective and focuses on what are perceived to be the key variables for the task at hand. There was an equivalent operator implicit in our modelling of the competitor firm since the competitor only processed certain key variables each period for the purposes of determining its product and pricing strategy. In both cases this implies the application of a control strategy (crude or otherwise) to cope with the complexity and uncertainty in the task.

There is no explicit reference to the application of the SF operator in S7's protocol and it is best viewed as representing the cumulative knowledge of the subject as he proceeds from one knowledge stage to the next. There are occasions where recall of this type of information is made explicit in the protocol ie. some of the lengthy topic statements that have been coded PA and SA in S7's protocol.

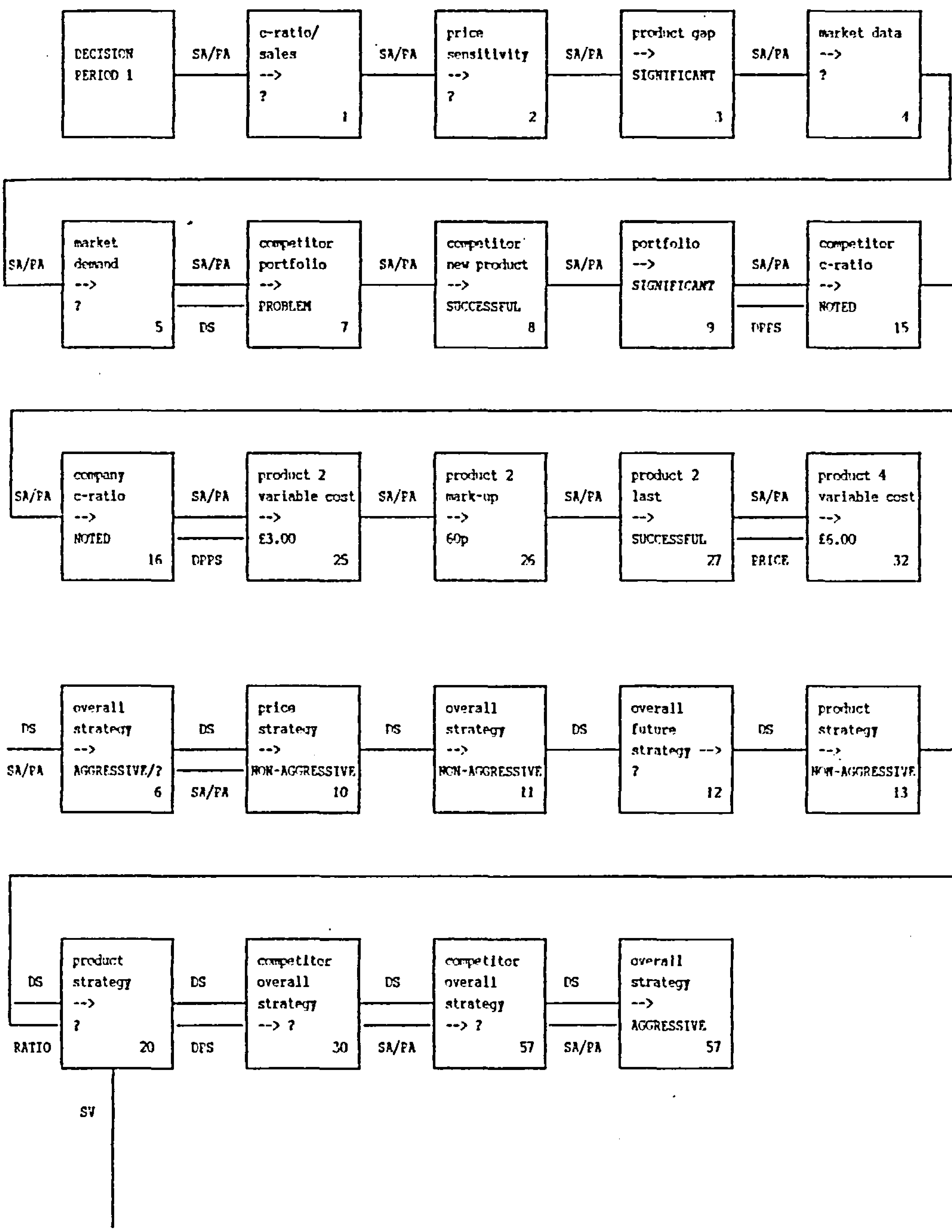
The discussion above of S7's problem space forms the basis for developing an information processing model of our subject in Chapter 7. In analysing S7's protocol we have identified in general terms the information used by our subject during decision making as well as the operators applied for transforming and processing knowledge states. We have indicated in general terms how the operators were used to derive new knowledge from existing knowledge. It should also be clear how the knowledge elements (identified in the protocol) included in our problem space form the inputs and outputs to these operator elements. In sum, we have the basic framework for developing a global model of S7's decision making process.

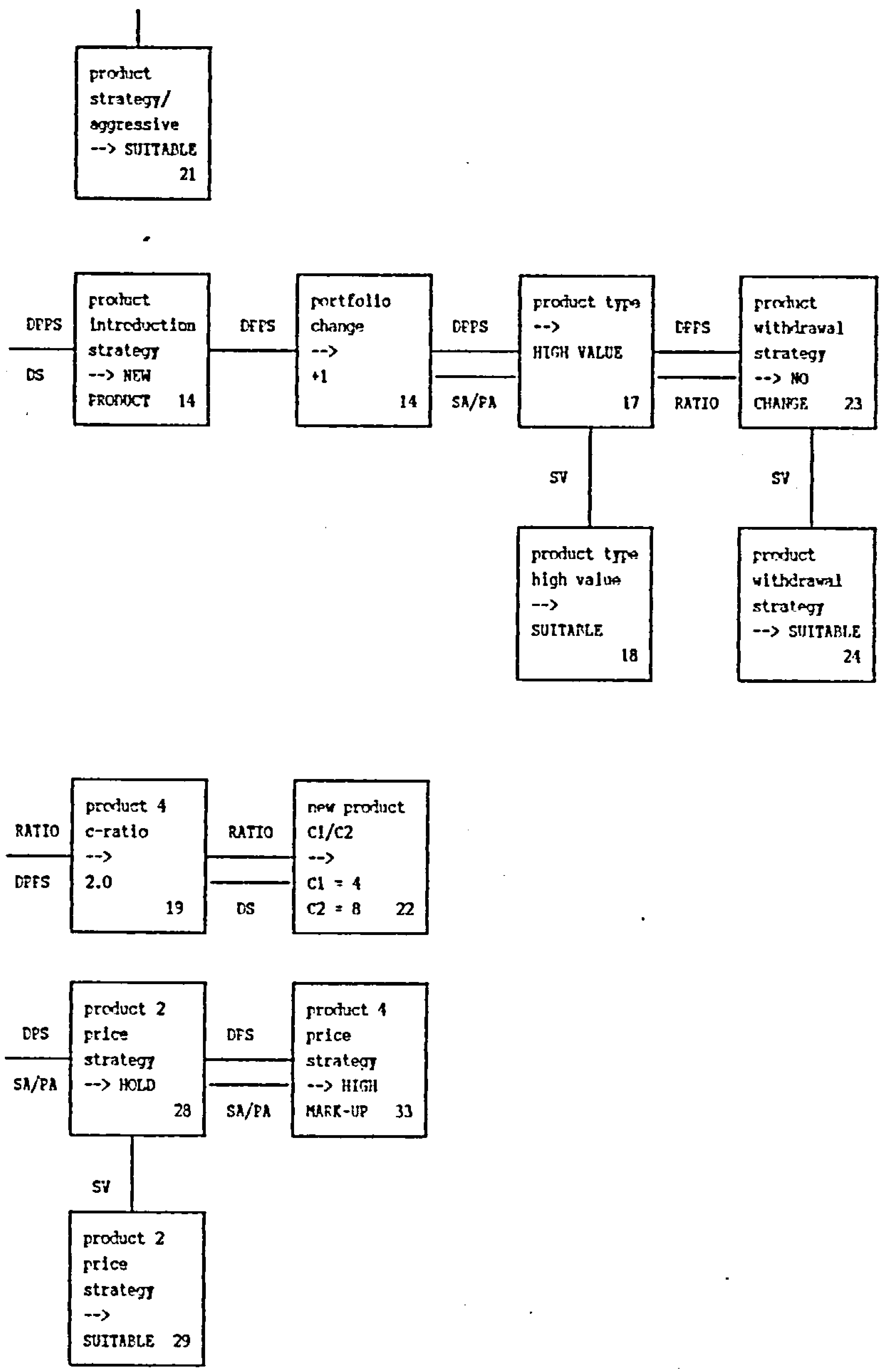
(ii) Problem Behaviour Graph for Subject S7:

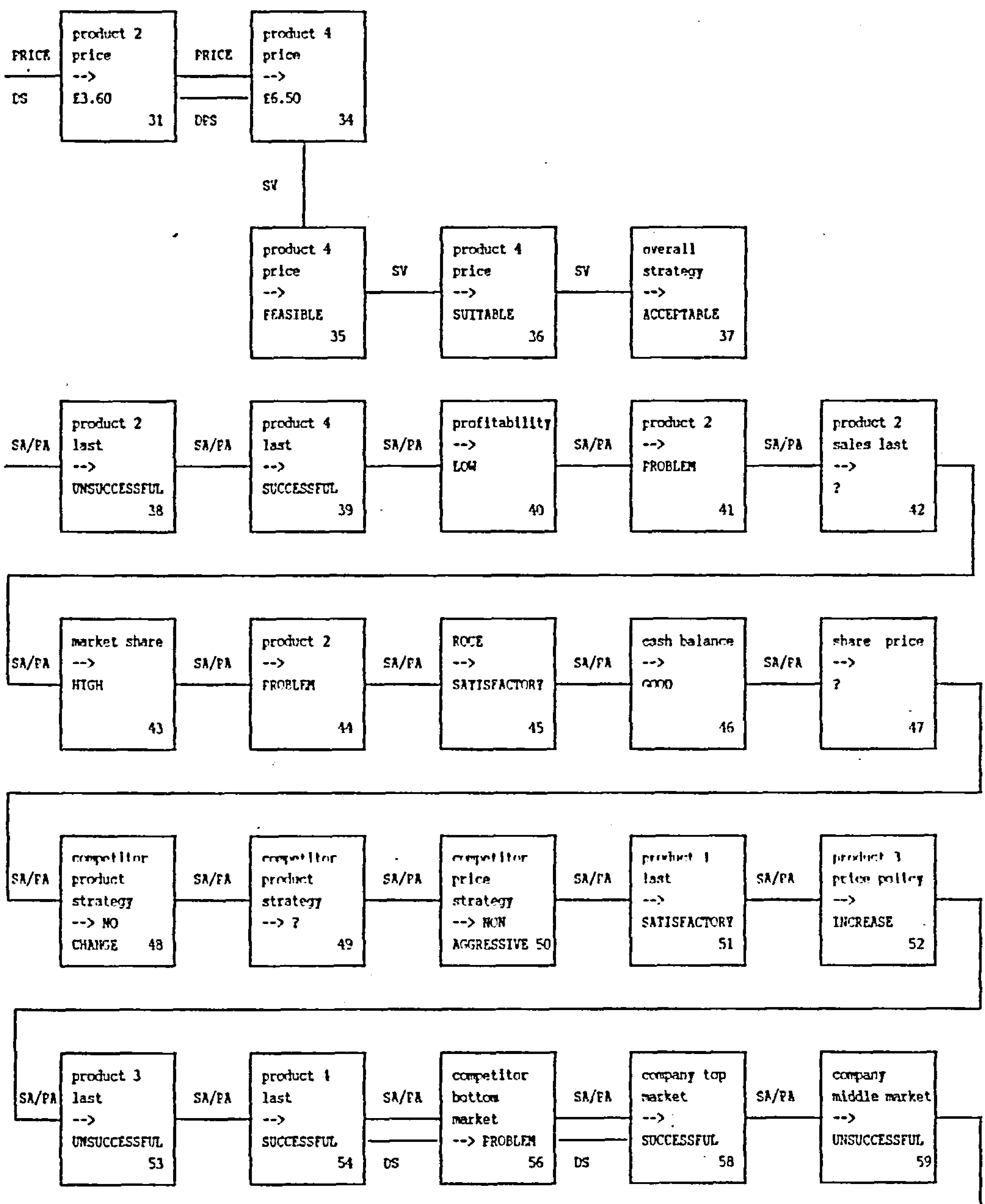
We have described how problem solving behaviour can be viewed as a path through a problem space, ie as a series of interconnected knowledge states. The dynamic representation of a subject's behaviour through the problem space can be summarised in the form of a problem behaviour graph (PBG). This shows the movement of the subject from one knowledge state to the next by applying the various operators defined in the problem space. The rules for constructing PBG's were outlined in Chapter 3 with each node representing a particular state of knowledge and each branch representing the application of an operator to that knowledge state.

Examples of PBG's for subject S7 are presented in Figure 5.2 and Figure 5.3. For the purpose of illustration, we have divided up our graph in terms of the operators defined in the problem space. A break in the operator sequence is illustrated by a double branch, with the previously fired operator identified below the second branch. It is possible to construct a separate PBG for subject S7 for each period of the decision making exercise. However, for illustrative purposes we shall simply restrict our analysis to PBG's for Periods 1 and 6. It should be noted that in presenting the PBG's in Figures 5.2 and 5.3 we have used abbreviated notation to aid the

Figure 5.2 Problem Behaviour Graph: Subject S7 Period 1 ACTUAL Behaviour




product strategy/ aggressive --> SUITABLE 21
DFPS
DS
product introduction strategy --> NEW PRODUCT 14
DFPS
portfolio change --> +1 14
DFPS
SA/PA
product type --> HIGH VALUE 17
DFPS
RATIO
product withdrawal strategy --> NO CHANGE 23
SV
product type high value --> SUITABLE 18
SV
product withdrawal strategy --> SUITABLE 24
RATIO
DFPS
product 4 c-ratio --> 2.0 19
RATIO
DS
new product C1/C2 --> C1 = 4 C2 = 8 22
DPS
SA/PA
product 2 price strategy --> HOLD 28
DPS
SA/PA
product 4 price strategy --> HIGH MARK-UP 33
SV
product 2 price strategy --> SUITABLE 29


PRICE
DS
product 2 price --> £3.60 31
PRICE
DFS
product 4 price --> £6.50 34
SV
product 4 price --> FEASIBLE 35
SV
product 4 price --> SUITABLE 36
SV
overall strategy --> ACCEPTABLE 37
SA/PA
product 2 last --> UNSUCCESSFUL 38
SA/PA
product 4 last --> SUCCESSFUL 39
SA/PA
profitability --> LOW 40
SA/PA
product 2 --> PROBLEM 41
SA/PA
product 2 sales last --> ? 42
SA/PA
market share --> HIGH 43
SA/PA
product 2 --> PROBLEM 44
SA/PA
ROCE --> SATISFACTORY 45
SA/PA
cash balance --> GOOD 46
SA/PA
share price --> ? 47
SA/PA
competitor product strategy --> NO CHANGE 48
SA/PA
competitor product strategy --> ? 49
SA/PA
competitor price strategy --> NON AGGRESSIVE 50
SA/PA
product 1 last --> SATISFACTORY 51
SA/PA
product 3 price policy --> INCREASE 52
SA/PA
product 3 last --> UNSUCCESSFUL 53
SA/PA
product 4 last --> SUCCESSFUL 54
SA/PA
DS
competitor bottom market --> PROBLEM 56
SA/PA
DS
company top market --> SUCCESSFUL 58
SA/PA
company middle market --> UNSUCCESSFUL 59

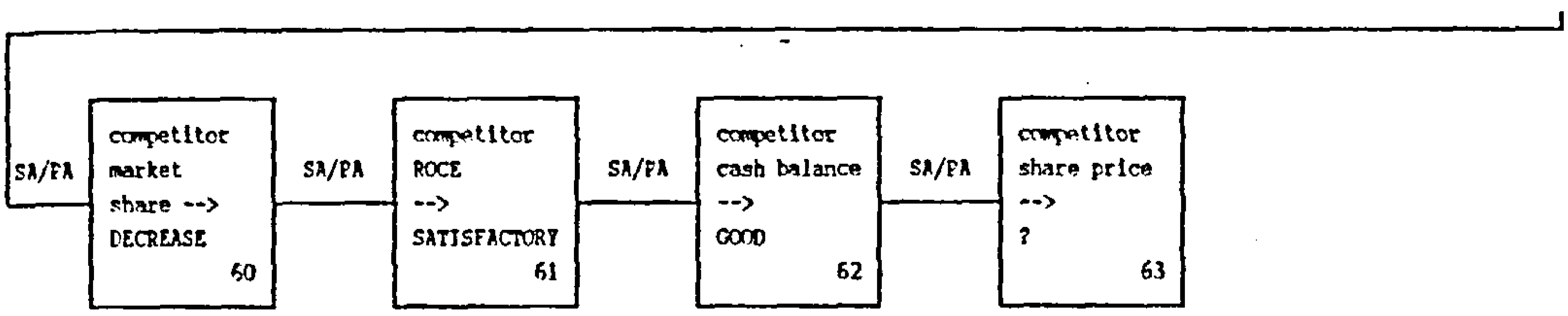
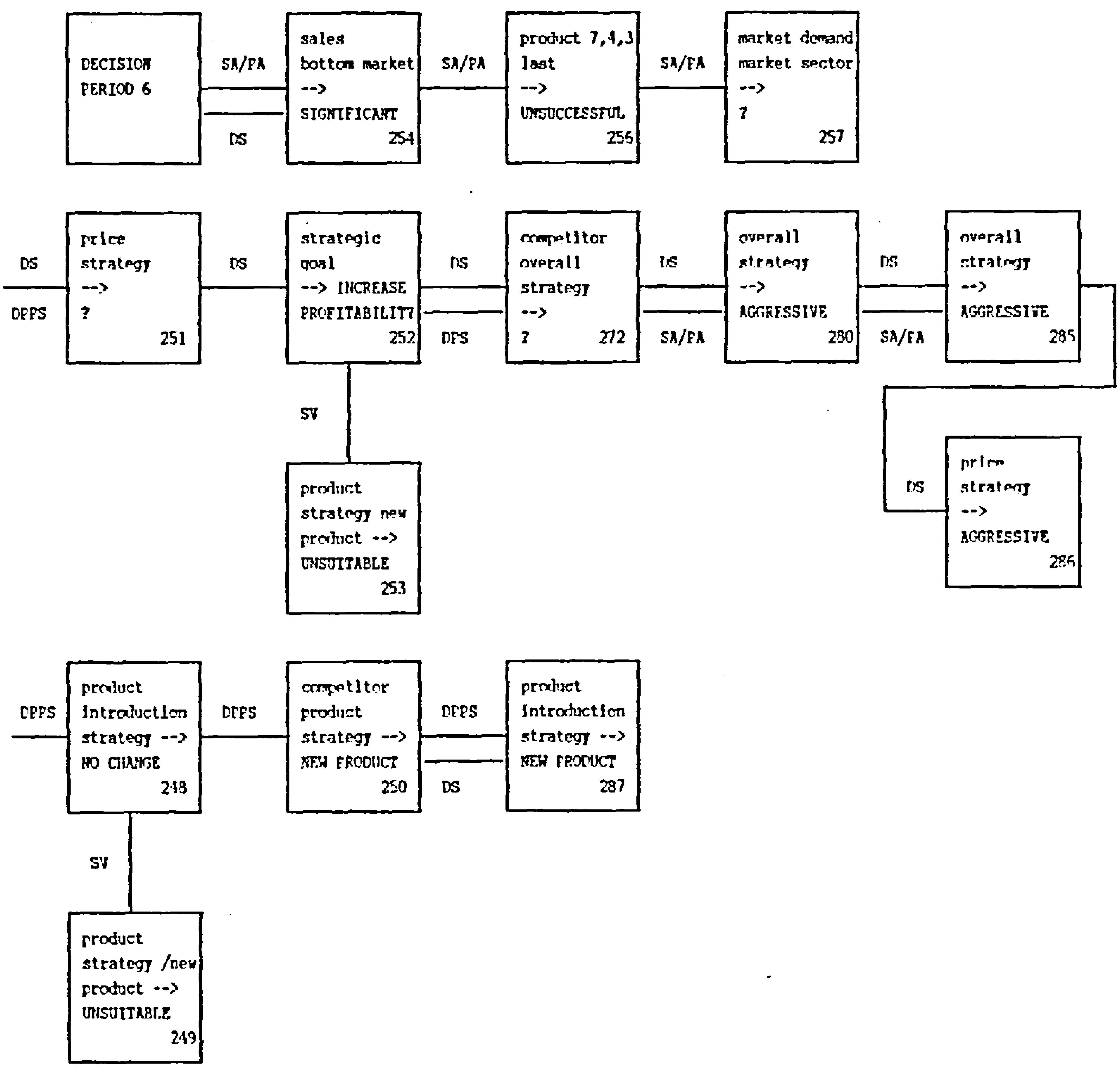
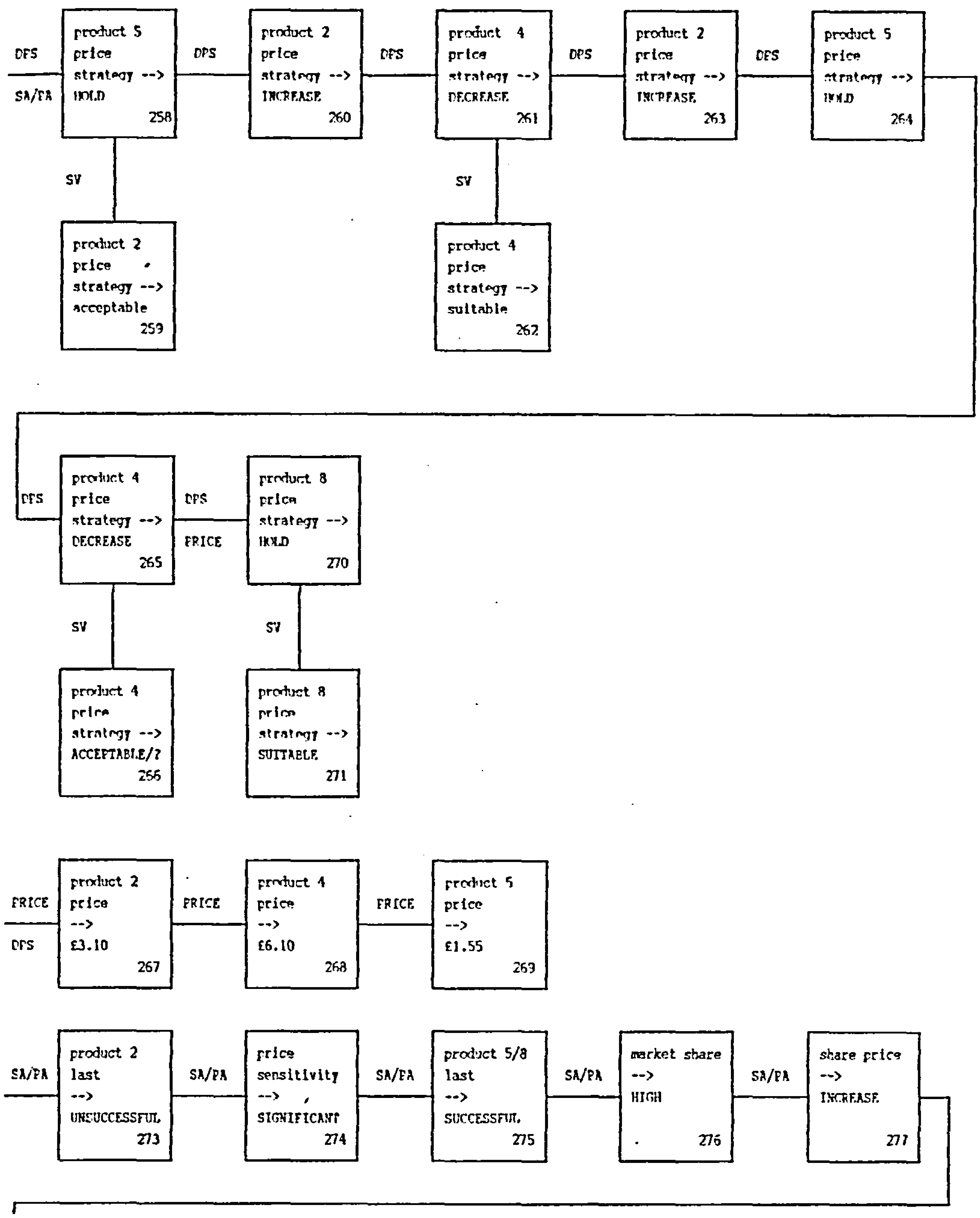
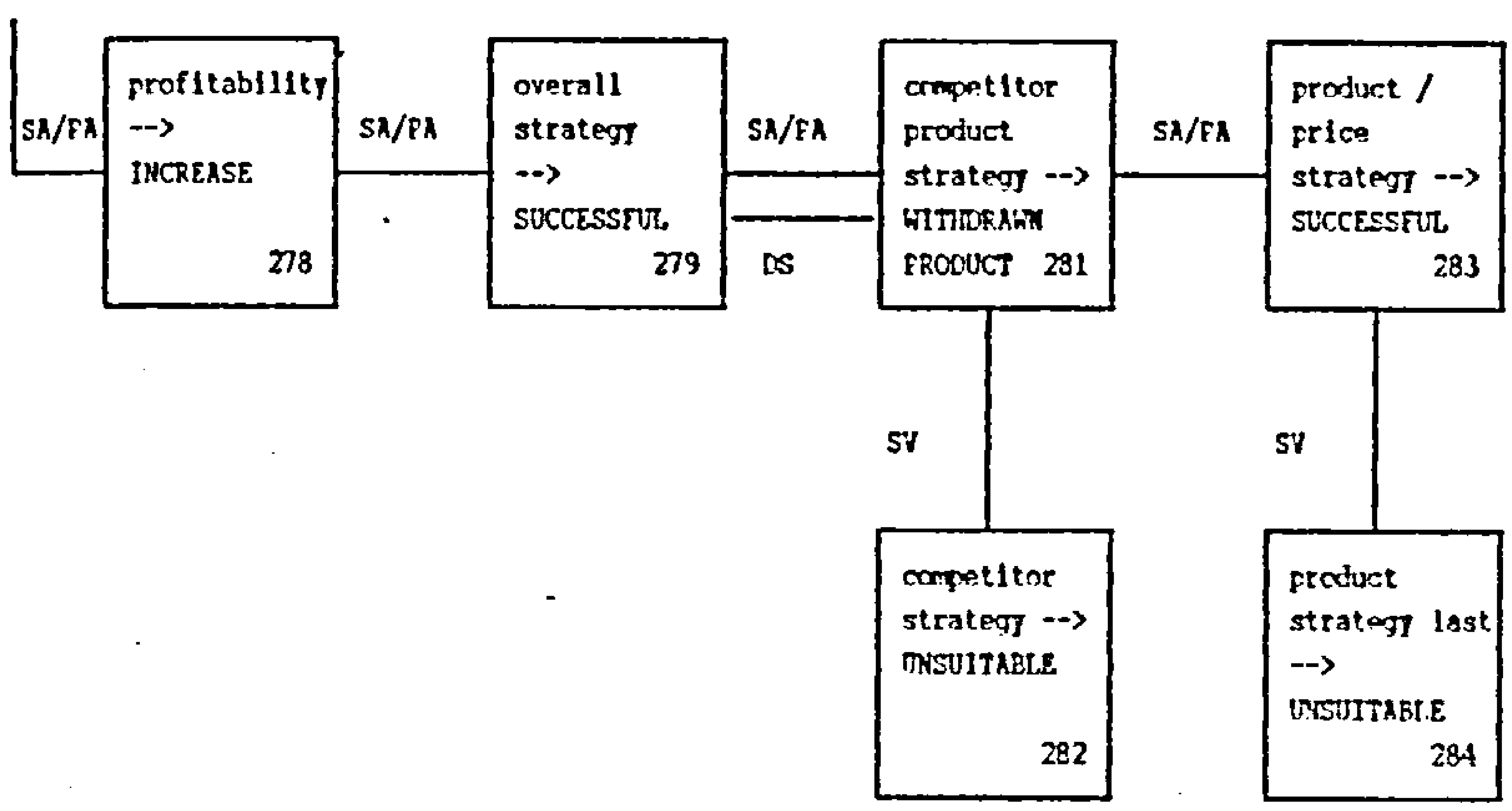


Figure 5.3 Problem Behaviour Graph: Subject S7 Period 6 ACTUAL Behaviour




DPS
SA/PA
product 5 price strategy --> HOLD 258
DPS
product 2 price strategy --> INCREASE 260
DPS
product 4 price strategy --> DECREASE 261
DPS
product 2 price strategy --> INCREASE 263
DPS
product 5 price strategy --> HOLD 264
SV
product 2 price strategy --> acceptable 259
SV
product 4 price strategy --> suitable 262
DPS
product 4 price strategy --> DECREASE 265
DPS
PRICE
product 8 price strategy --> HOLD 270
SV
product 4 price strategy --> ACCEPTABLE/? 266
SV
product 8 price strategy --> SUITABLE 271
PRICE
DPS
product 2 price --> £3.10 267
PRICE
product 4 price --> £6.10 268
PRICE
product 5 price --> £1.55 269
SA/PA
product 2 last --> UNSUCCESSFUL 273
SA/PA
price sensitivity --> SIGNIFICANT 274
SA/PA
product 5/8 last --> SUCCESSFUL 275
SA/PA
market share --> HIGH 276
SA/PA
share price --> INCREASE 277


profitability --> INCREASE 278
overall strategy --> SUCCESSFUL 279
competitor product strategy --> WITHDRAWN PRODUCT 281
product / price strategy --> SUCCESSFUL 283
competitor strategy --> UNSUITABLE 282
product strategy last --> UNSUITABLE 284
SA/FA
SA/FA
SA/FA
SA/FA
DS
SV
SV

clarity of the diagram. S7's accumulated knowledge at a particular stage of the decision making process (ie. the strategic facts) could not be summarised in each node of the diagram.

PBG's have a number of uses within the context of the human information processing paradigm. First, they can be viewed as representing the subject's problem space and a summary of behaviour in that space. The use of PBG's can often help the researcher gain an insight into the structure of a subject's information processing behaviour that is not clear from directly examining the protocol transcript in all its detail. In sum, PBG's offer a graphical representation of the complete decision making process as far as it was verbalised by the subject.

A second use of PBG's is that they provide the basis for extracting useful summary statistics about a subject's information processing behaviour, e.g. the frequency and sequencing of various operators; the knowledge elements that form input and output to operators. A third use of PBG's is to test information processing models in terms of how well they predict observed behaviour. We illustrate this use in Chapter 7.

To the extent that a PBG reflects a subject's verbal protocol, it is unlikely to be a complete record of information processing behaviour for the task. This should be clear from examining Figures 5.2 and 5.3. They are not in the form of a structured logic capable of simulation in a computer program (ie. a PS simulation model). For example, the PBG's do not illustrate the application of any control or attention operators implicit in S7's behaviour since we are only modelling behaviour in terms of the operators that result in changes in knowledge states. This is in accordance with the definition of an operator presented by Newell and Simon. However, the subject also displays evidence of using knowledge about knowledge. This type of information processing behaviour is not regularly accounted for in S7's protocol. We discuss the implications of this at a more general level in the next section.

One purpose in modelling the behaviour of S7 at the level of detail in Figures 5.2 and 5.3 is to relate it to the task analysis presented at the beginning of the chapter. In a sense, this task analysis, albeit at a fairly general level, outlined the requirements for the successful completion of our strategic decision making task. The PBG can thus be seen as a simple diagrammatic representation of S7's strategic decision making process. It is at this level that alternative models of behaviour for different subjects who participated in the experiment can be examined and compared. This is done in the next chapter.

(iii) A Global PS Model for S7:

The next representation of S7's behaviour is a global production system (PS) model. This model is presented in Figure 5.4 using BNF notation. The purpose of this global model is to give a broad picture of S7's decision making process. The BNF representation of the global model is general and stylised and is incomplete as a PS model for two reasons. First, it only provides an intuitive insight into the production rules that define each operator. Second, the sequence in which operators are 'fired' is not defined. Translating this global model into a PS model capable of simulating the behaviour of S7 requires the specification of each operator's production rules within a PS modelling framework. We present such a model in Chapter 7.

Figure 5.4 Production System for Subject S7 (BNF Notation)

```
P1:  get <decision>/<period> new

     --> get <strategic facts>
         get <company strategy>

P2:  get <company strategy>

     --> DS (<company> <period> <strategic facts>)
            (=> <company> <period>  <-- <strategic goal> <tag>/
                <company> <period> <strategy>  <-- <strategy type>
                                                   <tag>)
```

```
P3:  get <strategic assessment>

     --> SA (<expression>)
            (=> <expression>  <-- <strategic importance> <tag>)

P4:  check <performance assessment>

     --> PA (<company strategy> <period> <decision>
                                <company performance>)
         (=> <company strategy> <period> <company performance>
             <--  <performance measure> <tag>

            <decision> <period> <company performance>
             <-- <performance measure> <tag>)

P5:  get <strategic facts>

     --> SF (<performance assessment> <strategic assessment>)
         (=> <strategic facts> <tag>)

P6:  get <decision-1>

     --> DPPS (<company strategy> <strategic facts> <period>)
         (=> <product strategy> <tag>/<portfolio change> <tag>/
                                      <product type> <tag>)

P7:  get <decision-2>

     --> DPS (<company strategy> <strategic facts> <period>
                                <product attributes>)
         (=> <company> <product> <-- <price strategy> <tag>)

P8:  get <c-ratio>

     --> RATIO (<prod-id> <product type> <product strategy>)
         (=> <product> <-- <c-ratio> <tag>)

P9:  get <price>

     --> PRICE (<portfolio><product attributes><price strategy>)
         (=> <product> <-- <price> <tag>)

P10:  get <strategy assessment>

      --> SV (<company strategy> <period> <decision>
              <product attributes> <strategic facts>)
          (=> <company strategy> <period> <--
                                 <strategy appraisal>/
              <decision> <period> <-- <strategy appraisal>)
```

A PS simulation model of S7 would of course be similar in structure to our global model though at a much lower level of disaggregation. Each operator would be defined by a sub-set of production rules to reflect the way in which the operator was applied in particular circumstances during the exercise. This in turn would reflect the particular aspects of S7's decision making strategies. For example, in the case of the PA operator, we require a production rule that evaluates the sales performance of each product in terms of comparing the market share of the product in the current period with that of the previous period (ie. qualitative output - increase, decrease, or unchanged). A similar rule was modelled for the competitor, except that in this case the competitor firm compared the market share of each product with a set of target ranges (which varied from period to period).

With regards the 'firing' of operators, our global PS model reflects the interpretation of operators as information processing activities that result in changes in knowledge states. A complete PS program not only requires a set of rules for defining each operator but also an ordering of the rules to resolve conflict if several LHS conditions are satisfied simultaneously. In practice, the knowledge structures contained in short-term memory change during the performance of a task and a natural ordering of production rules emerges from the matching of the contents of STM with the LHS conditions of production rules. However, the researcher may need to incorporate a priority ordering of production rules (or a more sophisticated conflict resolution mechanism) where the structure of the decision making task does not eliminate totally the possibility of conflict between rules.

The PS model in Figure 5.4 provides an important insight into how S7 proceeds in making pricing and product decisions in our experimental exercise. Before making any decisions, S7 attempts to identify key strategic facts about the market and his relative position vis a vis the competitor firm. This involves the repeated application of the SA and PA operators. Part of this information processing will take place at the end of a decision period as well as at the beginning of new decision periods. It is from this analysis that the subject determines his broad strategy (via the DS operator) by specifying possible goals, e.g. increase market share, and the type of strategy that is required, e.g. an aggressive pricing policy.

S7 then proceeds to determine his product and price strategies for the period using the DPPS and DPS operators. This also involves the (occasional) application of the SV operator for the purposes of evaluating the appropriateness of any given strategy and confirming his reasoning behind following a particular strategy. As we have noted, the application of the SV operator rarely involved a change in strategy. Once the decisions for the period had been made by the subject and the simulation results reported the whole decision making cycle started again with the application of the PA and SA operators.

The global PS model for S7 in Figure 5.4 is incomplete for the purpose of developing a detailed PS simulation model. However, it is complete in the sense of capturing the broad decision making activities of S7 in our experimental task. We can relate our description of S7's problem space operators to the task analysis presented at the beginning of this chapter. The PA, SA and DS operators are clearly information processing activities concerned with problem finding behaviour. In terms of the Johnson and Scholes (1987) framework these activities represent the strategic analysis phase. The DPPS, DPS, RATIO, PRICE and SV operators can be classified as problem solving activities as they involve the subject selecting and evaluating particular strategies in response to the outputs of the three operators PA, SA and DS. Thus, the DPPS, DPS, RATIO, PRICE and SV operators represent the global activity of what Johnson and Scholes call strategic choice.

Given that all our subjects participated in the same decision making exercise, we would expect to see broadly similar problem spaces defined for all subjects. In the next chapter we shall examine the protocol transcripts of other subjects to support this view. Key differences between subjects will be in the specification of the problem space operators since, as we shall discuss in the next chapter, it is the operators that reflect the different product and pricing strategies employed by our subjects. Capturing differences in subject behaviour in terms of problem space operators could well be an important basis for studying expertise in decision making.

5.5 LIMITATIONS OF OUR GLOBAL INTERPRETATION OF S7's PROTOCOL

The collection of concurrent verbal protocols typically generates a high volume of behavioural data and allows the researcher to investigate many aspects of the decision making process. For the purpose of developing a PS model we have used protocol analysis to identify patterns and sequences in information processing behaviour. The regular application of a problem space operator by a subject allows the analyst to define the structure of the production rules that capture the essential characteristics of a particular information processing activity [ie. the LHS and RHS elements of rules].

Identifying repetition in information processing behaviour is not always immediately apparent on first examining a subject's protocol transcript. Indeed, the extent of repetition can only be assessed after specifying the problem space operators for a subject and the particular circumstances in which they are evoked. One limitation of this aspect of protocol analysis is that the researcher's interpretation of a subject's problem space may result in neglecting important features of problem solving behaviour.

While the previous argument can be applied to the application of many research techniques, it is useful to consider its implications for the interpretation of subject behaviour in our particular experimental setting. The protocol of S7 provides an insight into some important aspects of strategic behaviour that are not easily incorporated into our global PS model. There are two reasons for this.

First, the design of our decision making exercise highlighted the evolutionary nature of strategic decision making behaviour. The limited number of periods over which behaviour was observed has inevitably resulted in some later protocol statements having less impact upon our interpretation of S7's behaviour. However, the inability to observe repetition for some information processing phenomena in S7's protocol does not mean that they are unimportant. For example, some of these insights could be used to confirm findings in other studies or suggest directions for future research.

Second, in defining S7's problem space we have directed our attention to particular aspects of our subject's information processing behaviour. However, the protocol also documents the presence of other important behavioural phenomena e.g. the subject coping with uncertainty by using qualitative information and control strategies. In the remainder of this section we extend our discussion of S7's verbal protocol.

Two interesting features of S7's behaviour that can be identified from the protocol are the shift towards anticipating the behaviour of the competitor firm and the emergence of unintended strategies. Both these features reflect the adaptive nature of the subject's behaviour and the limited opportunity for developing co-operative strategies with the competitor firm.

S7 attempts to anticipate the behaviour of the competitor in two different ways. First, by suggesting what strategy he would follow in the same set of circumstances. This is illustrated in Period 1 when S7 notes:

PERIOD 1 <u>Topic Line 55</u>

he's not going to like that ... ... and almost certainly ... ... going to come in there between our products or above me ... that is what I'd do ....

A second and related factor is the attempt to anticipate competitor behaviour based on the subject's perception of the competitor firm's strategy and/or his understanding of key market relationships. For example, in Period 6, the subject comments:

PERIOD 6 Topic Line 222

How is he going to read it? If he is very sharp he will reckon I will come back at him hard ... he'll hardly think I will extrapolate the trend given that my prices are up ....

The definition of the operators we described above in S7's problem space are sufficiently broad to incorporate this aspect of the subject's behaviour e.g. the DS operator. However, the circumstances in which production rules are evoked for the purpose of trying to predict the competitor firm's behaviour are not generally clear from the protocol. In consequence, it is difficult to assess the significance of S7's attempts at anticipating the competitor firm's behaviour in later stages of the exercise.

While the resolution of uncertainty is one possible explanation of the shift from reaction to anticipation of competitor moves, a more likely rationale is that it reflected the nature of the gaming situation that emerged in the later stages of the exercise. For example, in Period 5 S7 states:

PERIOD 6 Topic Line 246

and his price ... ... yes, I'd figured he'd do that, he has followed on the price strategy ... but I've outguessed him this time ...

The importance of the subject outguessing the behaviour of the competitor in the later stages of the exercise appears to reflect his adoption of an aggressive price strategy. Given the similarity (in terms of the C2/C1 ratio) of the subject and competitor firm's products, and the emergence of low price margins on the market, S7 needed to price competitively in order to maintain market share. However, it is also clear from the protocol that S7 saw limits to his aggressive pricing policy; see for example topic statements 232 and 233 in Period 5.

Another interesting feature of S7's behaviour is the emergence of what appear to be unintended strategies. The subject makes a number of comments in his protocol to support this. However, one possible interpretation of this behaviour is in terms of a gradual adjustment to changing market conditions. For example, in Period 1 S7 makes an explicit statement about how he believed his strategy would develop:

PERIOD 1 Topic Line 10-11

Equally, I don't want to get into a price war ... or any other aggressive strategy early on ... I think I will tend to go for a policy of collaboration rather than an all-out aggressive policy ....

S7 recognised that this strategy may need to be changed, particularly in response to the behaviour of the competitor firm [topic statement 12]. This is what happened and it appears to be the result of careful deliberation of the changes in task conditions. For example:

PERIOD 2 Topic Line 88

- my strategy of conciliation has now evaporated since ... ... I've found out that I'm not selling one of my products ... I'm now more aggressive in my approach ...

The subject also reflects upon this point in other topic statements; see for example, topic lines 98; 151; 166; and 220. This interpretation of our subject's behaviour reflects some of the limitations in our experimental design that were noted in the previous chapter. In particular, the effectiveness of highly aggressive behaviour for the purpose of gaining market share. Given the scenario of similar products and low price margins, the awareness by the subject as to the possibility of competing purely on the basis of price was a major factor in the way the structure of the market developed.

S7's protocol also provides evidence of the use of reasoning activities employed for handling task uncertainty. However, the subject's comments are infrequent and were not considered in our analysis of S7's behaviour in the previous section. Two particular features of S7's behaviour are the use of confirmation routines and the role of qualitative information. Both these features suggest the absence (for obvious reasons) of a probabilistic approach to the handling of uncertainty. Moreover S7's statements in his protocol indicate the presence of control strategies that guide the style of his problem solving behaviour. For example, determining what type and form of information should be the focus of attention during decision making. Clearly, substantive knowledge about business strategies was not the only kind of expertise displayed by our subject.

Subjects faced uncertainty from two main sources in our experimental setting - both of which characterise the strategic decision making process of firms in practice:

- Missing information e.g. information about the competitor firm's decisions was not available at the time subjects had to make their decisions.
- Uncertain and incomplete information e.g. market demand relationships.

There is an extensive body of research literature regarding the representation of uncertainty in models of decision making behaviour. For example, research in expert systems and artificial intelligence has involved the widespread application of probability theory (including Bayes' Theorem). A good illustration can be found in Shortliffe (1976) where the MYCIN knowledge base is described in terms of rules having certainty factors attached to them to represent reasoning that is less than certain. An overview of the different approaches to incorporating uncertainty in AI and expert systems research can be found in Fox (1984); Graham and Jones (1988) and Kanal and Lemmer (1986).

There has emerged two broad approaches to modelling the impact of uncertainty on decision making. One approach (e.g. research in the AI field) has generally been associated with using ad hoc quantitative methods based on probability theory. In contrast, models developed from the perspective of HIP theory have tended to focus upon the qualitative treatment of uncertainty. The former models in their role as decision support mechanisms are concerned with system performance rather than cognitive emulation. For example, MYCIN performed successfully as a top class medical 'consultant' despite its application of certainty factors being non-rigorous and logically inconsistent. Cognitive models of decision making behaviour have largely been influenced by experimental work in psychology [see for example, Kahneman, Slovic and Tversky (1982)] and emphasise the adoption of heuristic rules by individuals in their handling of uncertainty.

Evidence from psychological research suggests that human experts are more successful at handling uncertainty by qualitative rather than quantitative reasoning. This highlights the limited information processing capacity of human STM [e.g. Bouwman, Frishkoff and Frishkoff (1983)]. The 'chunking' of information cues and the translation of quantitative data into qualitative information clearly facilitates the process of interpreting large amounts of uncertain information. A good example of this type of information processing behaviour can be found in the experimental work of Bouwman (1978;1983).

Bouwman's research involved presenting subjects with a number of hypothetical cases that summarised the financial performance of firms. As Bouwman (1983 p.658) states:

> "Although the diagnosticians are faced with largely quantitative data, they do not deal with it in that manner. Instead, they translate the series of figures into qualitative terms."

A second phase of qualitative reasoning was observed in Bouwman's research; this involved the application of heuristics to identify the most significant facts from all the information available.

The use of qualitative reasoning is a phenomena that is observed without exception in the protocols of all our subjects. This is clearly reflected in our definition of the knowledge elements for S7's problem space in Figure 5.1. Numerous examples of qualitative reasoning can be found in S7's protocol, particularly with regards to the application of the SA and PA operators:

PERIOD 1 Topic Line 40

operating profit looks low ... but the price was kept low

Topic Line 43

... mmm ... share of the market is good ... 68.16% ... that is encouraging ...

There are, of course, examples where S7 refers to quantitative data though, as topic statement 43 reveals, this is usually accompanied with a qualitative assessment. One difficulty facing the researcher in modelling this kind of qualitative reasoning is capturing the translation mechanisms employed by a particular subject. As we would expect, the form of these mechanisms are likely to differ between various subjects.

Another aspect of qualitative reasoning displayed by S7 is the use of heuristic mechanisms for focusing attention. We illustrate this more clearly in the next chapter when we discuss the behaviour of other subjects. However, S7's protocol also provides evidence of this directed behaviour. For example, S7 makes little reference to trends in market demand in his protocol. Given S7's concern with developing an aggressive strategy against the competitor firm, this neglect of market demand information is not surprising. In sum, there appear to be mechanisms that guide the subject's focus of attention and influence the nature of his evidence gathering strategies. To a certain extent we have been able to capture this aspect of subject behaviour by our definition of different generic strategies outlined in Chapter 6.

The distinction between control strategies and problem solving strategies cannot be clearly identified from S7's protocol. However, it is an important distinction for understanding how S7 appears to handle uncertainty in our exercise. S7 does not apply reasoning effort to all information cues but only to those that he perceives as being relevant to his particular problem solving strategies. Moreover, given the structure of our exercise, it is also important that the subject's attention neither fixates nor constantly changes. In either case this would hinder the emergence of successful problem solving strategies. In this respect an interesting comparison can be made between S7 and some of our other subjects whose behaviour we describe in the next chapter.

Another aspect of the emergence of control strategies in S7's behaviour is evidence of the use of confirmation routines. For example, early in the exercise S7 was concerned with assessing the significance of price sensitivity in the market [see topic statements 68-71; 119 and 121]. In Period 3 the subject notes, after analysing his performance:

PERIOD 3 <u>Topic Line 162</u>

.... about ... right ... well ... that's all right, I've done what I intended to do ... I've hit him in market share and ... profitability is not particularly good for him to make me vulnerable.

Similarly,

PERIOD 4 <u>Topic LIne 214</u>

What has the competitor done? ... Yes, just as I thought .... a pricing war on our hands. In a sense I've walked into this - I should not have shaded my prices up at the same time I expected him to shade his prices down ...

Other good examples of the subject applying confirmation routines are topic statements 246; 273; and 284. The use of confirmation routines underlines the exploratory nature of S7's behaviour in our experiment and the importance of establishing belief in key relationships perceived to be important in his problem space.

The emergence of confirmation routines suggests that S7, as part of his control strategy, examined some decisions in terms of whether they had the expected result. In our experimental setting the subject had to make decisions for each period and he was not presented with the opportunity to express a view about what he would do in particular circumstances. For example, the exercise was not designed to elicit information such as: ' in these market conditions there is a 50% chance I would increase price; a 20% chance of reducing price and a 30% chance of holding price constant'. In this sense, all decisions were clear cut and involved definite reasoning with the occasional qualification. One difficulty in developing process models within the HIP framework and using the methodology outlined in Chapters 2 and 3 is the problem of obtaining probabilistic data from small samples of data observations [see Hayes-Roth, Waterman and Lenat (1983)].

The use of probabilistic methods for representing our subject's treatment of uncertainty clearly has no behavioural meaning in the context of our experimental setting (eg. the length of subject observation; the nature of the decision making task). However, while the statements in S7's protocol suggest the emergence of meta-knowledge ie. the subject addressing the issue of "What do I know?" [Hayes-Roth et al (1983)], we have insufficient detail to devise meta-rules for representing a crude belief system. The modelling of a qualitative belief system for S7 demands a more comprehensive observation of the subject's behaviour eg. for the purpose of analysing his use of words for describing facts and data. For example, the use of the word "definite" by S7 [see topic statements 252; 258 and 284] suggests the identification of one possible meta-knowledge element. However, we would require more evidence on S7's use of the word 'definite' for the purpose of incorporating this kind of knowledge in our subject's problem space.

There is clearly a lot of scope for further research in developing a qualitative approach to modelling uncertainty using the methodology explored in this chapter. Such an approach has intuitive appeal given research findings in the psychological literature about how uncertainty influences human information processing behaviour. The work of Kahneman and Tversky has provided a valuable insight in this direction. Moreover, formal attempts to represent an individual's beliefs by explicit semantics are starting to be made in the AI literature [see for example Fox (1984)].

5.6 CONCLUSION

The main purpose of this chapter has been to present the first steps in the detailed analysis of the behaviour of a single subject in our experiment. We have illustrated the application of protocol analysis and developed a global PS model of S7's behaviour. The model presented in Figure 5.4 captures the essential elements of the strategic decision making process but is incomplete for the purposes of simulating the detailed information processing behaviour of our subject. The operators we have defined in our global model require detailed specification in terms of production rules. We conduct such an analysis in Chapter 7.

In the next chapter we consider the behaviour of other subjects who participated in our experiment. Our purpose is twofold. First, using the global model developed in this chapter we examine the decision making strategies of different subjects and make an assessment of 'good' and 'bad' strategies for our experimental setting. Second, we provide behavioural content to the production rules that define the global operators described in this chapter.

We have seen that the collection of concurrent protocols provides the researcher with a high volume of behavioural data. This data will typically provide many insights into different aspects of the decision making process. In focusing upon the repetitive sequences of information processing behaviour it is possible for the researcher to neglect important and interesting aspects of decision making behaviour. Particularly important is the insight provided by protocol data into the control strategies that govern problem solving behaviour. We have only been able to draw tentative inferences on these issues from the study of S7's protocol. However, the discussion in the last section of this chapter suggests a number of possible directions for future research.

CHAPTER 5 - APPENDIX I

This Appendix contains the full protocol transcript for subject S7. Each topic statement is operator coded and identified by a number to represent its sequence in the information processing behaviour of the subject. The operator codes correspond to the operators defined in subject S7's problem space in the main text of this chapter. The use of each problem space operator and its basic structure in terms of knowledge state inputs and outputs can be seen from the protocol transcript. At the end of the Appendix there is a summary of the trading and performance results for S7 and the competitor firm.

We noted in the main text the possibility of identifying more basic information processing activities that underpin the problem space operators we have defined for S7. The presence of these more basic operators is particularly evident when the subject employs the PA and SA operators. However, given the nature of our decision making exercise, it is not always clear from the protocol as to the exact form of these more fundamental activities. Equally, it is unlikely that their detailed specification will provide any further insight into the broad decision making strategies of the subject.

The work of Bouwman (1978,1983) provides a good example of a more disaggregated specification of information processing behaviour for a financial diagnostic task. Bouwman identifies a number of examining and reasoning codes that correspond closely to what we have called basic operators e.g. comparing two items; comparing an item with an internal or market norm; summarising and evaluating; identifying a problem. Bouwman's operators correspond more closely to Newell and Simon's notion of an eip than do the operators we have defined in the problem space of subject S7.

The issue of the level at which information processing behaviour should be specified is likely to be determined by a number of different factors. The major consideration is the level of detail captured in the subject's verbal protocol; this, in turn, reflects the experimental conditions under which behaviour is observed and, to a lesser extent, the ability of subjects to provide verbal reports. From previous research the important issue seems to be defining operators at a level that captures the problematical information processing activities for a particular decision making task. This is a very difficult aspect for the researcher to judge but it should reflect the factors considered when designing the experimental setting in which behaviour is to be observed.

Topic and Operator Representation:

Operator

Period 1

SA	1: We have on the screen the market data for the last period ... there appears to be little correlation between the c-ratio and sales ...
SA	2: and the pricing appears to be such that it is very hard to get any feel for price elasticity ...
SA	3: and in any case we are not talking about similar products ... there are wide gaps between the c-ratios.
SA	4: So very high uncertainty ... at this stage of the exercise ... there are a lot of strategic questions at the moment that I clearly don't know the answer to ... ...
SA	5: one is ... what is the overall market going to look like ?
DS	6: - is there going to be a good living for two companies in this market or ultimately am I going to have to go into a highly competitive strategy with the competitor ? ...
SA	7: he appears to have the edge at this stage ... ... since he has two products relative to my one ...
PA	8: and that is reflected in the sales figures ... there was quite a big change when he introduced that second product
SA	9: ... so clearly the number of products you have on the market is going to have an impact on your share of the market and ultimately I guess upon profitability.
DS	10: Equally, I don't want to get into a price war ... ...

DS	11: or any other aggressive strategy early on ... I think I will tend to go for a policy of collaboration rather than an all-out aggressive policy ...
DS	12: though I realise I may have to change ... maybe as a result of his action ... or as a result of the total size of the market and its elasticity.
DS	13: I ... will try to avoid getting too close to his products which will be seen as an aggressive action and ... I will explore other areas of the market the competitor is not in
DPPS	14: ... ... and I think that will be my opening strategy ... at this stage I'll introduce one new product ...
SA	15: my current portfolio ... the competitor's portfolio has products with c-ratios .25 and 5
SA	16: and I have a c-ratio of 1 ... so the competitor straddles me both sides ...
DPPS	17: I think ... I'm going to try a top end of the market product ... a relatively high valued product ... compared with my existing product ...
SV	18: and further it will not be seen as too aggressive if I do not go too close to Product 3
RATIO	19: ... I'll launch a product with a c-ratio of about 2 ...
DS	20: ... though an alternative strategy would be to be highly aggressive and launch two new products to straddle the competitor firm's products
SV	21: ... but this may be premature at this stage.
RATIO	22: I'll be launching Product 4 - and I think the characteristic mix will be ... ... OK - I'll have 4 units of C1 and 8 units of C2
DPPS	23: ... I won't withdraw any products at this stage -
SV	24: that would be ridiculous !

SA	25: Right ... so ... my pricing strategy ... I'll review last period's pricing data. Variable cost for my product was £3 ...
SA	26: ... and the mark up of 60p -
PA	27: good sales on that
DPS	28: ... I want to be cautious ... in fact, to avoid complicating issues I'm going to keep my price where it is - at £3.60 ... ...
SV	29: otherwise I'm going to be receiving too much information ... ... given that I'm launching this new product ...
DS	30: of course, I'm not sure what my competitor is going to do ... ... What he does, incidentally, will give me some idea of what his strategy will be ... is he going to attack me ? ...
PRICE	31: OK ... so I'll leave the price where it is ... at £3.60 for Product 2 ...
SA	32: Variable cost for Product 4 is £6 ...
DPS	33: it is a high value product ... and, therefore, it may stand a high mark-up.
PRICE	34: Equally, I want to be sure that I'm not overkilling it on price ... so I am going to go in at a conservative price of about £6.50 ...
SV	35: that will cover my costs ... a margin just below my other product ...
SV	36: yes, that doesn't seem too expensive in relation to products on the market last period ... that is probably underpricing ...
SV	37: but at this stage I don't want more information than I can cope with and ... and ... I will probably get too much noise in the system if I start changing too many things ...

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PA	38: ... that's interesting ... Product 2 has taken a considerable hammering ... we haven't sold any ... ...
PA	39: ... Product 4 on the other hand isn't bad ... revenue was £40,691 ...
PA	40: operating profit looks low ... but the price was also kept low ...
PA	41: Product 2 is worrying ... however, I suppose it depends upon what my market share is going to be ... ...
PA	42: Product 2 may be suffering from my introduction of Product 4 or maybe from what my competitor has done ...
PA	43: ... mmm ... Share of the market is good ... 68.16% ... that is encouraging,
PA	44: but I'm getting it all on one product ... which isn't ... so I'll need to decide what to do with Product 2.
PA	45: ROCE isn't fantastic ...
PA	46: cash balance is OK ...
PA	47: share price ... ... can't really interpret at this stage ...
PA	48: OK ... let's look at the competitor ... The competitor didn't introduce any new products ...
SA	49: which is interesting ... maybe he knows something I don't in the sense he has 2 products already ...
PA	50: aah ... if I look at the previous results ... seems to have changed his price ... odd ... pushed his price up slightly -
PA	51: though it didn't have much impact upon Product 1 ... sales have stayed pretty flat.
PA	52: Product 3 ... now that is interesting ... price has been increased by 15p
PA	53: but it has dropped very substantively on sales revenue

SA	54: - that presumably is because I've a chunk of his market with my Product 4 ...
PA	55: he's not going to like that ... ... and almost certainly ... ... going to come in there between our products or above me ... that is what I'd do ...
SA	56: OK ... so ... the competitor has the bottom end sewn up and I'm going to have to look at that.
PS	57: I'll probably need to become aggressive down there ...
SA	58: and I appear to have the top end of the market at this stage.
SA	59: My product in the middle appears to be badly squeezed - and I've got to decide what I'm going to do with it.
PA	60: Share of market for competitor is well down there - that's great
PA	61: ... his ROCE is not much better than mine;
PA	62: his cash balance is fairly healthy
PA	63: and share price ... I'm not too bothered about share price behaviour at this stage.

Period 2

SA	64: Right, Period 2 ... I'll need to do some thinking here. I'm sitting pretty good at the top end of the market
SA	65: and my key problem is with the "squeezed" product in the middle ...
SA	66: now that might be a pattern that is beginning to emerge if you get into that position ... ... Yes ... I've a product here with a ratio of 1 ... which is doing nothing ... ...
SA	67: presumably because he is coming in with his product at a lower price.

DPS	68: I'm going to sound out the price sensitivity of Product 2 by ... virtually selling it at cost ... ...
SV	69: before I remove it from the market ... I'll risk the product for another period ... for the sake of £750 ...
PRICE	70: in fact, I'll price it fractionally above cost at about £3.10.
SV	71: That will tell me how much price sensitivity there is ...
DPPS	72: However, I'll also introduce a new product ... so I'll change my product portfolio ... This will be Product 5.
RATIO	73: Now, here is the tricky bit ... what am I going to do ? ...
SA	74: My competitor has a c-ratio of .25 for Product 1
SA	75: and is "clearing up" that end of the market.
DS	76: I'm going to come under him in price there, which will be interesting
DPPS	77: ... so I'll put a product on the market with a low ratio ... compared with my mid range product - Product 2 -
RATIO	78: about .5 ... so I'll come in with a C1 of 2 and a C2 of 1.
DPPS	79: I'm not going to withdraw any products at this stage
SV	80: ... at £750 there is little point and they are worth that for market research ... ... so there may be a case for keeping products alive indefinitely ...
SV	81: although there is some money to be had back by releasing them.
DPPS	82: However, I've not got a cash flow problem so my overall strategy is not to kill products at all.
SA	83: OK ... my pricing strategy ... right ... er ... Product 2 ... my price last period was £3.60,

SA	84: variable costs £3.00 ... ... ok ...
DPS	85: that is the one I'm going to go in at quite aggressively ...
DS	86: though I'll expect some reaction from my competitor ... he won't like this:
PRICE	87: er ... price ... £3.10
DS	88: - my strategy of concilliation has now evaporated since ... I've found out that I'm not selling one of my products ... I'm now more aggressive in my approach ...
SA	89: My next product ... ... Product 4 ... I had that end of the market and
DPS	90: ... I'm going to shade that up to about £6.70;
SV	91: I don't think that will hit me too hard ... there should be a fair amount of leeway there ...
SA	92: though I don't know how price sensitive the whole market is at this stage ... but the margin seems about right for the market ...
SV	93: but I'm pretty sure at this stage that I can get away with a litle bit of an increase ...
PRICE	94: so let's push that up to £6.70.
SA	95: Right, new Product 5 ... no previous price history ... variable cost is £1.50 and ...
DPS	96: I'm not going to get away with much on this ... er ... a low value product ...
PRICE	97: I'm going to go in there at £1.55 ... a little cheaper than my unsuccessful product ...
DS	98: A strategy seems to be emerging ... not so much consciously ... as just from a series of incremental decisions in that I do appear to be following a very low price strategy ...

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PA	99: ... Very interesting ... ah yes ... I've now reversed my position on Product 2 completely ... my original product has now responded quite dramatically to price ...
PA	100: but Product 4, my expensive product has sold nothing ...
SA	101: is that because of price or has my competitor done something there? ...
PA	102: My two low priced products seem to be doing well ...
PA	103: My market share has dropped ... that's worrying ...
PA	104: cash balance has dropped and
PA	105: my ROCE has dropped too ...
PA	106: so I'm in all sorts of trouble ... and my share price has dropped too.
PA	107: ... Right, ok ... My competitor hasn't launched any new products ...
SA	108: that's interesting ... what is hitting me is entirely price related - I think ... Let's have a look at his results ... so what is happening there?
PA	109: His Product 1 has taken a hammering ...
PA	110: so my strategy has paid off in that direction ... I've cornered that end of the market ...
PA	111: but his Product 3 is doing very nicely;
SA	112: Yes, I've reversed my position completely, and yet all I've done ... ... well ... I've introduced the new product ...
SA	113: but essentially all I've done is change price. All right, let's go and see what that means.
PA	114: His market share has gone up and roughly equals me ...
PA	115: got a nice ROCE and

PA	116: a reasonable cash balance ...
PA	117: nothing there to worry me too much, but I've clearly got to do something. Yes, ... he is looking much better than I am.
	Period 3
SV	118: The question now is what am I going to do ... I'll incur high costs if I introduce any new products ...
SA	119: and I increasingly feel price is probably everything in the market ...
DS	120: which may make it difficult to evolve an effective strategy against the competitor ...
SA	121: I'm going to work on that assumption and play entirely with price in this period ...
DPPS	122: I'm not going to introduce any new products
DPPS	123: ... since my competitor isn't, though he might well do in the light of my actions over the last two periods ... it'll be surprising if he doesn't come back at me ...
SV	124: But I think that price is emerging as the key element to the strategy for this exercise ... but it seems also quite responsive to small price changes ...
DPPS	125: Right ... I'm not going to change my portfolio.
SA	126: I'm quite conscious here that part of my strategy seems to be dominated by trying to get market information ... trying to reduce the uncertainty I feel by ... almost buying information ...
SV	127: maybe it is a common uncertainty reducing ploy but I'm conscious of the fact that it could get me into trouble. However, I'll continue this ...

DPS	128: I think I'll review last period's market data ... Price for Product 2 ... I'll leave it at £3.10 same as last period ...
SV	129: tempted to shade it up a bit ... but that might confuse my interpretation of the results ... I want to find out exactly what is happening here ... and our overall market share is not high anyway ...
DPPS	130: though it wouldn't surprise me if my competitor messes all this up by putting a new product in !
PA	131: Product 4 at £6.70 did disastrously ...
SA	132: let me ... my competitor's dropping his price ... his margins ... mmm ...
DPS	133: I'm going to put that down to £6.40 - 40p - roughly in line with the competitor's margins ...
SV	134: I've got no product introduction costs ... so, I can live with small revenues this period ...
DS	135: although ultimately I've got to get those margins up.
DPS	136: Product 5 ... well ... we'll leave that where it is ... it did OK ...
SV	137: this period is really becoming a period for market research on price elasticity ... ...

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PA	138: Right - let's look at unit sales ... drop in unit sales on Product 2 from 19,345 to 15,828
SA	139: - where I kept the price flat ... probably reflects more products on the market.
PA	140: Product 4 has come back by dropping the price and sales have gone up ...

SA	141: so the implication there is that the market is growing I think ... but you'd expect that at this stage of the life cycle ...
SA	142: I must have a good share of the market unless the market has grown enormously ... I'm beginning to get the feel for the pricing pattern of this market ... ...
PA	143: My market share has gone up ... 65.62%
PA	144: ... ROCE not much better ... but this is not surprising given my policy.
PA	145: Share price has improved ...
PA	146: cash balance is adequate.
PA	147: Yes, reasonably happy with that ... let's look at my summary performance ... yes, a distinct reversal in fortunes there ... had the previous trend continued I would have been worried ...
PA	148: Profitability does seem to be my problem ... and that presumably is the name of the game ... ...
DS	149: although I do appear to be following a market share objective ...
DS	150: But profitability is still the name of the game as far as I am concerned ...
DS	151: er ... ... I am following a market penetration strategy quite clearly at this stage ... and even though I didn't plan it that way ... it appears to be emerging as my strategy.
DS	152: Much more aggressive than I was and much more into market share and pricing penetration policies.
PA	153: Ah ... my competitor has introduced a new product -
PA	154: Product 7 -... didn't do very well with it ...

SA 155: the c-ratio is very close to 1 and its price looks very low.

PA 156: He's increased the price for Product 3 to £3.47 ...

PA 157: I wonder why he did that ... now ... his sales revenue has dropped substantially there ... though it is fairly successful ...

DS 158: he is bound to come back at me with price and if we are not careful we will end up "cutting each other's throats" ...

PA 159: No sales of Product 7 ... why hasn't he sold any Product 7 ? ...

SA 160: I'll see that better when I review the market data ... but I guess I'll have him trapped somewhere ... probably with a low margin product that is somewhere near the same characteristics.

PA 161: Right ... his profitability is £8,500

PA 162: ... about ... right ... well ... that's all right, I've done what I intended to do ... I've hit him in market share ... and ... profitability is not particularly good for him to make me vulnerable.

PA 163: Yes ... his profitability is marginally down

PA 164: though his ROCE is still fairly satisfactory ...

PA 165: and his share price ... while it is dropping is not any grounds for concern ...

Period 4

DS 166: This is the make or break period ... since I can't just hold in the position I am in ... I'm squeezed in a sense ... because I feel he is going to go for a lower pricing strategy this time ...

SV	167: and that means if I start putting my prices up ... ... which I'm going to have to do at some stage, I'm in trouble ...
DPPS	168: I think I'll introduce a new product. Yes, I'm going to put a product in this period and
DPS	169: ... I'll try and milk Product 5 which I think will stand a bit more ...
DPS	170: I'm going to try and put up all my prices a shade to try and milk my reasonably successful portfolio ... ...
PA	171: apart from Product 4 ... which is not that cheap anyway ...
SA	172: Let's look at products marketed last period ... particularly c-ratios where ... ... Product 1 the .25 product is still doing reasonably well - with a fairly good price margin ... that is doing nicely
PA	173: Product 5 ... which is ... ... is also doing pretty well ...
SA	174: and now if I look at the differences in pricing there, he is doing extremely well on price there compared with me ... although he may come down this period. But he is holding very nicely on price there ... I'm getting a trivial mark-up ... he is getting 23p ... which is interesting ...
DPPS	175: I'm not going to hit him with exactly the same product ... and price under him ... that would be too aggressive ... therefore I'll make a conscious effort not to hit the same ratios as he is hitting.
SA	176: Then I've got Product 2, which is low priced but holding market share ...
SA	177: and then Product 4 - more highly priced - but they're both pretty well dominating the market at the moment.
SA	178: His Product 7 is obviously squeezed ...

SA 179: because his pricing is by no means more outrageous there ... in fact, it's quite competitive there ... but because I'm squeezing with Product 2 and Product 4 ... at a low price ... he is doing badly.

SA 180: That is beginning to tell me something about the market here that there seems to be this pincer effect ... and I'm clearly pincering Product 7 ... ... Product 7 is doing disastrously

DS 181: ... he might strike back on price ... but he hasn't got much to go at ... only 20p on margin ... admittedly on a low cost product.

SA 182: Product 3 ... which is occupying the top end of the market ... it's doing OK.

DPPS 183: I've got two options here ... er ... I can try and do more pincer movements on him or

DPPS 183: I can go to the extreme and get "under" him at one or other end of the market ... ... I can either come in under Product 1 at less than .25 or I can come in over Product 3 with the 5 c-ratio.

SA 184: This pincer effect seems to refer to the c-ratio in this exercise and the absolute levels of the characteristics may not be as important ... this was hinted in the case notes ... but I've not exploited this so far.

DS 185: A slight change in strategy then ... I'll focus on c-ratios more directly.

DPPS 186: I'm going to go either above or below ...

SA 187: there appears to be some nice margins above ...

RATIO 188: I'm going to go above ... above 5 ... I'll go 1 to 6 ... or should I go .5 to 2.5 ? ...

SV 189: which will give me a lower price ...

RATIO	190: No, I'll go in at 1 to 6 ... just so my new product will be pitched above that c-ratio at the top end there ... above his Product 3 ... and is going to have a c-ratio of 6 ... one extra unit of C2 ...
DPS	191: and I'll price it competitively against his product.
DS	192: I'll also shade up my prices in those areas where I have the competitor pincered ...
DS	193: but I don't know what he is going to do ... ... he might try and pincer me ... ... in fact he almost certainly will.
SV	194: Nonetheless, the strategy for this period is a new product at the top end of the c-ratios ... more stress on the c-ratio than previously
DPS	195: and price shading on the 'cash cow' end of my portflio ...
DS	196: to get more profitability hopefully ...
RATIO	197: Therefore, Product 8 ... C1 is 1 and C2 is 6 units.
DPPS	198: I'll stick with the policy of not withdrawing any products
SV	199: unless I get really desperate for cash and I don't anticipate problems there.
DPS	200: Price strategy ... Product 2 ... I'm going up on my price there ... £3.20.
DPS	201: Product 4 - £6.40 ... I'm keeping that flat ... it's already got a good margin.
DPS	202: Product 5 ... ... I'm going to shade up by 5p to £1.60 ...
DS	203: I'm getting worried now about what my competitor is going to do; I'm sure he is thinking along the same lines ...
SA	204: Product 8 ... variable cost is £3.50 ... well ... well ...

DPS	205: I'll go 30p mark-up on that one ... which is still low ... relative to the competitor's product ...
PRICE	206: I'll go £3.80.
SV	207: It sholud allow me to increase profitability ... right ... into the simulation ... once again ...

****

PA	208: ... Ah well ... that exploded into some sort of disaster ...
PA	209: it can't be my actions, it must be my competitor's actions. He must have hit me on price - I've shaded up and he has gone down I guess - that was predictable.
PA	210: Mmm! ... Market share must be virtually a write-off ... down to 5% ...
PA	211: ROCE is a disaster;
PA	212: cash balance is Ok;
PA	213: share price understandably has dropped.
PA	214: What has the competitor done ? ... Yes, just as I thought ... a pricing war on our hands. In a sense I've walked into this - I should not have shaded my prices up at the same time I expected him to shade his prices down ...
SA	215: but I'd not realised how sensitive the market was to price ... The "pincer" theory still holds good ... but there is a lot of sensitivity on price.
DS	216: There is only one way I can go this period - my strategy is quite clear ... it won't do much for profitability, but it will allow me to capture market share.
DS	217: So ... aggressive pricing is the only way out given I've walked right into this ...

SV 218: it was bad strategy, I should have introduced my new product without shading up my prices. That should have been an obvious mistake - in hindsight.

Period 5

DPPS 219: No change in product portfolio strategy this period ...

DS 220: while my strategy appears to be a bit incremental ... but there has been a clear policy that has emerged very easily ... this is a market share capturing and pricing penetration policy.

PA 221: In a sense deviating from this last period was a mistake - I should have stayed where I was ... ... I guess.

DS 222: How is he going to read it? If he is very sharp he will reckon I will come back at him hard ... he'll hardly think I will extrapolate the trend given that my prices are up ...

DS 223: So, ... it's going to have to be some very keen prices indeed - virtually selling at cost again ...

PRICE 224: Product 2 ... we'll go in at £3.10 ... er ... no ... £3.05 ...

SV 225: I don't have a cash flow problem and even though my share price doesn't look good ... I'm not in any liquidity problems, so I can afford to be aggressive ... as I was in period 2 ... a similar policy I think ...

PA 226: Product 4 ... last period £6.40 - it didn't do very well ...

SA 227: that is interesting since I held that one steady ... I wonder why that one went down ? ...

SA 228: because he dropped the price of a ... product close in c-ratio I guess -

PRICE 229: ... £6.20

PRICE 230: Product 5 - £1.60 ... not much I can given away on that one ...

PRICE 231: ... £1.55

DPS 232: There is, of course, the possibility of going into loss making pricing -

SV 233: but seeing as I don't see any possibility of squeezing him out of the market ... there is little point in trying to do that.

PA 234: Product 8 ... that one did sell something at £3.80 -

PRICE 235: but nonetheless it's coming down to £3.60 ...

236: Right, into the simulation ...

****

PA 237: Interesting ... Product 4 didn't sell anything ...

PA 238: well I've got the market share I wanted, that's all right - exactly what I expected. I think I'm reading the signals right ...

PA 239: but I don't like the profitability position I am in.

PA 240: The way I've got to play it ... mmm ... that's OK ... my share price is coming up;

PA 241: profitability has risen again ...

PA 242: though it's still pretty abysmal ...

PA 243: and market share is back to where I wanted it ... that's fine.

PA 244: What's happened here with the competitor ? Product 1 is holding his market share ... he is holding a third of the market with Product 1;

PA 245: He hasn't introduced any new products

PA 246: and his price ... yes, I'd figured he'd do that, he has followed on the price strategy ... but I've outguessed him this time ...

PA	247: His cash balance is getting big ... but there is not much he can do with it so that's all right ... ...
	<u>Period 6</u>
DPPS	248: I'm not going to introduce any new products ...
SV	249: we've gone far enough down that road and we are only splitting the market between competing products. So, no new products ...
DPPS	250: I bet he does this period.
DS	251: I'll review the market data this period ... ... since I'm in real trouble when it comes to pricing ... I daren't go up -
DS	252: I'm definitely in a position now where I need to increase profitability ... and that's going to be very difficult to do ... ...
SV	253: So ... I can't out-manoeuvre him in terms of introducing new products since I've already got enough I feel and ... and I don't think I want to follow that strategy ...
SA	254: Right ... it seems sales revenue is coming entirely from the bottom end of the spectrum ... that is ... the c-ratio spectrum ...
SA	255: I don't know why that is? Somethinkg to do with low margins maybe? No ... I don't think so ... prices are right for high c-ratio products as well ...
SA	256: it's pretty clear that Products 7,4 and 3 - which are mid-range products - are doing nothing and
SA	257: that suggests maybe demand is switching around in the market ...
DPS	258: Well, I'm now committed to a definite pricing strategy ... even though ... what I'll do is hold the price for Product 5 constant
SV	259: and I'm going to ... if I price up Product 2 ... he may hit me with Product 7

DPS	260: and I'm right to the bone on Product 2 ... I'm going to price up there ...
DPS	261: and price down on Product 4 ... in line with the prices charged on other products ...
SV	262: in the hope that even if I do damage my sales on Product 2 from Product 7 I'll get some of it back on Product 4.
DPS	263: Therefore, I'll put Product 2 up ...
DPS	264: hold Product 5
DPS	265: and reduce Product 4 ...
SV	266: though I'm a bit concerned at having to hold entirely everything on price strategy ... ...
PRICE	267: Product 2 ... I'll price at £3.10 ...
PRICE	268: Product 4 ... I'll come down to £6.10.
PRICE	269: Product 5 I want to keep flat at £1.55 - it's only a low value product ...
DPS	270: Product 8 ... I've not decided what to do with that ... mmm ... I'll leave it where it is;
SV	271: it's "mopping up" some of that top end ... and its' priced competitively ...
DS	272: This is all going to depend on what the competitor does ... though I guess he is in the same position as I am in ...

****

PA	273: ... Right ... Product 2 which I increased in price has dropped - predictably to zero ...
SA	274: the exercise is very sensitive to price movements ...
PA	275: The ones I kept flat ... seem OK.

PA	276; What about market share? ... 84.5% ... we're putting the competitor out of business ... my aggressive policy seems to have worked.
PA	277: Well, share price has gone up nicely
PA	278: and profits are much improved ...
PA	279: with market share high and the improvement in profitability ... I'm happy with that ...
DS	280: though the strategy is really aggressive at this stage of the exercise and ... there seems no turning back now ... I guess this is my fault. I followed the policy that was aggressive ...
PA	281: Let's look at his problems ... He has dropped a product!
SV	282: What a stupid thing to do! The firm hasn't a cash problem ... I think that is silly since neither of us is in liquidity problems and they're always there if you get trapped ... to do some aggressive pricing with ... I don't know what he is at there ...
PA	283: The interesting thing is that he has priced his Product 1 at £2.69 and got a huge revenue.
SV	284: That now really is ... yes, I should definitely have "gone under" Product 1 ... I was quite right in my intuition there ... no, it's not intuition, it's knowledge ...
DS	285: that's obviously what I'm going to do this period, obviously ... all out aggression this time ...
DS	286: very low pricing strategy ... ...
DPPS	287: and hit him underneath Product 1 with a new product ...

<u>Period 7</u>

DPPS	288: I'm going to introduce a new product ...

DPS	289: I want to review the market data ... right ... I'm going to keep all prices exactly where they are ... ... I've little room to drop them ...
DPS	290: I will drop them if I can ... I'll go for the throat and shade them down a little further ...
RATIO	291: I'll hit the competitor with a new product with a ratio of under .25 ... so I'll go in with 5:1 ... ... an extra unit of C1 characteristic ... to give a lower ratio ...
DS	292: He might ... go under me ... no, he won't do that ... there is no reason to ... if anything he will go higher if he introduces a new product.
RATIO	293: I'll go in with a new product that will have 5:1 as a c-ratio ... Product 9 ... 5 for C1 ... 1 for C2.
DS	294: Pricing strategy - cut to the bone ...
DPS	295: price of Product 2 ... dropping that to £3.05 ...
SV	296: I can still make reasonable profitability if I take a huge share of the market ...
DPS	297: so ... Product 4 ... £6.05 ... a real cut-throat price ...
DPS	298: Product 5, I'll hold ... no I won't ...
PRICE	299: I'll go at £1.54 - shade it by a penny ...
SA	300: Product 8 ... variable cost £3.50 ...
SA	301: price last was ... £3.60 ...
PRICE	302: I'll sell at £3.55 ...
SA	303: Price of Product 9 ... variable cost is £3.00 ...
PRICE	304: aah ... right ... well, let's use the same pattern - £3.05 ...

305: let's see the results of that ... into the simulation.

****

PA 306: ... OK, my big earners are the two ... Product 4 has come all right ...

PA 307: Product 9 has hit where I wanted to ...

PA 308: yes, 100% share of the market ... looking good ...

PA 309: though share price is looking low ...

PA 310: let's see what the competitor has done ... his share price is in all sorts of problems ...

PA 311: he has introduced a new product ... yes, that explains my results somewhat ... didn't do him any good ...

PA 312: His share price is on the slide and he is ripe for a takeover ...

END OF TRANSCRIPT

The following table provides a summary of the performance of the subject and the competitor firm:

Subject 7 :

PERIOD	REVENUE	MKT.SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP(%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	123427.70	65.62	5962.61	9.16	1.40
4	15288.17	5.01	1613.99	2.42	.92
5	260613.40	65.81	6772.73	9.22	1.08
6	461934.40	80.45	12958.84	14.99	1.37
7	550000.00	100.00	7839.61	8.32	1.13

Competitor Firm:

PERIOD	REVENUE	MKT.SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP(%)	SHARE PRICE
1	19008.29	31.64	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	64672.24	34.38	8557.03	12.22	1.70
4	290061.80	94.99	19490.64	21.77	2.21
5	135386.60	34.19	10649.28	12.38	1.61
6	112265.70	19.55	7782.58	11.62	1.24
7	–	–	1097.19	5.49	.77

CHAPTER 6

THE STRATEGIC DECISION MAKING EXERCISE: AN EXAMINATION OF THE DIFFERENCES IN BEHAVIOUR BETWEEN SUBJECTS

6.1 INTRODUCTION

In this chapter we compare and contrast the behaviour of some of our other subjects in terms of a number of generic decision making strategies. We relate these differences in subject behaviour to the global model of the strategic decision making process developed in the last chapter. The discussion is limited to considering the behaviour of a further five subjects: S1, S2, S3, S4, and S6. These five subjects provide good examples of the contrasting strategies used by our subjects.

Differences in behaviour between our subjects are clearly reflected in the various performance indicators that were generated during the running of the experiment, e.g. profits, market share, ROCE and so on. Moreover, the protocol transcripts reveal differences between subjects in terms of both the problem solving strategies and the control strategies used during decision making. In examining the behaviour of other subjects we shall make a tentative assessment at identifying what appear to have been "good" and "bad" decision making strategies in our experimental setting. We shall consider the possible implications for how we might study the strategic behaviour of firms in practice.

In the following section we examine and summarise the behaviour of three other subjects in terms of their relative performance to other subjects and the competitor firm. Our purpose is to illustrate the variety of behaviour that our experimental setting generated despite all subjects being faced with the same task environment. We also demonstrate the generality of the problem space representation developed for S7 in the previous chapter. In essence, the knowledge elements and global operators describing S7's behaviour also appear to capture the behaviour of other subjects in our exercise. Given our experimental setting it was not possible to compare each subject's behaviour against some objectively defined optimal strategy; indeed such a strategy does not exist. However, all subjects were concerned with their relative performance in terms of measures such as profit and market share. It is on this basis that we can evaluate the strategies of different subjects and provide an insight into the type of strategies that appear to have been "successful".

While we can view all subjects as operating in a similar problem space to that defined for S7, this does not mean that all decision making activity was identical. Indeed, it clearly was not. Some small differences can be identified in terms of the knowledge elements that various subjects used in defining their problem space - but these are minimal. All subjects used similar global operators to those we defined for S7, e.g. DS, DPPS, DPS and so on. However, it is at the operator level that differences in behaviour can be studied. It is in specifying the operators that we can capture particular decision rules and information processing behaviour of individual subjects.

In the following section we examine the behaviour of two further subjects - one who was 'successful' and one who was 'unsuccessful'. We contrast the decision rules and information processing heuristics adopted by these subjects and identify reasons for their relative success. At this level, our discussion becomes more detailed than that provided for S7 in the previous chapter and it serves a useful purpose in providing a structure for how we could model the information processing operators described in Chapter 5. We conclude with a brief discussion of the limitations of our experimental setting for the purpose of interpreting subject behaviour and drawing general lessons about 'good' and 'bad' decision making.

6.2 AN OVERVIEW OF THE DECISION MAKING BEHAVIOUR OF S2, S3 AND S4

In Figure 6.1 we present a summary of the performance information relating to all ten of our subjects. It shows the relative success of each subject compared with other subjects and the rival in terms of the key performance variables e.g. profits, market share, ROCE and so on. Figure 6.1 also summarises the decision output data for each subject.

From Figure 6.1 we can identify those subjects who performed more successfully when evaluated in terms of the financial and market performance variables generated during the experiment. Whilst we did not specify a particular goal to be pursued by subjects (such as maximise profits), the protocol data is rarely ambiguous with regard to an individual subject's assessment of their performance. In this respect, the objectives and goals of subjects are amongst the behavioural variables that need to be explained and predicted. This is also an important aspect of the strategic decision making process in practice. Not surprisingly, all subjects in our exercise perceived increases in profits, market share, ROCE, cash and share price as signals of success. Our protocols reveal the majority of subjects focusing upon market share as the key target variable and profitability as a secondary measure of performance.

The most successful subjects were - S3, S6 and S7, with the least successful subjects being - S1, S2 and S9. The remaining subjects can be broadly classified as of 'average' performance. This latter category, however, covers a variety of different levels of achievement in terms of profits, market share and so on. Generally, this 'average' category of subjects underperformed the competitor firm in terms of all five key performance variables. This appears to reflect that the majority of subjects found the ambiguity and complexity of our experimental setting difficult to cope with when implementing particular product and price strategies. It also suggests that our modelling of the competitor's decision making module resulted in the generation of strategies that were particularly robust in terms of adapting to the various product and price decisions actually made our subjects. Importantly, no subject appears to have perceived a 'trivial' solution to our decision making task and the competitor firm appears to have provided 'real' competition.

Figure 6.1 also demonstrates the richness of possible outcomes generated by our experimental simulation. There are examples of quite different different strategies being developed by both our subjects and the competitor firm. This resulted in a variety of competitive market structures emerging from the simulation. For example, in the case of S5, the competitor firm did not launch or withdraw a single product throughout the period of observation. In contrast, the competitor launched and withdrew four products when competing against subject S6. Similarly, the competitor firm's market share varied from an average as low as 16%, in the case of subject S3, to as high as 74% in the case of both subject S5 and S1. On the other hand, average profit for the competitor varied from as low as £638 for the case of subject S3 and as high as £33,966 for subject S9.

All we wish to emphasise here is that a fairly simple experimental simulation is quite capable of generating a rich variety of behaviour for investigation. Figure 6.1 emphasises the significance of studying the differences between the behaviour of our subjects and that it is inappropriate to assume these differences are not important for developing behavioural process models. A more sophisticated simulation exercise designed to replicate say, a specific industrial environment, could provide very valuable behavioural data for studying the economic processes that characterise firms and market

Figure 6.1 Summary of Subjects' Performance in the Strategic Decision Making Exercise

S= Subject
C= Competitor

Subject		1	2	3	4	5	6	7	8	9	10
Decisions		7	6	6.	7	7	7	7	8	7	6
Cash Balance at End(#000)	S	28.9	95.7	77.3	102.4	120.8	109.0	56.7	74.1	99.1	90.7
	C	189.1	167.9	28.1	155.5	233.5	93.0	96.1	160.5	261.9	144.2
Average ROCE (%)	S	-.02	11.00	11.68	11.70	12.70	14.00	8.50	6.48	10.74	11.51
	C	19.81	20.67	5.56	17.00	20.10	13.12	12.70	15.83	22.26	19.37
Average M. Share (%)	S	26	27	84	41	26	65	62	51	30	40
	C	74	73	16	59	74	35	38	49	70	60
Periods of 0% M.Share	S	2	1	0	1	3	1	0	1	2	1
	C	0	0	1	1	0	1	1	0	0	0
Periods of 100% M.Share	S	0	0	1	1	0	1	1	0	0	0
	C	2	1	0	1	3	1	0	1	2	1
Periods of M. Share Incse.	S	3	3	5	4	3	4	5	4	3	3
	C	4	3	1	3	4	3	2	4	4	3
Periods of M. Share Decse.	S	4	3	1	3	4	3	2	4	4	3
	C	3	3	5	4	3	4	5	4	3	3
Average Profit (#)	S	160	8813	9492	9584	12212	13738	6274	4848	9107	9224
	C	23554	22698	638	17682	28834	8755	9190	16091	33966	19982
Periods of Losses	S	3	0	0	0	0	0	0	2	0	0
	C	0	0	3	0	0	0	0	0	0	0
Periods of Profit Decse.	S	4	2	2	2	2	2	4	5	4	2
	C	1	1	5	3	1	5	5	3	2	2
Periods of Profit Incse.	S	3	4	4	5	5	5	3	3	3	4
	C	6	5	1	4	6	2	2	5	5	4
Share Price at End (p)	S	50	122	194	178	128	242	113	65	74	154
	C	333	357	51	190	376	61	77	180	325	261
Average Share Price (p)	S	87	169	162	188	177	182	124	111	120	178
	C	249	295	101	290	318	126	156	176	284	281
Products Launched	S	8	2	6	6	2	5	4	5	3	2
	C	2	1	4	2	0	4	1	2	1	2
Products Withdrawn	S	6	2	3	5	1	1	0	4	2	1
	C	1	1	3	2	0	4	1	2	0	1
No. of Price Incse. Strat.	S	3	2	0	0	4	7	4	2	3	0
	C	7	6	3	3	3	3	3	4	5	3
No. of Price Decse. Strat.	S	4	4	3	3	6	5	11	7	4	3
	C	4	4	8	5	5	6	8	9	6	6
No. of Price Hold Strat.	S	5	2	9	3	2	2	6	6	5	5
	C	5	4	2	7	6	4	4	7	3	6

structures within a particular industry. Such simulation experiments will be resource intensive to develop but they offer greater opportunity for generalising to real world industrial environments than is possible in this research.

The fact that there was no transparently obvious way for subjects to behave in our decision making exercise captures an important element of business reality. Our decision making exercise - although rather stylised - resulted in subjects following quite different strategies in the same task environment. These differences provide a useful basis for contrasting successful and unsuccessful pricing and product strategies in our experimental setting. Conducting this type of analysis of subject behaviour cannot simply be based upon decision outcome data. It is our subjects' protocol data which provides the insight (though not necessarily a complete picture) into the reasons why certain subjects were more successful than others in maintaining their relative competitive position against the rival.

Whilst, as we shall see , the operators defined for S7 apply in general terms to all subjects in our experiment (reflecting the nature of the decision making task), they do not in terms of the detailed production rules that define the nature of their different strategies. Thus, the different knowledge elements used in defining the LHS and RHS elements of production rules for each operator will be determined by the nature of the different product and pricing strategies used by our subjects. It is thus necessary to determine the nature of these different strategies used by our subjects.

In the remainder of this section we shall briefly describe the behaviour of three other subjects: S2, S4 and S3. Our purpose is twofold. First, to demonstrate that other subjects worked in a problem space very similar (if not identical) to that we described for subject S7. We cannot prove this but we shall present short extracts from the transcribed protocols of our subjects to support this interpretation. The similarity in terms of knowledge elements and operators defined for S7 and used by these subjects should be clear. We illustrate this by representing the output of the various global operators defined in the previous chapter in terms of S7's problem space knowledge elements. Second, we demonstrate that despite other subjects having a similar problem space to S7; the nature of the global operators are different. These differences provide the behavioural content to our interpretation of subject behaviour. In sum, we are able to identify different classes of generic strategies used by our subjects.

(a) Behaviour of Subject S2

It can be seen from Figure 6.1, that S2 is an example of a subject whose pricing and product strategies were unsuccessful when evaluated in terms of the performance variables incorporated in our exercise. The experimental run was six periods and the subject achieved an average market share of 27% and an average profitability of £8,813. Extracts from his protocol are contained in Figure 6.2 and these topic statements demonstrate that S2 was employing similar global operators to those we defined in the previous chapter. Each topic statement is followed by an indication of the output of the operator expressed in terms of the knowledge elements defined in S7's problem space. We are thus moving closer to the detailed specification of production rules that is necessary for developing a process model of any particular subject. Due to limitations of space we do not list all the input knowledge elements to each operator.

There is one additional operator that can be identified. This operator, which we have identified as PPW, is used by S2 (and other subjects) for identifying which product(s) are to be withdrawn from the market in any period.

Figure 6.2 Examples of Global Operators Used by Subject S2

DS Operator

Period 2 Topic Line 34

... although our market ... our company share of market revenue has dropped. So see if we can do something about that ...

Output: strategic goal --> INCREASE MARKET SHARE

Period 3 Topic Line 45

I think ... er ... I'm going to be rather aggressive here ... er ... I'm going to imitate the success of the competitor's product ... yes ...

Output: product strategy --> AGGRESSIVE

DPPS Operator

Period 1 Topic Line 2

With regard to product strategy, I think ... that what we will do is keep with the existing product mix and play around with price just for the moment ...

Output: product strategy --> NO CHANGE

Period 3 Topic Line 43

So ... given the entry barriers and marketing costs ... er ... these don't seem excessive ... er ... given our cash balances - but even so ... there is quite a bit of uncertainty ... so we'll just launch one new product onto the market ...

Output: portfolio change --> +1

DS Operator

Period 1 Topic Line 6

I think what we'll do is take it down to £3.55 from £3.60 ...

Output: Product 2: price strategy --> DECREASE

Period 6 Topic Line 142 - 143

mmm ... variable costs ... er .. I think what we will do is ... increase the price very marginally ...

Output: Product 4: price strategy --> INCREASE

PRICE Operator

Period 4 Topic Line 97

... so I think we will go to £3.70 ... so lets try that ...

Output: Product 4: price strategy --> PRICE = £3.70

RATIO Operator

Period 3 Topic Line 47

So units of characteristic 1 - think we will go for 1 on that. Characteristics of number 2 ... I think we will go for 5 on that ...

Output: Product 4: C-ratio --> C1 = 1 : C2 = 5

SV Operator

Period 3 Topic Line 46

though I can't be sure how the competitor is going to react to this ...

Output: aggressive product strategy --> SUITABLE<unclear>

Period 4 Topic Line 114

We can probably accept some lower margins given our cash position ...

Output: price strategy: aggressive --> FEASIBLE

SA Operator

Period 1 Topic Line 7

so let's move on from there ... The variable cost is £3.00 - let's make a note of that ...

Output: Product 2: variable cost = £3.00 --> NOTED

Period 3 Topic Line 50

Right, total market turnover goes up to £170,000 or so

Output: total market demand: £170,000 --> NOTED

PA Operator

Period 1 Topic Line 10

Right sales revenue for the period is £26,124 ... that doesn't look too bad ...

Output: sales revenue: £26,124 --> SATISFACTORY

Period 2 Topic Line 33

Our share price has gone up as well ...

Output: share price --> INCREASE

PPW Operator

Period 5 Topic Line 118

I think we will review and ... then we will ... ... let's see ... yes ... this must be the worst scenario that can be imagined ... So let us take out number 2 ... and ... Right, I think what we will do is delete Product 2

Output: product strategy: withdrawal --> Product 2

Figure 6.3 summarises the pricing and product decisions of both S2 and the competitor firm (ie. decision output data). From this information and S2's protocol we can interpret the subject's strategy in the first two periods as being exploratory and he appears to be satisfied with his performance in terms of market share. It is only when the subject notes the dominance of the competitor firm's

Product 3 at the end of Period 2 that he decides to respond by launching a new product. Essentially, the first three periods of S7's behaviour can be described as being passive and no detailed account of his decisions is given in the protocol.

Figure 6.3 Subject S2: Decision Outcome Data

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 1:				
Subject-				
Product 2	decrease	38%	20	18
Competitor-				
Product 1	increase	31%	28	30
Product 3	increase	31%	25	28
Period 2:				
Subject-				
Product 2	hold	44%	18	18
Competitor-				
Product 1	decrease	16%	30	18
Product 3	increase	40%	28	30
Period 3:				
Subject-				
Product 2	decrease	42%	18	17
Product 4	new	-	-	23
Competitor-				
Product 1	decrease	12%	18	12
Product 3	hold	46%	30	30
Product 5	new	-	-	15
Period 4:				
Subject-				
Product 2	increase	-	17	23
Product 4	hold	34%	23	23
Product 6	new	-	-	24
Competitor-				
Product 1	hold	31%	12	12
Product 3	decrease	-	30	1
Product 5	increase	35%	15	18
Period 5:				
Subject-				
Product 4	decrease	-	23	3
Product 6	decrease	-	23	14
Product 2	withdrawn	-	24	-
Competitor-				
Product 1	hold	65%	12	12
Product 3	increase	35%	1	5
Product 5	decrease	-	18	1
Period 6:				
Subject-				
Product 4	increase	11%	3	7
Product 6	withdrawn	-	14	-
Competitor-				
Product 1	hold	47%	12	12
Product 3	increase	42%	1	5
Product 5	withdrawn	-	5%	-

In Period 3 S2 launches a new product which is based upon the presence of a successful competitor product in the market. This type of new product strategy we have defined as a Competitive Product Strategy (CPS) and, as we shall see with other subjects, is used to introduce new products with a similar characteristic mix to that of a product marketed by the competitor firm. In an extreme version of this type of strategy (as displayed by S2 in Period 3) it involves the launch of an imitation product with an identical mix of C2 and C1 as that for a product marketed by the competitor firm.

An alternative type of product strategy used by our subjects was a Market Product Strategy (MPS). This strategy reflected the launch of new products aimed at exploiting perceived 'gaps' in the market. Typically this strategy involved a subject maintaining some 'distance' between his products and those of the competitor firm for fear of retaliation. We have seen topic statements from S7's protocol that support our interpretation of this type of strategy.

In sum, these two types of product strategy reflect that subjects could either attempt to differentiate their new products from the rival's or compete directly with a product that had a similar C2/C1 ratio. Our description of these two strategies provides an insight into the nature of the information that is likely to be processed by a subject when using these strategies. For example, the CPS strategy would typically involve a subject identifying successful competitor products and noting their mix of C2/C1.

S2's product withdrawal strategy is relatively straightforward though it is only demonstrated in Periods 5 and 6. The subject appears to employ a very simple rule and one which we have defined as Product Performance Withdrawal Strategy (PPWS). This, in essence, reflects the subject monitoring the performance of a product and, as with our modelling of the competitor firm, withdraws a product if it has not achieved any positive market share in two consecutive periods.

An alternative strategy used by some subjects for product withdrawal we have defined as Product Type Withdrawal Strategy (PTWS). This is used when a product is viewed as being unsuitable in terms of its fit with the subject's existing product portfolio. As we shall see, this may result in a product being withdrawn by a subject even when it is successful in terms of acquiring market share. This type of product withdrawal strategy typically reflected a subject's perception of what characteristics may be attractive to consumers in the market - an approach that subjects found very difficult to develop effectively. Given the design of our experimental setting, the PTWS strategy had strong links with a MPS type of product strategy.

The CPS type of product strategy appears to have been used successfully by our subjects. This is because it eliminated an element of uncertainty surrounding product strategy and it also provided a basis for developing an effective pricing strategy. The CPS strategy, however, was an aggressive strategy. S2 illustrates this in Period 3 when he prices his new product marginally below that of the rival's product against which it is competing. In using the price of a competitor product as a reference point for product pricing, S2 is demonstrating the strategic significance of using this type of information over other possible reference points e.g. variable costs.

From analysing the protocols of all our subjects we can identify three broad types of generic pricing strategy that were adopted. Not surprisingly, these correspond closely to pricing rules that have been observed in empirical studies of actual business practice [see for example Coutts, Godley and Nordhaus (1978)]. The three strategies are:

(i) Cost Based Pricing Strategy (CBPS): a strategy that involved a subject basing the price of a product upon its variable cost. The difficulty in modelling this type of pricing strategy is in eliciting from the subject's protocol the basis for a particular cost mark-up margin.

(ii) Market Based Pricing Strategy (MBPS): a strategy involving the pricing of a product in relation to what it is perceived the market will accept. This typically involves the subject monitoring the sales performance of a product. For example, subjects using this type of rule typically increased the price of a product if it had achieved a high market share in the previous period.

(iii) Competitive Based Pricing Strategy (CMBPS): was employed by subjects when attempting to price a product in direct competition with a product of the rival. Differences between subjects in applying this type of strategy tended to reflect their perception of what was a competing product.

Just as with the two different types of product strategy, these pricing strategies are not mutually exclusive. Importantly, each type of strategy imposes different information processing requirements on subjects and has implications for the overall coherence of a subject's strategy. Examples of these strategies being applied can be found in S2's protocol. For example, in Periods 3 and 4 S2 notes:

<u>Period 3</u> <u>Topic Line 53 - 54</u>

Now the variable cost is £3.00 ... mmm ... so ... the price of the product this period ... mmm ... this is Product 4 - we have no previous price history ... so let us try that ... marginally below the competitor's product price.

<u>Period 4</u> <u>Topic Line 105 - 105</u>

... ... now this is where there is no previous price history ... variable cost is £2.50 ... mmm ... the price of the product this period will be ... let's have a look ... I think we will go for £3.10.

These two extracts provide examples of the use of a CMBPS type production rule in Period 3 and a CBPS production rule in Period 4. In both cases the protocol does not provide a complete record of how the subject determines a value for price. However, the protocol extracts do indicate the kind of knowledge element information that is required for the application of each type of strategy. This is important for the purposes of modelling a particular subject's operators in terms of specifying the LHS and RHS elements of production rules.

From the protocol of S2 it is clear that the subject largely focuses upon a cost-based pricing strategy throughout the experimental run. After a successful attempt at a CPS type of product strategy in Period 1 the subject fails to explore the strong link between pricing and product strategy in the exercise. It is clear from his protocol that the subject resorts to CBPS type decision rules - though there are few explicit comments in his protocol as to the basis of his choice for particular price margins. This is a problem of this type of pricing strategy in our experimental setting and is illustrated in the subject's reasoning when pricing Product 2 in Period 4:

Period 4 Topic Line 92 - 97

So I think what we will do ... is ... I must say I can't work out why Product 5 is seemingly doing so well ... mmm ... it doesn't seem to have a mix of C1 and C2 so radically different from ours ... the variable costs are higher - the price is higher ... their sales revenue is £67,000 almost and ours was zero ... so I think what we will do is ... increase our price on that ... I think we will go to £3.70 ... so - let's try that ...

S2's protocol also provides examples of the application of information processing heuristics as part of his control strategy for placing a structure on the decision making task. For example, in Period 4 S2 decides to launch another new product as a result of his successful product launch in Period 3. In the protocol he summarises his strategy:

Period 4 Topic Line 85 - 86

Right, I think what we will do is to launch one new ... ... so we will launch one new product ... This will be Product 6 ... mmm ... so let's continue with that ... Now this is the difficult part ... actually getting the characteristic mix ... I think with C1 ... er ... what we will do is ... er ... go for something broadly ... as ... er ... before ... mmm ... that seemed quite successful - no ... we'll change that slightly ...

This type of reasoning would appear to provide a very simple example of the judgmental heuristic - representativeness - identified in the research of Tversky and Kahneman (1974). This heuristic involves a decision maker overestimating the extent to which a situation is representative of the circumstances to which he wishes to generalise. In Period 4 the subject is clearly trying to relate the success of his previous new product in terms of its mix of characteristics C1 and C2 to the possible characteristic mix for a new product. The representativeness heuristic has also been identified as a source of bias in the corporate strategy literature [see Schwenk (1984)]. The argument is that the nature of strategic decisions rarely provides the opportunity to generalise from a long history of past strategies.

In this particular case, the judgmental heuristic used by S2 does appear to lead to bias since he neglects to give consideration to the nature of his CPS type strategy in the previous period. It appears that his new product strategy for Period 4 is of a MPS type and this causes difficulties in terms of developing an appropriate price strategy for the new product. The subject fails, for example, to recognise that his new product will be competing against one of his own products. This is a good illustration of how a subject's strategy influenced the way a decision making situation was perceived.

(b) Behaviour of Subject S4:

The decision strategies of S4 cannot be considered as being highly successful when compared against the performance of other subjects and the competitor firm. Figure 6.4 provides brief extracts from S4's protocol transcript and illustrates that the subject applied similar global decision making operators to those defined for S7's problem space. Figure 6.5 summarises the decision output data for both S4 and the competitor firm.

Figure 6.4 Examples of Global Operators Used by Subject S4

DS Operator

Period 1 — Topic Line 10 - 11

I understand from the case notes that we have lost a lot of market share ... mmm ... but I think as much to get a feel for what the competition is about as for any other reason I'm going to stick with what we have got at the moment and see what happens in the next period ...

Output: overall strategy --> NON AGGRESSIVE

Period 4 — Topic Line 109

And this time I'm going to have to make a concerted effort to ... actually grab some of the competitor's Product 1 and Product 4 market ...

Output: strategic goal --> INCREASE MARKET SHARE

DPPS Operator

Period 2 — Topic Line 32

Don't think I want to change the present product portfolio - so let's go on to price strategy ...

Output: product strategy --> NO CHANGE

Period 3 — Topic Line 113 - 115

OK - we want to introduce another product if we can here ... another two products ... because I think that is the only way I can compete against the product that has a 2/2 ratio ...

Output: portfolio change --> +2

DPS Operator

Period 1 — Topic Line 12

Pricing strategy ... we're not going to change that ... so that is going to stay at £3.60

Output: Product 2: price strategy --> HOLD

Period 4 — Topic Line 90 - 91

Yes, I'll have a go at that I think and we'll bring that down to be a direct competitor to ... er ... £3.80 ... ... Ok new Product 6 is going to be a direct competitor to Product 4 ...

Output: Product 6: price strategy --> COMPETING PRODUCT

RATIO Operator

Period 5 — Topic Line 116 - 118

So we'll make Product 7 - 2/2.10 ... ... and Product 8 is now going to compete with ... Product 1 ... so we'll go 4 to 1 ...

Output: Product 7: c-ratio --> C1 = 2.00
C2 = 2.10

Product 8: c-ratio --> C1 = 4.00
C2 = 1.00

PRICE Operator

Period 5 — Topic Line 122 -123

Right - changing prices ... ... so ... Product 5 now ... we'll make £3.60 ... mmm ... Product 7 ... er ... we'll maintain at £2.30 ...

Output: Product 5: price --> £3.60
Product 7: price --> £2.30

SV Operator

Period 3 — Topic Line 57

... unless and until ... things get pretty tough with my firm at the moment ... although we aren't market leaders and although we aren't performing so well ... er ... as the competition - we are doing all right ...

Output: price strategy: hold --> SUITABLE

Period 4 Topic Line 84

- rather than to start ... reducing the price ... ... because we are never going to be able to get a contribution from that particular product ... if we ... charge a price that is going to get anywhere near that of Product 4 ...

Output: product strategy : withdrawal --> ACCEPTABLE

SA Operator

Period 1 Topic Line 5

Obviously price isn't the all important factor here ... mmm ...

Output: price sensitivity --> ? <unclear>

Period 2 Topic Line 51

in total then the market this period is ... er ... Struggling at this stage to make sense of the size of each ... products segment in the overall market ...

Output: market sector --> SIGNIFICANT <unclear>

PA Operator

Period 1 Topic Line 18

It's looking all right .. the "do nothing" strategy seems to ... er ... have been OK ...

Output: overall strategy --> SUCCESSFUL

Period 3 Topic Line 62

OK - er - maybe I've stayed the same for too long ... we have got a situation here where this period we've sold nothing

Output: market share --> UNSATISFACTORY

PPW Operator

Period 4 Topic Line 83

er ... so I think I'm tempted on that sort of basis to actually withdraw our product ... Product 2

Output: product strategy : withdrawal --> Product 2

Figure 6.5 Subject S4: Decision Outcome Data

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 1:				
Subject-				
Product 2	hold	38%	20	20
Competitor-				
Product 1	increase	31%	28	30
Product 3	increase	31%	25	28
Period 2:				
Subject-				
Product 2	hold	42%	20	20
Competitor-				
Product 1	decrease	16%	30	20
Product 3	increase	42%	28	30

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 3:				
Subject-				
Product 2	hold	41%	20	20
Competitor-				
Product 1	decrease	12%	20	14
Product 3	hold	47%	30	30
Product 4	new	-	-	15
Period 4:				
Subject-				
Product 2	withdrawn	-	20	-
Product 5	new	-	-	27
Product 6	new	-	-	16
Competitor-				
Product 1	hold	30%	14	14
Product 3	hold	24%	30	30
Product 4	hold	47%	15	15
Period 5:				
Subject-				
Product 5	decrease	13%	27	20
Product 6	withdrawn	-	15	-
Product 7	new	-	-	12
Product 8	new	-	-	10
Competitor-				
Product 1	hold	50%	14	14
Product 3	decrease	-	30	1
Product 4	hold	37%	15	15
Period 6:				
Subject-				
Product 5	decrease	-	20	0
Product 7	withdrawn	-	12	-
Product 8	decrease	73	10	0
Competitor-				
Product 1	decrease	-	14	12
Product 3	increase	27%	1	5
Product 4	decrease	-	15	1
Period 7:				
Subject-				
Product 5	withdrawn	46%	0	-
Product 8	withdrawn	54%	0	-
Product 9	new	-	-	11
Product 10	new	-	-	11
Competitor-				
Product 1	withdrawn	-	1	-
Product 3	withdrawn	-	5	-
Product 4	hold	-	1	1
Product 11	new	-	-	1

From Figure 6.5 we can interpret that S4's strategy during the first three periods appears to be characterised by satisficing behaviour. S4 did not make any changes to his product portfolio or his pricing strategy during these periods. This "do nothing" strategy proved reasonably successful in the first two periods and it was only in Period 4 that he adopted a more proactive strategy as a result of obtaining zero market share in Period 3. S4's protocol provides clear evidence that he had a strategy of 'no change' in the first three periods. For example, there was no commitment to increasing profitability or market share:

Period 1 Topic Line 31

But we are not worrying too much at the moment - er ... depends on what our objectives are ... maybe we'll formulate them more precisely as we go along ... ... Let's move on to the next stage

Period 2 Topic Line 41; 53

OK - so things are looking good ... er ... share of market ... is fluctuating slightly - but I don't think that's anything to worry about at the moment ... er ... I'm very risk averse and I'm sort of following the follower attitude here ... er ... ... certainly ... I don't think I want to change anything too much - so we'll keep moving ... ...

These extracts from S4's protocol illustrate a very important aspect of subject behaviour in our experiment - notably the concern with relative rather than absolute performance. In the first three periods of the exercise there was no attempt by S4 to identify a 'best' possible decision in terms of maximising profits or market share. In fact, the subject was clearly satisfied with decisions whose outcomes were simply 'good enough'. It is only as a result of a significant change in the behaviour of the competitor firm in Period 3, that S4 decides to modify his "do nothing" strategy and launch a new product in Period 4. From that period his strategy becomes much more aggressive in response to a deterioration in his relative performance.

S4's new product strategy in Period 4 illustrates an example of a CPS type strategy. It involved the launch of two imitation products focused upon two of the competitor firm's products - Product 3 and Product 4. The subject summarises the basis for the strategy in his protocol:

Period 3 Topic Line 75 - 76

... ... OK - I think we are going to have to try direct competition ... we know that there are profits to be made ... er ... from the prices that have been charged by the competition and the ratios that they are using ... so I think what we will have to do next is to introduce new products ... that compete head on - let's see what happens ...

Period 4 Topic Line 89 - 93

... I'm now working out whether on a contribution per unit sold basis ... I'd be better off competing with Product 3 ... that is offering the same ratio but undercutting the £3.90 price ... ... Yes, I'll have a go at that I think and we'll bring that down to ... er ... £3.80 ... ... OK - new Product 6 is going to be a direct competitor to Product 4 ... and this time we'll go for a price of £2.30 - because the problem here is that ... mmm ... er ... OK - we are introducing new Product 6 - ratio of 2 to 2 ...

These extracts also demonstrate the strategic significance of subjects linking a CPS product strategy with a CMBPS price strategy. The link between product and price strategy in general appears to have been an effective mechanism adopted by some of our subjects for coping with the complexity and uncertainty surrounding market demand. In the next section we shall rationalise this link between CPS and CMBPS rules in the context of what appears to have been a 'reasonable' strategy in our experimental setting.

The product withdrawal strategy of S4 in Period 4 demonstrates both PPWS and PTWS strategy type decision rules. Whilst the product withdrawn had been unsuccessful in the previous period, the subject also noted in the protocol:

<u>Period 4</u> <u>Topic Line 84</u>

- rather than to start ... reducing the price ... because we are never going to be able to get a contribution from that particular product ... if we ... charge a price that is going to get anywhere near that of Product 4 ... ...

The aggressive product strategy of S4 is continued in Period 5 when another product is launched to imitate a successful product of the competitor firm. In this period the subject achieves a portfolio that is identical in every respect to that of the competitor firm. The subject's pricing strategy in Period 5 is once again of the CMBPS type with the subject marginally pricing below the prices charged by the competitor in the previous period. The subject summarises his position in the protocol:

<u>Period 5</u> <u>Topic Line 126</u>

So I've eventually achieved a situation where I'm competing ratio for ratio and trying to undercut prices - still maintaining a contribution from each product ...

In Periods 6 and 7 S4 develops a more aggressive strategy which results in his abandonment of the pricing and product strategies adopted in Periods 4 and 5. In particular, his strategies become directed towards dominating the total market through aggressive break-even pricing. S4 was the only subject to adopt this extreme form of a CBPS type of strategy. The strategy was successful in terms of achieving 100% market share but it resulted, not surprisingly, in low profitability. S4 states in Period 6:

<u>Period 6</u> <u>Topic Line 145; 151</u>

What we may try to do now is to achieve the situation where we can totally dominate the market by getting into the situation where we make a loss ... on the ... er ... see how it goes ... So what I'm going to do is actually go for break even prices this period and see what that does to market share ...

At this stage the pricing strategy of S4 appears to be a hybrid of CBPS and CMBPS type of decision rules and whilst successful in terms of achieving the subject's objective, it was clearly not seen as a sustainable strategy in the longer term. In Period 7 S4's strategy involved the restructuring of his product portfolio by introducing new products to replace all existing products. The aim was to reduce product costs. Following this strategy, the subject perceived that he would be able to reduce variable costs and, by holding prices constant, increase his overall profitability position.

In sum, we can see that our earlier discussion classifying different types of generic pricing and product strategies still permits the possibility of considerable variety in behaviour between individual subjects. Subject S4's behaviour provides examples of quite different decision making rules compared with those of the previous subject. The passive strategy of the first three periods quickly evolved into a highly aggressive strategy upon the successful launch of a new product by the competitor firm. This is a good, if unsuccessful, example of adaptive behaviour which reflected a change in the strategic goals of the subject. However, our different types of generic strategies do appear to be sufficiently rich for explaining the differences in behaviour between our subjects.

(c) Behaviour of Subject S3

S3 provides another contrast in decision making behaviour when compared with our description of the two previous subjects. It can be seen from Figure 6.1 that S3 was one of the most successful subjects relative to both the rival and other subjects. This subject captured the highest average market share of 84 per cent and he was the only subject who forced the competitor firm to sustain losses. Arguably, S3's overall performance is marginally inferior to that of S6 when evaluated in terms of the full range of performance variables reported in our experiment.

Figure 6.6 provides extracts from S3's protocol transcript for the purpose of demonstrating the application of the global problem space operators that we have previously defined. Figure 6.7 summarises the decision output data for the subject and the rival firm.

Figure 6.6 Examples of Global Operators Used by Subject S3

DS Operator

Period 2 — Topic Line 49

Basically, I'm trying to beat my competitor with price competitiveness ... certainly in Product 2 ...

Output: price strategy --> AGGRESSIVE

Period 2 — Topic Line 55

I think I shall go up market and test market demand ... since I know very little about it at this stage ...

Output: product strategy --> NON AGGRESSIVE

DPPS Operator

Period 1 — Topic Line 4

My query is now to decide whether to introduce an additional product ... basically, to compete with Product 3 ... I think I shall do ...

Output: product strategy --> NEW PRODUCT

Period 1 — Topic Line 9

The decision now is ... do I launch one or two new products? Currently, my uncertainty ... I'm certainly going to introduce one ... I think I shall ... play safe and just go for the one.

Output: portfolio change --> +1

DPS Operator

Period 2 — Topic Line 62

and I could afford perhaps to reduce the price on Product 2 a little bit and test consumer reaction ...

Output: Product 2: price strategy --> DECREASE

Period 4 — Topic Line 149

Pricing strategy ... right ... Product 4 ... I'm going to keep it steady ... er ... £4.20

Output: Product 4: price strategy --> HOLD

RATIO Operator

Period 1 — Topic Line 13 - 16

I think what I shall do is to do something broadly similar at the moment with some slight amendments ... I'll offer two units of characteristic 1 ... characteristic 2 ... the competitor launched a product with 5 units ... I'll try and market a superior product ... mmm ... 6 units.

Output: Product 4: c-ratio --> C1 = 1
C2 = 6

PRICE Operator

Period 1 — Topic Line 21

The new product - Product 4 has a variable cost of £4.00 - we'll put it in at £4.25 and see whether the market will hold this price.

Output: Product 4: price strategy --> price=£4.25

SA Operator

Period 2 — Topic Line 67

Now the new product ... the variable cost is £5.00

Output: Product 5: variable cost --> NOTED

Period 6 — Topic Line 224

Now the only thing that was competing with me really was his Product 3 ... which had characteristics 1 and 5 ... priced very similar ...

Output: Product 3: c-ratio: price --> SIGNIFICANT

PA Operator

Period 2 — Topic Line 81

So at the end of Period 2, my profit has dropped from the previous period ...

Output: total profit --> DECREASE

Period 3 — Topic Line 120

I've sold nothing on Product 4 ...

Output: Product 4: sales --> NOTED

SV Operator

Period 1 — Topic Line 23

So what I've done - I've tried to do is to ... has been to extend the range of my products from one to two ... but also to make a more varied product price and product mix available to the market

Output: overall strategy --> ACCEPTABLE

Period 2 — Topic Line 63 - 64

Product 2 ... right, I'll reduce the price of that ... £3.30 ... it should get an increased response from consumers

Output: Product 2: price strategy: decrease --> SUITABLE

PPW Operator

Period 3 — Topic Line 111

I'm going to withdraw Product 2 ... that's Product 2 withdrawn

Output: product withdrawal --> Product 2

Figure 6.7 Subject S3: Decision Outcome Data

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 1:				
Subject-				
Product 2	decrease	38%	20	15
Product 4	new	-	-	6
Competitor-				
Product 1	increase	31%	28	30
Product 3	increase	31%	25	28
Period 2:				
Subject-				
Product 2	decrease	26%	15	10
Product 4	decrease	60%	6	5
Product 5	new	-	-	3
Competitor-				
Product 1	decrease	14%	30	16
Product 3	decrease	-	28	10
Product 6	new	-	-	16
Period 3:				
Subject-				
Product 4	hold	14%	5	5
Product 5	hold	46%	3	3
Product 7	new	-	-	5
Product 2	withdrawn	-	10	-
Competitor-				
Product 1	decrease	20%	16	5
Product 3	decrease	20%	10	5
Product 6	decrease	-	16	5
Period 4:				
Subject-				
Product 4	hold	-	5	5
Product 5	hold	38%	3	3
Product 7	hold	40%	5	5
Competitor-				
Product 1	hold	-	5	5
Product 3	increase	22%	5	7
Product 6	withdrawn	-	5	-
Product 9	new	-	-	7

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 5:				
Subject-				
Product 4	withdrawn	-	5	-
Product 5	hold	28%	3	3
Product 7	hold	63%	5	5
Product 10	new	-	-	5
Competitor-				
Product 1	withdrawn	-	5	-
Product 3	decrease	9%	7	5
Product 9	decrease	-	7	5
Product 11	new	-	-	5
Period 6:				
Subject-				
Product 5	hold	23%	3	3
Product 7	hold	71%	5	5
Product 10	withdrawn	-	5	-
Product 12	new	-	-	7
Product 13	new	-	-	3
Competitor-				
Product 3	hold	6%	5	5
Product 9	withdrawn	-	5	-
Product 11	decrease	-	5	4
Product 14	new	-	-	5

As with S7, subject S3 adopts an aggressive strategy early in the exercise by launching a new product using a modified CPS type of product decision rule. This strategy appears to reflect the subject's perception that characteristic C2 is preferred by the market because of the competitor firm's successful Product 3 (this product had a high proportion of characteristic C2). S3 states in his protocol:

Period 1 — Topic Line 11

Now if we look at what the competitor has done ... basically ... they seemed to have stressed characteristic 2 in their new product ...

Period 1 — Topic Line 26 - 28

Product 4 has been more successful ... in fact, quite a bit ... suggests that perhaps the market will sustain a larger ... er ... higher price and the trends suggest that ... perhaps, characteristic 2 is probably seen as more favourable in the eyes of the public.

This would appear to provide a very simple example of Kahneman and Tversky's representativeness heuristic and results in the subject launching a further product in Period 2 with a relatively high proportion of C2. One implication of this interpretation of S3's behaviour is that his product strategy is not a pure CPS type and involves the subject in attempting to anticipate the preferences of the market for particular characteristics. Given the non-availability of market research data, this was clearly likely to be a very difficult strategy to implement successfully.

S3's pricing strategy includes rules from all three generic types of pricing strategy, as described earlier, ie CBPS, MBPS and CMBPS. For example, in Period 1 the subject notes:

<u>Period 1</u> <u>Topic Line 18 - 20</u>

Now ... I'll need to do something with my price ... I shall drop the price of my original product slightly ... to ... £3.45 ... this should allow me to compete effectively with the competitor.

<u>Period 1</u> <u>Topic Line 21 - 22</u>

The new product - Product 4 - has a variable cost of £4.25 and see whether the market will hold this price. This is quite expensive compared with previous periods ...

Another interesting feature of S3's behaviour is that he was clearly prepared to adapt his strategy to changing market conditions and in anticipation of likely decisions of the competitor firm. We described the significance of anticipatory behaviour for S7's strategy in the previous chapter. For example, S3 states in his protocol in Period 2:

<u>Period 2</u> <u>Topic Line 47</u>

My query is do I stand steady perhaps ... or perhaps modify Product 2 ... then again basically ... I'm tempted to change both on the assumption my competitor will at least change one ...

S3's attempts at anticipating the behaviour of the competitor firm appears to have been an important factor in the relatively poor performance of the competitor. This is illustrated in Period 2 when S3's anticipation of the competitor firm's decisions resulted in a very successful pricing strategy (particularly since the competitor firm had applied rules to reduce prices as a result of poor sales performance in Period 1). As with subject S7, S3's protocol transcript does not provide sufficient detail for modelling these anticipation mechanisms.

S3's protocol also provides an example of the difficulties that faced a number of subjects when attempting to assess the relative significance of price and product quality in our experimental market. This problem emerged most notably when subjects were pricing products that did not have a sharp competitive focus (ie were not associated with a competing product). This, of course, is a practical marketing issue, particularly in markets where knowledge of consumer preferences is imperfect. In the case of S3, his decision making appeared to be dominated by decision rules based on both CPS and MPS type product strategies. Price strategy does not appear as a major consideration in his overall strategy. This is reflected in Figure 6.1 which shows that the majority of S3's pricing decisions were of the type "hold" or associated with the launch of new products. S3's protocol highlights the problems that this created at various stages in the exercise:

<u>Period 2</u> <u>Topic Line 89 - 90</u>

This begins to suggest that ... given the 40p margin per unit of Product 1 ... er ... it's probably product mix that may be important at that end of the market ... he's picking upon a product ... that might be worth investigating ...

<u>Period 4</u> <u>Topic Line 145 - 146</u>

Product 4 ... didn't do anything at all ... £4.20 ... it's not price ... the mark-up is only 20p ... it's product characteristics mix ... it has been beaten by Product 3 - I would say. Which way?

<u>Period 4</u> <u>Topic Line 167 - 168</u>

Now that requires some thought ... the market didn't like the product ... it's not the price either ... he isn't being greedy ... maybe it's the mix that is not appropriate. Now what I've done ... yes ... so basically my one ... my unit 4 - my Product 4 ... is perhaps similar in some respects to his Product 9 ... not in terms of price - or was it?

The ability of subjects to adapt to this aspect of the exercise appears to have been an important factor in identifying successful and unsuccessful strategies. Inevitably, some of the pricing and product strategies we have described above were more robust in terms of allowing subjects to cope with the complexity and uncertainty in our experimental setting.

In summarising the discussion of this section, our main purpose has been twofold. First, to support our interpretation of subject behaviour presented in the previous chapter. We have examined the behaviour of a further three subjects and illustrated their application of the knowledge elements and global operators we defined in S7's problem space. Second, we have provided behavioural content to the different types of strategies employed by subjects in our experiment. Two important factors that reflect the behavioural content of our subjects' strategies are: (i) the knowledge state structures that subjects refer to when applying a particular strategy, and (ii) the decision outcome.

We have seen that the different types of generic pricing and product strategies can be interpreted within our description of the problem space operators described for S7 in the previous chapter. In examining the protocol extracts of other subjects in this section we have illustrated the general form of the production rules for each type of strategy, though we have seen that they can and do vary between subjects. This emphasises the focus upon problem space operators for exploring the differences in behaviour between subjects.

6.3 THE NATURE OF SUCCESSFUL AND UNSUCCESSFUL DECISION MAKING STRATEGIES: A COMPARISON OF SUBJECTS S1 AND S6

In this section we contrast the behaviour of two further subjects - a successful subject (subject S6) and an unsuccessful subject (subject S1). Our purpose is to identify the nature of 'good' and 'bad' decision making strategies in our experimental setting. We assess the characteristics of good and bad decision rules in the context of the generic pricing and product strategies described in the previous section.

Before examining the behaviour of S1 and S6 we shall briefly consider the characteristics of what might be regarded as a 'reasonable' competitive strategy in our experimental setting. We use the term reasonable as it is not possible to identify an optimal product and pricing strategy that should have been followed by our subjects.

Baumol (1967) has previously examined the notion of an optimal competitive strategy for a firm operating within a Lancastrian model of consumer demand. Baumol models the behaviour of a firm (a retail store) competing with two other firms in terms of sales force expenditure (characteristic C1) and maintenance expenditure (characteristic C2). As with our description in Chapter 4, each firm was represented in terms of a 'strategy point' (in our case each product on the market) defined by the level of the two different types of expenditure. For the given strategy points of the two competing firms, and a given rectangular distribution of consumer demand, Baumol defines an optimal strategy for a third firm pursuing an objective of maximising market share.

Baumol's conditions for defining an optimal strategy are not satisfied in our simulation exercise. Notably, Baumol's optimal strategy ignores the importance of competitor firm countermoves in an oligopolistic market environment. Indeed, as Baumol (1967, p.675) states in relation to this particular aspect of his analysis:

> "As in the case with so many models of the firm that seek to show how optimal decisions are arrived at my construct simply ignores this vital issue and quite illegitimately assumes away the counter measures to which our company's competitors are likely to be led by its decisions."

Another assumption implicit in Baumol's analysis is that the firm has knowledge about the level and distribution of demand. Once again, this assumption is not satisfied in our experimental setting. However, despite the differences between the assumptions of Baumol's model and the conditions simulated in our experiment, his analysis is useful as a reference point for identifying the nature of a reasonable strategy in our particular experimental setting. What is of interest here is the generic nature of Baumol's optimal strategy.

Within a Lancastrian framework Baumol suggests two possible reasons why firms might develop a differentiated product strategy. First, as a non-aggressive move to reduce the possibility of retaliation by a competitor firm. Second, to locate a product in a market niche and discourage other firms entering that sector of the market. By ignoring the threat of competitor countermoves, the nature of the optimal business strategy in Baumol's model is for the firm to locate a new product 'close' to a competitor firm's strategy point and thereby maximise potential market share. This distinction between 'competitor focus' and 'differentiation' strategies provides a useful framework to examine the nature of the generic strategies used by subjects in our experiment.

In our experiment the strategy point for a product was determined by its C1/C2 mix and the price of the product. The former influence on the strategy point is fixed for the life of the product while the latter influence can be varied from period to period. A subject's product portfolio can thus be viewed as a set of strategy points and adjusting a product's position in strategy space (eg. by changing price) will directly influence the market share and profit potential of the whole product portfolio.

For example, decreasing a product's price has the effect of making the product more competitive. Of course, in our experimental setting, subjects faced the uncertainty of not knowing how sensitive the market was to a change in price. Ultimately, there is a trade-off between capturing market share and increasing profitability. We have seen an extreme form of this trade-off when discussing the behaviour of subject S4 in the previous section.

An alternative aggressive strategy is to launch a new product that has a similar characteristic mix to a product of the rival firm. Again, assuming no change in the strategy of the competitor firm, a subject might capture 100% share of the market if the new product was priced competitively. Given our experimental setting this latter strategy may be preferable for the purposes of achieving high market share and maintaining profitability. This is because of the strategic significance of the different types of knowledge being processed for the two kinds of strategy.

The previous discussion suggests what might be a reasonable strategy for subjects to pursue in our experimental setting. Given the complexity and uncertainty surrounding key market relationships and the lack of opportunity for collusion with the competitor firm, an effective and robust strategy would be to locate new products close to the strategy points of the rival. Fear of competitor retaliation aside, this strategy reduces some of the uncertainty attached to making price changes for products with strategy points that are distanced from those of potential competitor products. Specifically, it focuses the subject's attention on more strategically significant variables ie. behaviour of the competitor firm.

The are two limitations of product differentiation strategies in our laboratory setting. First, subjects were unaware of the market's preferences for the two product characteristics C1 and C2. Furthermore, there was no opportunity for subjects to conduct formal market research to rectify this problem. Second, marketing differentiated products was difficult because of the problems in evaluating the impact of both characteristic mix and product price on the product's potential to generate a competitive advantage.

The protocols for S4 and S3 provide a good example of the difficulties facing subjects implementing a strategy based upon product differentiation in our experiment. This scenario is not uncommon in business practice, particularly for firms marketing products in the early stage of the product life cycle. In the UK, Sinclair Industries is often quoted as anecdotal evidence of the problems that face firms that market differentiated products in highly uncertain market conditions.

The discussion above regarding what is a reasonable strategy for our subjects clearly reflects the nature of our experimental design. For example, if we had simulated a different market scenario then our inferences about what would be a reasonable strategy may also have been different. However, the possibility of drawing general lessons about strategic behaviour from our study extend beyond conclusions about substantive problem solving strategies. In particular, the previous chapter emphasised the link between substantive problem solving strategies and control strategies in complex and uncertain task domains. This highlights an important aspect of behavioural research method ie. the consideration of issues of procedural rationality. In this chapter we assess the reasonableness of a subject's strategy not purely in terms of its substantive content (eg. competitor focus vs. differentiation) but also its procedural content (ie. the 'how' and 'why' of a particular strategy).

(a) Subject S1 - Unsuccessful

Figure 6.1 indicates that S1 was the least successful subject when assessed in terms of the performance variables incorporated in our experiment. The full protocol for S1 is contained in Appendix I to this chapter. It has been transcribed and coded to illustrate the application of the global operators we defined in Chapter 5. Figure 6.8 provides a summary of decision outcome data for S1. We shall now consider the nature of S1's pricing and product decisions against the background of our previous description of the generic strategies used by our subjects.

Figure 6.8 Subject S1: Decision Outcome Data

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 1:				
Subject-				
Product 2	hold	38%	20	20
Product 4	new	-	-	6
Competitor-				
Product 1	increase	31%	28	30
Product 3	increase	31%	25	28
Period 2:				
Subject-				
Product 2	withdrawn	-	20	-
Product 4	increase	61%	6	7
Product 5	new	-	-	35
Competitor-				
Product 1	hold	39%	30	30
Product 3	decrease	-	30	2
Product 6	new	-	-	13
Period 3:				
Subject-				
Product 4	decrease	-	7	6
Product 5	decrease	-	35	15
Product 7	new	-	-	18
Competitor-				
Product 1	hold	45%	30	30
Product 3	increase	55%	2	5
Product 6	decrease	-	13	1
Period 4:				
Subject-				
Product 4	decrease	-	6	5
Product 5	withdrawn	-	15	-
Product 7	decrease	-	18	13
Product 8	new	-	-	10
Product 9	new	-	-	10
Competitor-				
Product 1	hold	39%	30	30
Product 3	hold	18%	5	5
Product 6	increase	43%	1	5
Period 5:				
Subject-				
Product 4	hold	29%	4	4
Product 7	withdrawn	-	13	-
Product 8	hold	-	13	13
Product 9	increase	36%	10	12
Product 10	new	-	-	20
Competitor-				
Product 1	decrease	13%	30	9
Product 3	increase	22%	5	9
Product 6	withdrawn	-	5	-
Product 11	new	-	-	5
Period 6:				
Subject-				
Product 4	hold	37%	4	4
Product 8	withdrawn	-	13	-
Product 9	increase	-	12	13
Product 10	decrease	-	20	10
Competitor-				
Product 1	increase	47%	9	12
Product 3	increase	16%	9	10
Product 11	decrease	-	9	1
Period 7:				
Subject-				
Product 4	hold	12%	4	4
Product 9	withdrawn	-	13	-
Product 10	withdrawn	-	10	-
Product 12	new	-	-	11
Product 13	new	-	-	4
Competitor-				
Product 1	hold	40%	12	12
Product 3	hold	15%	10	10
Product 11	hold	33%	1	1

(i) Subject S1's Product Strategy

We have previously identified two types of generic product strategy: (i) Market Product Strategy (MPS) and (ii) Competitor Product Strategy (CPS). In this section we are concerned with assessing whether one strategy type is preferable in the context of our particular experimental setting. Previously we have argued that CPS type decision rules are more robust in terms of allowing subjects to cope with the complexity and uncertainty that characterised our experimental task. Specifically, our decision making exercise involved a considerable degree of uncertainty about market demand relationships whereas it was possible to observe (albeit with a lag) the behaviour of the competitor firm. MPS type rules are largely characterised by LHS conditions with market and demand type knowledge elements. In contrast, CPS strategy rules focus attention on the nature and performance of the rival's products. From the perspective of maintaining a competitive position a CPS strategy has a number of obvious advantages in our experimental setting.

All subjects found the task of trying to predict demand in our experiment difficult. Indeed some subjects (notably subjects S5 and S9) appeared to view market demand as almost random and failed to perceive the trend of the product life cycle. Given the complexity of the factors influencing market demand, the monitoring of successful products on the market was by far the most effective source of market research information. For example, the competitor firm's Product 1 was a particularly successful product given its characteristic mix and the pricing strategy of the competitor firm. Some subjects recognised this and those who adopted an aggressive CPS type of product strategy were successful in forcing the competitor to withdraw this product from the market in the later stages of the exercise.

S1's protocol transcript provides a clear indication that the subject mainly adopted a MPS type product strategy.

Moreover, given S1's emphasis on product strategy, he failed to exploit the role of pricing strategy in influencing the positioning of his product portfolio in strategy space. For example, a common feature amongst subjects who developed MPS product strategies was the emphasis given to the absolute level of the characteristics C1 and C2 when defining new products. This is an important deficiency of MPS type rules since it implied the use of knowledge elements that limited subjects in terms of considering their relative competitive position. The following extracts from S1's protocol illustrate the subject's reasoning in developing his product strategy:

Period 1 — Topic Line 7

I've also increased the mix of characteristics to a total of 7 to try and give it a competitive edge in terms of overall quality .. ...hopefully we'll get a higher margin ...

Period 2 — Topic Line 37-39

I'm going to launch an additional product ... it's Product 5 ... ... now in terms of characteristics I've decided to ... move towards ... a lower quality type of product ... ... I suppose in this sense I might be accused of being a market follower ... because the lowest quality product on the market is the competitor's product - Product 1

Period 3 — Topic Line 64-65

Right now - this new product ... I'm going to make it a middle of the road product and I'm going to give it ... characteristics which are attractive and even ... er ... I'm going to give it 4 C1 and 4 C2 ...

Period 4 — Topic Line 97-98

I'm going to withdraw the cheap product from the market ... because if I'm going to produce a good quality product I want to reduce the extent to which the firm is identified with a cheap product ...

Period 5 — Topic Line 129 - 131

My new product onto the market ... ... now I shall give this very much improved characteristics - 7 C1 and 8 C2 ... a real expensive product ... I wonder if I can get away with a high margin ... even if I don't sell many ...

These protocol extracts emphasise the concern of S1 with absolute values of C1 and C2; it is this information that appears to determine the subject's perception of product type ie. 'high value', 'low value' or 'mid-value'. S1 perceives the quality of a product as a strategically significant variable in determining his competitive strategy. For example, the extract for Period 4 shows the subject using the quality profile of his product portfolio as one possible explanation for his poor performance. This extract suggests that S1 was of the view that strategy points were largely determined by the characteristic mix of products.

One interpretation of S1's behaviour is that his control strategy of focusing upon the quality of products reflects his perception of the nature of the product market in our experiment. There may be a variety of explanations for this aspect of S1's behaviour. For example, it could reflect his interpretation of the information contained in our pre-experimental briefing notes. However, what is clear is that the subject was strongly committed to the assumption regarding the importance of product quality despite evidence to the contrary in his experimental results. In consequence, this focus on market phenomena results in the subject giving relatively little consideration to more overt competitive factors when developing his strategy. For example, in Periods 4 and 6 the subject summarises:

<u>Period 4</u> <u>Topic Line 114</u>

Marginally better ... we've still got the problem of two products that have characteristics which are not acceptable to the market ... Products 7 and 8 ... unsuccessful ...

<u>Period 6</u> <u>Topic Line 165</u>

Err ... obviously the better products are not acceptable to the market ...

However, in Periods 2, 3 and 5 the S1 also notes in his protocol:

<u>Period 2</u> <u>Topic Line 54</u>

and ... er ... has obviously captured my share of the market on that very ... on that basis of very strong price competition ...

<u>Period 3</u> <u>Topic Line 59</u>

Right, my price strategy was obviously disastrous ... er ... I must ...

<u>Period 5</u> <u>Topic Line 146</u>

the other three products - obviously the pricing policy very, very wrong ... so back to the drawing board ...

Despite the subject's apparent recognition of the importance of price in determining the acceptability of a product to the market, S1 still continues to focus upon product quality as one of the important strategic variables in the exercise. Indeed, there appeared to be no deliberate policy by the subject to assess the market's sensitivity to price and he readily withdrew products rather than attempt to aggressively market them through keen price competition. All this suggests the strong dominance of MPS and MBPS type decision rules in determining S1's behaviour.

One possible explanation of this feature of S1's behaviour is its link with the 'adjustment and anchoring' judgmental heuristic identified by Kahneman and Tversky (1974). This heuristic suggests behaviour is generated by initial judgements about the value of variables critical to the decision making task e.g. product quality. In the case of S1 it would appear that despite information to the contrary the subject did not revise his judgement as to the significance of price as a critical marketing variable. In the previous chapter we saw that S7's awareness of price elasticity in the later stages of the exercise was a significant factor in him developing an aggressive and successful pricing strategy.

Further evidence of S1's narrow perspective of the marketing mix can be found in connection with his product withdrawal strategy. S1's protocol illustrates the subject applying both PPWS and PTWS type decision rules. For example:

Period 4 — Topic Line 97-98

I'm going to withdraw the cheap product from the market product I want to reduce the extent to which the firm is identified with a cheap product ...

Period 5 — Topic Line 127-128

I'm going to take ... ... I'm going to take Product 7 off the market which has a c-ratio of unity ... it has not been successful for the last two periods as a middle of the road product ...

The first extract presents an example of a PTWS type of decision rule, while the extract for Period 5 appears to imply the application of both PTWS and PPWS type of rules. As with the competitor firm, the PPWS rule is triggered by the market share of the particular product having been zero for two periods. Once again, the important point to note is the subject's failure to appreciate that a product's strategy point is a function of price as well as characteristic mix.

In general, subject S1 appeared to focus his product strategy largely around the application of MPS type decision rules. For the successful application of this type of strategy it was necessary for the subject to have information about the relative importance of the two characteristics C1 and C2 in the market. This information was not available to subjects in our experiment and it would prove very difficult for a subject to identify consumer preference patterns for C1 and C2 during the early stages of the experimental run. In consequence, S1's strategy was generally exploratory - almost of a 'muddling through' type. This is reflected in the large number of new product launches by the subject and the relatively small number of price changes that he made.

A fundamental weakness of the MPS type of product strategy in this exercise was that it presented subjects with difficulty in formulating an effective pricing strategy. This was because new products were launched that did not have a strong competitive focus (ie. they were generally launched to exploit perceived market gaps). We can illustrate this weakness by considering S1's pricing policy.

(ii) Subject S1's Pricing Strategy

As with our earlier discussion regarding product strategies each generic price strategy has implications for the information processing behaviour of our subjects.

For example, a MBPS strategy is associated with protocol statements referring to product quality and the market's preferences for the two characteristics C1 and C2.

S1's protocol transcript does not reveal extensive insight into the subject's price strategy, particularly in the earlier periods of the experiment. Indeed, the subject's behaviour appears to have been largely dominated by his concern with product strategy throughout the exercise. This is evident by the subject providing a relatively 'thin' protocol with respect to the application of the DPS and PRICE operators. The subject's application of a MPS product strategy resulted in the focus upon product differentiation as the basis for his competitive strategy. This created difficulties for developing an effective pricing strategy. The following extracts from S1's protocol illustrate the rather shallow reasoning of the subject in formulating his pricing strategy as well as indicating its generic nature:

<u>Period 1</u> <u>Topic Line 10; 16-21</u>

... as the existing product seems to be giving a good return at the moment ... that is Product 2 ... ... Now the variable cost of the new product given its additional characteristics is £3.50 ... I'm going to accept a low margin on it to start with ... given that it is a launch and ... I want to - if possible - see how I can affect the market share of the competitor ... its variable costs are £3.50 ... and I'm going to price at £3.70 ... which is slightly above my Product 2 and slightly below the competitor product ... ...

<u>Period 3</u> <u>Topic Line 73-77</u>

Now Product 4 - which is the middle of the road product with a bias towards characteristic 2 - I've currently got priced at £3.75 ... its variable costs is £3.50 - so I'm going to ... keep the price at £3.75 ... no I'm not - I'm going to reduce it to £3.70 ... to distance it from my new product ... it was unsuccessful last period ...

<u>Period 5</u> <u>Topic Line 138-141</u>

Product 9 - I'm going to increase it to £5.60 ... since it did ok last period ... ... Now the new product ... variable cost £7.50 ... so we'll go for a very high margin on this ... see if the market will take it ...

<u>Period 6</u> <u>Topic Line 158-164</u>

Right, Product 4 - I'm going to keep its price as it was because it seemed acceptable to the market ... Product 9 ... ... I'm going to increase the price slightly ... ... Now this is a difficult one - this is my flagship product - the market didn't accept it ... perhaps the price is to high ... so we'll bring it down to ... its variable costs are £7.50 - we'll bring its price down to £8.25 ... ...

Other topic statements from S1's protocol also suggest that his price decisions were largely determined by heuristics based on CBPS and MBPS type pricing strategies. S1's extensive processing of cost information and inferences about the nature of market demand support this view. There is little evidence (except towards the end of the exercise) that the subject attempts to use pricing rules based on CMBPS type strategies. However, one difficulty in interpreting S1's pricing behaviour is the large number of 'hold' pricing decisions he makes. This limits dramatically our ability to observe the emergence of active price strategies from analysing the subject's protocol. Of course, this may have been a deliberate strategy by the subject in an attempt to increase the visibility of market signals that resulted from his product decisions.

Given the importance of relative competitive position in developing an effective business strategy [Porter (1980)], we can interpret CBPS and MBPS price strategies as having a number of deficiencies in our experimental setting. This can be seen from studying S1's protocol and his decision output data. However, the general lesson here is not so much in terms of the effectiveness of particular pricing strategies per se but their implications for the processing of important strategic information.

S1's neglect in monitoring the strategic behaviour of the competitor firm is in sharp contrast to the decision making behaviour of S7 described in the previous chapter. However, S1's behaviour also illustrates the link between product and pricing strategy in our experimental setting. S1's adoption of a MPS product strategy was a significant factor in his use of CBPS and MBPS pricing rules. For example:

<u>Period 5</u> <u>Topic Lines 131-133</u>

My new product on to the market ... now ... ... I shall give this very much improved characteristics - 7 C1 and 8 C2 ... a real expensive product ... I wonder if I can get away with a high margin ... even if I don't sell many ....

This and other extracts from the protocol suggest that S1 focused upon absolute cost and price levels rather than relative cost and price levels. This severely hindered S1's interpretation of his own strategic weaknesses vis a vis the competitor firm.

In summary, by distinguishing between different generic strategies we are able to highlight the strategic significance of various knowledge elements in our experimental setting. In this way we can assess the relative success of our subjects in developing particular strategies. For example, S1's focus upon product quality in an experimental scenario where signals about market demand were poor clearly inhibited his development of an effective strategy against the competitor firm. We can contrast this behaviour with that of subject S6 - arguably the most successful subject in our experimental runs.

(b) Subject S6 - Successful

Figure 6.1 highlights S6 as being one of the most successful subjects. A full transcription of the subject's protocol can be found in Appendix II to this chapter and, as with subject S1, we have coded the protocol using the previously defined global operators. Figure 6.9 summarises the decision output data for S6's experimental run.

Figure 6.9 Subject S6: Decision Outcome Data

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 1:				
Subject-				
Product 2	hold	38%	20	20
Product 4	new	-	-	19
Competitor-				
Product 1	increase	31%	28	30
Product 3	increase	31%	25	28
Period 2:				
Subject-				
Product 2	increase	35%	20	23
Product 4	increase	48%	19	22
Competitor-				
Product 1	decrease	17%	30	25
Product 3	decrease	-	28	10
Product 5	new	-	-	14

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE LAST	MARK-UP % THIS
Period 3:				
Subject-				
Product 2	decrease	-	23	5
Product 4	decrease	-	22	5
Competitor-				
Product 1	hold	26%	25	25
Product 3	hold	74%	10	10
Product 5	decrease	-	14	4
Period 4:				
Subject-				
Product 2	increase	40%	5	7
Product 4	hold	38%	5	5
Product 6	new	-	-	24
Competitor-				
Product 1	decrease	21%	25	8
Product 3	withdrawn	-	10	-
Product 5	withdrawn	-	4	-
Product 7	new	-	-	6
Period 5:				
Subject-				
Product 2	withdrawn	-	7	-
Product 4	increase	33%	5	6
Product 6	decrease	-	24	4
Competitor-				
Product 1	increase	67%	8	14
Product 7	decrease	-	8	5
Period 6:				
Subject-				
Product 4	increase	6%	6	8
Product 6	decrease	77%	4	2
Product 8	new	-	-	60
Product 9	new	-	-	1
Competitor-				
Product 1	decrease	-	14	5
Product 7	hold	17%	5	5
Period 7:				
Subject-				
Product 4	increase	9%	8	11
Product 6	increase	33%	2	4
Product 8	decrease	-	60	20
Product 9	increase	39%	1	8
Product 11	new	-	-	4
Competitor-				
Product 1	hold	19%	5	5
Product 7	withdrawn	-	5	-
Product 12	new	-	-	10

(i) Subject S6's Product Strategy

In contrast to S1, the pricing and product strategies of S6 were developed by giving consideration to the impact of both characteristic mix and price in influencing the market share and profitability of a product. This is reflected in the generic strategies employed by S6. S6's product strategy appears to be dominated by the application of CPS type decision rules.

In the previous section we noted that CPS decision rules were characterised by subjects focusing their attention on identifying competing products in terms of the relative mix of the two characteristics C1 and C2 and product price. The strategic significance of these rules is in terms of the recognition given to the link between market share and relative competitive position. While a subject's market share in our exercise was also influenced by the shifting pattern of market demand, this was a factor (as S1 demonstrated) that subjects found difficult to assess. The following extracts from S6's protocol highlight the application of CPS type decision rules during his experimental run:

Period 1 — Topic Line 3-5

Its characteristics are very different from ours having a 5 to 1 relationship between C2 and C1 - whereas ours has an equal relationship ... therefore, their product is quite different from ours ... we have nothing in that sector ... perhaps we did ought change our product portfolio ... yes ... ... we'll launch a new product in this period ....

Period 3 — Topic Line 111; 125

I've still not succeeded in dealing with that Product 1 £39816 ... ... so I think next period I need to launch a product that will deal with Product 1 in the competitive arena. So here goes ...

Period 4 — Topic Line 132-134

Now - going back to what I was saying - I want a product to deal with Product 1 ... my competitor's product ... I only want to launch one product ... though I could launch 2 I suppose ... er ... to tackle different segments of the market - no I'll keep to my original strategy.

The CPS basis for S6's product strategy is also reflected in the one product that he withdrew from the market in Period 5. The development of the subject's reasoning in the protocol illustrates this point:

Period 3 — Topic Line 124-125

My assumption at the beginning that Product 1 and Product 2 were in competition doesn't appear to be correct ... so I think in the next period I need to launch a product that will deal with Product 1 in the competitive arena. So here goes ...

Period 4 — Topic Line 142

I regard Product 2 as a 'miscellaneous' product ... it may respond ... I think if I go for £3.20 - I'll not be too far out ...

The subject concludes in Period 5:

Period 5 — Topic Line 180

Product 2 looks to be surplus to requirements - so lets make some changes here ...

While S6's product strategy is clearly focused upon launching products that directly compete with the competitor firm, there is evidence, particularly in early periods of the exercise, that he also considers the quality of products in terms of their absolute amounts of the characteristics C1 and C2. For example, in Period 1 when applying the RATIO operator for defining a new product, S6 notes :

Period 1 Topic Line 10-13

now his Product 3 that I'm trying to compete with is ... ... his has a characteristic C1 of 1 ... so I'll go for 1.1 and ... mine will be marginally better ... his is ... characteristic 2 is 5 - so I'll go for 5.1 - so mine is marginally better ... that's ok.

Indeed, S6's first two product launches suggest that he considered the attractiveness of new products to consumers by reference to the absolute level of the characteristics C1 and C2. This could also reflect the subject's attempts to increase profitability, since with high value products the absolute profit margin is greater relative to that of low value products. Furthermore, given that the costs of launching a new product were fixed for all quality types in our experiment, a reasonable strategy to adopt in launching a product was to introduce products with high values of C1 and C2. Not only would this give additional profitability (if the product were priced competitively) but also provide a subject with more flexibility for implementing an aggressive price strategy.

In Period 6, S6's product strategy changes when he applies both CPS and MPS type decision rules. In fact this appears to reflect upon the subject's attempt to anticipate the launch of a new product by the competitor firm. The subject's protocol provides a full account of his reasoning and as with S7 we can also note the emergence of anticipatory behaviour towards the end of the experimental run. The following extracts indicate that the subject's anticipation of competitor behaviour is very much based on what his strategy would be in the competitor's position:

Period 6 Topic Line 231-236

Well I think if I was him I would go for a new product to try and compete with my Product 4 ... or try to move to a new segment of the market ... Now I need a new product at the risk of cannibalising my own product range ... one that will compete directly with his Product 7 as it stood and also one that might go for a new range. Now if I look at ... the c-ratios ... er ... he has one at 0.25 - I have one at 0.3 ... and he has one at 2.8 - I have one at 4.6 ... His one at 3 is doing reasonably well ... so he is probably going to go for one in and about the 1.5 range ... so I think I need to launch one at about 1.5 ...

This new product launch was a departure from S6's previous strategy and the new product's lack of competitive focus resulted in difficulties for developing an effective pricing strategy.

The previous extracts from S6's protocol support our interpretation that his product strategy was of a CPS type. This is reflected in the knowledge elements that he processed, e.g. competitor product performance data, c-ratios and so on. There is little reference to market demand or to the notion of product quality. The protocol also reveals that the nature of S6's CPS rules appear to become more refined in later periods of the experiment. This is captured in the detailed reasoning provided by the subject when launching new products. For example, in Period 7 S6 summarises:

Period 7 Topic Line 278-281

Now lets pause a minute and think about this very carefully ... we've got to take out Product 1 ... Product 1 is akin to my Product 6 ... variable costs are £2.50 each ... if I went in at under his price ... What effect would that have ? If I scrapped my existing product 6 and launched a new product ... er ... that was in direct competition with ...

The result of S6's deliberation was the launch of a new product that imitated the competitor firm's Product 1. This was in contrast to the new products that had been launched previously where the subject had simply gone 'close' to the c-ratio mixes of the rival's products.

One interesting aspect of S6's protocol is the extensive use of quantitative data (this can be contrasted with S7). Many topic statements reflect the subject reporting on the numeric values for the various performance data. On first analysis of the subject's protocol this may appear to hide important information processing activities. However, a closer inspection of the protocol reveals that the subject does note trends and compares the values of variables, e.g. see topic statements 130-131; 154; and 311.

(ii) Subject S6's Pricing Strategy

S6's behaviour provides a good illustration of how a CPS product strategy appeared to have an uncertainty avoidance role by eliminating the need to analyse differences in characteristic mix between products. Clearly, this type of analysis would have been worthwhile if subjects had been able to identify market niches where there was high demand for a particular type of product. In these circumstances S6's pricing strategy had a strong competitive focus with a tendency towards the adoption of CMBPS type decision rules. Invariably, this resulted in the emergence of aggressive strategies as subject and competitor products were 'close' in terms of their position in strategy space.

S6's protocol reveals the subject adopting CMBPS type pricing rules. For example, the protocol provides evidence of the subject regularly making a thorough assessment of competitor behaviour with only limited reference to identifying trends in market demand. The following extracts from S6's protocol provide an insight into the nature of his CMBPS decision rules:

<u>Period 1</u> <u>Topic Line 24- 26</u>

variable cost of Product 4 is £3.10 ... oh ... didn't note the variable cost of Product 3 ... What price do I want here ? I'm competing against £3.75 ... so ... lets go in at £3.70 this time ...

<u>Period 3</u> <u>Topic Line 92-94</u>

Price of product this period ... well Product 2 really competes with Product 1 ... yes - Product 1 was £3.14 last period having come down from £3.25 ... I think I'll go in ... at ... £3.15 ... a massive reduction in price there ...

Period 4 Topic Line 143-146

Product 4 - £3.25 ... he's likely to have spotted ... mmm ... he'll respond ... I'd better hold that price the same at £3.25. Product 6 - I've attempted to deal with Product 1 which went in at £3.14 - so we'll put it in at £3.10 ...

The strategic advantage to be gained in exploiting the link between pricing and product strategy by applying both CPS and CMBPS decision rules is clearly reflected in the performance of both S6 and S7. This advantage can be assessed in terms of the strategic significance of the knowledge elements that comprise the LHS and RHS components of production rules for both types of strategy. Given the conditions of our experimental setting, an effective competitive strategy required the close monitoring of competitor firm behaviour. Cost information, and to a lesser extent market demand data, had limited strategic value for subjects attempting to monitor their competitive position in our simulated market environment.

The combined role of CPS and CMBPS rules in allowing subjects to reason about the role of product price and characteristic mix in determining strategy points is illustrated in S6's protocol:

Period 2 Topic Line 56-58

Product 3 ... now that's interesting ... my consumption technology ratio for Product 4 was below ... Product 3 but my price was 20p below and I wiped him out on that ... so it would appear that price ... on that basis the market appears to be more price sensitive ... that it was sensitive to the quality of the product ...

There are, however, examples of where CMBPS type price rules break down for the subject. Not surprisingly, this is where the subject develops a less aggressive CPS type of product strategy. The consequence was that one of S6's products did not have any close competing product and hence no reference strategy point for developing a competitive price strategy. For example, in Period 5 the subject notes:

Period 5 Topic Line 190-192

Product 7 ... that didn't do anything ... that was a further attempt to compete with Product 4 ... last time he reduced his price ... and his variable cost is £3.91 ... my price is below his variable cost so he has got to launch a new product - I think ... and get out of product 7. So I've got to be careful in terms of what I do in relation to Product 4 ...

This protocol extract shows the subject trying to 'link' Product 4 with Product 7 for the purpose of developing a competitive pricing strategy for his product. However, the difficulty of trying to successfully apply a CMBPS type of price strategy to Product 4 is recognised by the subject and in Period 6 he resorts to a CBPS decision rule for that product. This suggests that cost information may have had strategic significance for pricing in terms of preventing the emergence of loss-making pricing:

Period 6 Topic Line 248-249

Now Product 4 ... the last time for me ... didn't sell particularly well ... but I'm getting near to the variable costs ... I think I will have to stick roughly with the same price - I'll just add a little extra on

A similar problem faced S6 with respect to Product 8. This product was launched by the subject in an attempt to try to anticipate the product strategy of the competitor firm. It suggests S6 applying a hybrid rule employing CBPS and CMBPS type knowledge elements. Figure 6.10 highlights the problem since the margins that are charged by S6 for Product 8 were clearly excessive in relation to margins charged for other products on the market. The subject appears to be unaware of this problem and it illustrates the difficulty of trying to price products without close strategy points for competitor products. In these circumstances, the subject does not know where to locate the product's strategy point given the lack of knowledge about shifts in market demand and the likely price strategy of the competitor firm. The subject's reasoning in the protocol illustrates this point:

Period 6 Topic Line 251-253

that's the one that roughly competes with Product 1 - now he is likely to bring his price down on that ... I would - so I'll go in at £2.60 this time ... Variable cost of Product 8 ... this is the new product that I'm going for ... nothing below that ... so lets go in at a price of £2.00 for that.

Period 7 Topic Line 298-299

Product 8 - we didn't sell anything last time ... so we had better go for a reduced price here ...

The difficulty in applying MBPS type pricing rules appears to result in S6 using simple analogies to place a structure on his perception of the strategic problem at hand. For example, in Period 1 the subject notes:

Period 1 Topic Line 21-23

Now we are dealing with Product 2 first of all - now last period was - £3.60 ... now that it is coming to the end of its' life cycle by the looks of it since we had to drop the price and the volume is coming down ... don't want to loose too much money on that - so let's keep at £3.60 and ... see what the volume does ...

However, in general terms S6's CMBPS price strategy was effective for the purpose of pricing his product portfolio competitively to capture market share and maintain profits.

Our discussion of S1 and S6's behaviour has been developed around the generic pricing and product strategies that were described in the previous section. An important aim has been to interpret what was a reasonable competitive strategy for subjects to pursue in our experimental setting. The basis for our interpretation has been that the essence of any strategic game is the need to take account of, and respond to, the decisions of competitors. Our various generic strategies each emphasise a different focus of attention in terms of the information processed during decision making. To the extent that our subjects applied different generic strategies this had implications for how different subjects coped with the complexity and uncertainty of our experimental task. We have captured this aspect of subject behaviour in the protocol transcripts we collected and each verbal report highlights the strategic significance of the various knowledge elements that define the perceived problem space for a subject. To complete the discussion of this section we shall briefly consider some of the general lessons that emerge about assessing the nature of 'good' and 'bad' decision making strategies.

In generalising about the reasonableness of particular generic strategies described above, it is important to highlight some features of our simulated market environment. Specifically, we described in Chapter 4 how our experimental setting had a degree of similarity with the Prisoners' Dilemma situation of game theory. Subjects were faced with a considerable degree of strategic uncertainty regarding the behaviour of the rival and there was no explicit communication mechanism to facilitate the development of co-operative behaviour. Another important feature of our experimental setting was that subjects were not provided with detailed information about the nature of consumer preferences or trends in market demand. This provided an additional element of strategic uncertainty.

The different generic pricing and product strategies described above characterise two broad approaches to strategic decision making in our exercise. These we identify as 'competitor focus' and 'differentiation'. While there are examples of subjects who appear to have taken an 'in-the-middle' stance, the majority of our subjects can be categorised in terms of competitor focus or differentiation strategies. As broad strategy types it is possible to provide support for this classification from the business policy and corporate strategy literatures. For example, Porter's work on competitive strategy distinguishes between three types of generic strategy [see Porter (1980, p.35)]: (i) cost leadership; (ii) differentiation; and (iii) focus. Cost leadership was not appropriate as an approach to strategy in our experimental setting. There was no opportunity for subjects or the rival to gain a competitive advantage through cost leadership. Porter's differentiation approach is similar to our use of that term in describing the behaviour of our own subjects. In contrast, Porter's 'focus' concept is a demand based approach to strategy rather than a competitor based concept. However, our interpretation of the strategic significance of a focus based approach to strategy is similar to its use in Porter's work. Moreover, as we have seen in our decision making exercise, these broad approaches to strategy translate into more specific strategies for particular market scenarios. This is the basis upon which we have distinguished between the behaviour of our different subjects.

The appropriateness of particular strategy types for maintaining competitive position depends on competitive and market conditions [Porter (1980)]. The discussion above has suggested that a competitor focus basis for strategy was particularly effective in allowing subjects to cope with the complexity and uncertainty in our exercise. This interpretation clearly reflects our particular experimental conditions - notably, the uncertainty surrounding market demand and the inability to communicate with the competitor firm. However, the importance of competitor focus type strategies reflects more than the impact of uncertainty avoidance. Different strategies have implications for identifying the key relationships and information that characterise processing behaviour during decision making. In sum, it is the strategic significance of various types of knowledge that is an important basis for assessing the nature of good and bad decision making strategies.

The previous argument highlights the importance of studying decision processes for the purpose of assessing good and bad decisions. This procedurally rational perspective contrasts with one based on substantive rationality e.g. evaluating good and bad decisions against an optimal strategy. For example, we have linked CPS/CMBPS decision rules with a competitor focus type of strategy. Subjects who attempted to employ these types of strategies appeared in their protocols to demonstrate more clearly defined processes of reasoning and showed a greater awareness of the possible consequences of their decisions, eg. the anticipation of the competitor firm's moves. We can thus view our different generic decision strategies as having procedural content as well as substantive content. Different strategies imply the use of different search paths by subjects through their perceived problem space. For example, each generic strategy suggests that certain knowledge elements in the problem space will be rarely processed or may even be totally ignored. We can thus assess the quality of decision making in terms of what information is used and how it is processed.

Assessing strategies in terms of the strategic significance of the information that is processed reflects the concern of this research in looking at decision processes from the perspective of HIP theory. In practice, there are many other factors which determine the effectiveness of particular strategies for maintaining the relative competitive position of a firm, eg. the role of organisational factors. However, the importance of relevant strategic information as a basis for developing a business strategy has received wide recognition in the management literature [see for example the research on strategic management accounting systems e.g. Simmonds (1981)]. Of course, different generic strategies are likely to be successful in different market environments. In this sense, it is not possible a priori to generalise the arguments of this section about competitor focus vs. differentiation to other sets of market conditions.

6.4 CONCLUSION

In this chapter we have taken our examination of subject behaviour beyond the study of a single individual. Information processing psychology stresses the importance of the need to pay attention to differences in the behaviour of subjects. The collection of verbal protocols for all ten subjects who participated in our experiment has facilitated our ability to compare their individual behaviour in terms of a number of generic pricing and product strategies.

Each of our generic strategies has implications for subject behaviour in terms of the strategic significance of the various knowledge elements that comprise the LHS and RHS components of production rules. The detailed specification of these production rules involves defining the global operators described in Chapter 5. It now remains to demonstrate this process of building a PS model for an individual subject. For this purpose we return to modelling the behaviour of subject S7 in the next chapter. The behavioural content of the production rules we specify for defining S7's global operators will reflect the discussion of this chapter regarding the different generic strategies we identified as being used by our subjects.

This chapter has also evaluated the reasonableness of particular price and product strategies in our experimental setting. For this purpose we contrasted the behaviour of two subjects - S1 and S6. The relative success of a 'competitor focus' type strategy reflects the strategic significance of the information processed by subjects applying CPS/CMBPS decision rules. In contrast, a strategy based on 'differentiation' was generally more difficult to implement successfully in our experimental setting and was particularly affected by uncertainty surrounding market demand relationships. In general, subjects who attempted to apply decision rules from differentiation based strategies were less successful in terms of maintaining their competitive position relative to the competitor firm.

CHAPTER 6 - APPENDIX I

This Appendix presents the fully transcribed protocol for subject S1. The protocol has been coded to reflect the subject's application of the global operators described in Chapter 5.

SUBJECT 1: **TRANSCRIPT OF PROTOCOL**

Topic and Operator Representation

Operator

Period 1

DS	1:	Right, I think my strategy overall this period will be exploratory ... though I need to respond to the competitor's successful product launch ...
DS	2:	mmm ... hopefully I can increase my market share back to its previous level ... ...
DPPS	3:	I have decided to introduce one new product on to the market - not two -
SV	4:	because being conservative - I want to find out what competitor reaction is to a particular product and its characteristics ... as well as what the market reaction of the new characteristics will be relative to the existing characteristics of Product 2 - which is my existing product
RATIO	5:	... ... I have decided that my new product ... Product 4 will have characteristics which are marginally different from my existing product ... er ...
DS	6:	but still maintain a substantial distance in characteristics from rival products ... although I am going to bring it closer to the competitor's Product 3 ... ... I don't want to be too aggressive at this stage ...
DPPS	7:	I've also increased the mix of characteristics to a total of 7 to try and give it a competitive edge in terms of overall quality ... ... hopefully we'll get a higher margin ...

RATIO	8:	a c-ratio ... of ... 2 units of C1 and ... I think 5 units of C2 ...
DPPS	9:	... I do not intend to withdraw any products from the market
SV	10:	... as the existing product seems to be giving a good return at the moment ... that is Product 2 ... ...
SA	11:	Right - my product characteristics in terms of mix ... Product 2 - 3 C1 and 3 C2 ...
SA	12:	Product 4 ... 2 C1 and 5 C2 ... ...
SA	13:	A quick review of market pricing at the moment ... in the last period that is ...
DPS	14:	I ... what I intend to do is to ... price Product 4 between my own Product 2 and competitor Product 3 - given the mix of characteristics that I've selected ...
DPS	15:	and ... er ... keeping Product 3 at its existing price of £3.60 ... sorry Product 2
SA	16:	... ... Now the variable cost of the new product given its additional characteristics is £3.50 ...
DPS	17:	I'm going to accept a low margin on it to start with ...
SV	18:	given that it is a launch and ... I want to - if possible - see how I can affect the market share of the competitor ...
SA	19:	... its variable costs are £3.50 ...
PRICE	20:	so I'm going to price at £3.70 -
SV	21:	... which is slightly above my Product 2 and slightly below the competitor product ... ...

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PA	23:	Now - somewhere - I must have hit the wrong key ! ... er ... because I've got zero unit sales on my existing Product 2 ... and zero sales revenue
PA	24:	- unless that is a consequence of launching the new product ... ...
PA	25:	I've ended up with a decline in the ROCE ...

PA	26:	but an increase in market share ...
PA	27:	and a fall in share price from £1.60 to £1.46 ... ...
PA	28:	Aaagh ... ... right - now the competitor ... I've wiped his Product 3 from the market entirely - just as it wiped my Product 2 from the market
PA	29:	... but he has boosted his sales of Product 1 ...
SA	30:	... so my interpretation of that would be that customers with a ... mmm mmm ... the two products with the nearest mix of characteristics have disappeared from the market as a consequence of launching Product 4 ...
SA	31:	and the rival products in terms of the greatest difference of characteristics has attracted more customers ... ...
PA	32:	The competitor share price has increased ...
PA	33:	and his ... ROCE has also increased ...
PA	34:	so it has not been too bad a trading period for me ... I have increased market share ...
		<u>Period 2</u>
DPPS	35:	I've decided to withdraw Product 2 from the market ... er ... since it was unsuccessful last period ...
DPPS	36:	and launch a new product - Product 5 ... ...
SA	37:	... I'm briefly reviewing the previous market period ... ...
DPPS	39:	I'm going to launch an additional product ... it's Product 5 ... ...
DPPS	40:	now in terms of characteristics I've decided to ... move towards ... a lower quality type of product ...
SV	41:	... I suppose in this sense I might be accused of being a market follower ... because the lowest quality product on the market is the competitor's product - Product 1

PPW	42:	So I'm withdrawing Product 2 from the market ... ...
DPS	43:	Right - the existing product - Product 4 ... I've decided to increase its price slightly in view of the market reaction to it last period ...
PRICE	44:	... so I'm increasing the price from £3.60 to £3.75 ... ...
SA	45:	Now Product 5 is my cheap product and the variable costs are only £2.00 ...
DS	46:	and I want it to take a big chunk of the market away from the rival's cheaper product - to increase my market share ...
DS	47:	- so I'm going to substantially underprice him -
PRICE	48:	I'm going to price it at £2.70 ... ...

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PA	49:	Infact - this was obviously a terrible strategy ... because given the product characteristics I opted for and the pricing policy I opted for ... I don't appear to have sold anything at all ...
PA	50:	and I have negative profits ... ie. the fixed costs ... my total loss is quite considerable ...
PA	51:	Negative ROCE ...
PA	52:	share price collapsed to 90p - so obviously - I'm in trouble ... ...
PA	53:	My rival has introduced a new product ... he matched my improved characteristics from the previous time period - infact he over matched them ... er ...
PA	54:	but as a consequence of having to charge a high price he has sold nothing ...
PA	55:	but given the more modest characteristic profiles of Products 1 and 3 ... he has reduced his price below mine ...
PA	56:	and ... er ... has obviously captured my share of the market on that very ... on that basis of very strong price competition ...

PA	57:	And - as a consequence he has got a 100% share of the market ...
PA	58:	er ... 26% ROCE and
PA	59:	... er ... his share price has almost doubled to £2.31.
PA	60:	So in that time period at least - he matched my every move in terms of pricing according to characteristics and ... er ... has got me in a lot of trouble ... ...

Period 3

PA	61:	Right ... my price strategy was obviously disastrous ... er ... I must ...
DS	62:	I need to capture market share back from my competitor ...
PA	63:	and I probably adopted a too cheaper product in terms of characteristics mix for the new product
DPS	64:	and it seems to me ... that what I've got to do is either withdraw it from the markst er ... or ... price it even lower ... I think I'll have a go at pricing it even lower
DPPS	65:	and introduce a product similar to Product 2 back onto the market ... ...
DPPS	66:	Right now - this new product ... I'm going to make it a middle of the road product and
RATIO	67:	I'm going to give it ... characteristics which are attractive and even .. er ... I'm going to give it 4 C1 and 4 C2 ...
SV	68:	... this is matching the up-market version - not quite matching it - of the rival product
SA	69:	which didn't sell anything in the last time period because it was priced too high - so I must watch that ...
DPPS	70:	... I'm not going to withdraw a product

SV	71:	- I still think there might be a market for a product at the cheap end of the market - it's just that I priced it wrong.
SA	72:	Right - my product portfolio at the moment then is ... I've got 3 products on the market ... er ... a relatively cheap in terms of characteristics and price
SA	73:	... a middle of the road product with a bias in terms of charcteristics in terms of C2 ...
SA	74:	and a slightly above middle of the road product with an eveness in terms of the charcteristic mix ... ...
SA	75:	Now Product 4 - which is the middle of the road product with a bias towards characteristic 2
SA	76:	- I've currently got priced at £3.75 ...
SA	77:	its variable cost is £3.50
DPS	78:	- so I'm going to ... keep the price at £3.75 ... no I'm not - I'm going to reduce it to £3.70 ...
SV	79:	and distance it from my new product ... ... and it was unsuccessful last period ...
SA	80:	My cheaper product - variable cost £2.00 -
PA	81:	I probably over priced last period - went for too high a margin on it ... and sold nothing ...
DPS	82:	so I'm going to reduce the margin quite dramatically down to £2.30 ... that will give me a 30p margin ... ...
DPS	83:	My new product ... this is the flagship of the portfolio and I'm going to price it ... accordingly ... I'm going to go for a higher margin to see if I can't cream that end of the market a bit ...
PRICE	84:	we'll put it on the market at £4.70 ...

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PA	85:	Obviously I'd be totally unsuccessful in business ... because once again I've sold nothing ...

PA	86:	Right ... again a further deterioation in share price ... ...
PA	87:	... and my competitor looks to be doing very nicely ... although his products ... ... are pretty closely matched to mine ... I'll just look at that ... ...
PA	88:	... ... his share price has once again risen quite sharply ...
PA	89:	and all he has done is adjust his pricing policy ... each time ... ...

<u>Period 4</u>

DPPS	90:	Right, I think I'm going to withdraw a product and restructure my product portfolio ...
PPW	91:	So, I'm now going to withdraw my cheaper product from the market ...
SV	92:	I don't think there is a market for it ...
DS	93:	my main aim here has to be to increase market share ... and I ... ...
DPPS	94:	... ... I think this time we'll introduce two new products
DPPS	95:	... go for real top end of the market type of products ...
RATIO	96:	So Product 8 - I'm going to give it a total level of characteristics of 10 and I'm going to break them down as ... 5 ... no - 4 C1 and 6 C2 ... ...
RATIO	97:	Product 9 - I'm going to reverse that order ... 6 C1 ... and ... ... 4 C2 ... ...
SV	98:	in an attempt to see if the market has any preference for the two characteristics ... ...
DPPS	99:	I'm going to withdraw the cheap product from the market ...
SV	100:	because if I'm going to produce a good quality product I want to reduce the extent to which the firm is identified with a cheap product ...

PPW 101: ... so ... I'm going to withdraw Product 5

SV 102: - which is the product with the least qualities ... ... in terms of the quantities of C1 and C2 ...

DS 103: Right now ... ... now ... in terms of pricing I'm ... going to bring my better products very close to the rival's price ...

DPS 104: ... and I'm going to keep my middle of the road product ... ... I might reduce its price ... slightly - bring it close to the rival ...

SA 105: Right, the middle of the road product ... a variable cost of £3.50

SA 106: and the price last period was £3.70 ...

PRICE 107: so we'll go for a price of £3.65 ... ...

SA 108: ... Product 7 ... a slightly better product - variable cost £4.00 ... ...

SA 109: price last period £4.70

DPS 110: - I think we'll go for £4.50 to distance itself from the top end of the range ... particularly since it was unsuccessful last period ...

DPS 111: Right we've now got the good product - or at least one of them ... Product 8 ... we'll try and price it competitively ...

PRICE 112: I'm going to go for £5.50 ...

DPS 113: Product 8 ... ... its balance of charcateristics are different from the rival ... although in total they are the same ... so we'll need to price it the same ...

SV 114: until we see how the market responds to the products ...

PRICE 115: Again - I'm going to go £5.50 with Product 9 ... ...

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PA 116: Marginally better ... we've still got the problem of two products that have characteristics which are not acceptable to the market ... Products 7 and 8 ... unsuccessful ...

PA 117: ... but performance overall has improved ... ...

PA 118: Share price has increased to £1.10 ...

PA 119: ROCE for this particular period increased to 13.5% ...

PA 120: and I've got a share of market revenue for this period of 65% ...

PA 121: which suggests that I'm on the right lines in bringing in a better product - at least one of them ... ...

PA 122: Now my strategy that time killed the top of the range product of the competitor dead ...

DS 123: what I'm going to try to do now is ... ... take some of his ... middle of the range products away by matching his characteristics ... ...

PA 124: His share price has reduced ...

PA 125: and his ROCE for this period is more or less the same as my own ... ...

PA 126: ... But - overall, for the number of time periods he is doing substantially better ... ...

<u>Period 5</u>

DPPS 127: I'm going to change my portfolio ... er ... yes ... I'm going to launch one new product ... ...

DPPS 128: and in launching the new product ... er ... I'm going to take one off the market ... ...

PPW 129: I'm going to take ... ... I'm going to take Product 7 off the market which has a c-ratio of unity ...

SV 130: it has not been successful for the last two periods as a middle of the road product ...

DPPS 131: My new product on to the market ... now ... ... I shall give this very much improved characteristics

RATIO	132:	- 7 C1 and 8 C2 ...
DPS	133:	a real expensive product ... I wonder if I can get away with a high margin ... even if I don't sell many ...
DPPS	134:	Do I intend to withdraw any products ? - yes
PPW	135:	- I intend to withdraw product 7 which has a C-ratio of 1 ... ...
DPS	136:	Right - Product 4 - I'm going to hold its price at £3.65 ...
PA	137:	Product 8 ... it didn't take off too well ...
DPS	138:	however, I don't want to differentiate it too much from Product 9 ...
PRICE	139:	so I'm going to keep its price at £5.50 ...
DPS	140:	Product 9 - I'm going to increase its to £5.60
SV	141:	... since it did ok last period.
SA	142:	... Now - the new product ... variable cost £7.50 ...
DPS	143:	so we'll go for a very high margin on this ... see if the market will take it ...
DS	144:	it might increase our profitability ...
PRICE	145:	I'm going to charge a price of £9.00 ... ...

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PA	146:	Product 4 is ok ... but ...
PA	147:	not very good overall ... unfortunately ... not a good strategy ... ...
PA	148:	the other 3 products - obviously the pricing policy very, very wrong ... so back to the drawing board ...
PA	149:	The share price collapsed - 76p ... ...
PA	150:	The rival improved again ... increase in ROCE
PA	151:	and increase in share price ... yes

PA	152:	... ... Introduced a new product ... matching mine ... ...
PA	153:	and ... undercutting me ... matched my chracteristics exactly and undercut me ... so it took all my market for that particular product away ...
PA	154:	... and the product that I took sales away from him - he has now withdrawn from the market ... ... Right ... ...
		<u>Period 6</u>
DPPS	155:	I'm not going to introduce any new products ...
SV	156:	since we have a large portfolio at this stage ... so
DPPS	157:	... but I'm going to withdraw a product ...
PPW	158:	Now ... ... I'm going to withdraw Product ... ... I'm going to withdraw Product 8
SV	159:	- because it is too close to the rival's Product 11 - same ratio as the rival's - same direction as the rival's ... virtually the same price ... ...
DPS	160:	Right Product 4 - I'm going to keep its price as it was
SV	161:	because it seemed acceptable to the market ...
DPS	162:	Product 9 ... ... I'm going to increase the price slightly ...
SA	163:	... Now this is a difficult one - this is my flagship product - the market didn't accept it ... perhaps the price is to high
DPS	164:	... so we'll bring it down to
SA	165:	... its variable costs are £7.50
PRICE	166:	- we'll bring its price down to £8.25

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PA	167:	Err ... obviously the better products aren't acceptable to the market ...

DPPS	168:	they'll have to be withdrawn - that's Products 9 and 10 ... ...
PA	169:	Share price collapsed further ...
PA	170:	ROCE negative ... ...
PA	171:	average ROCE for the six trading periods is 2.13% ... ...
PA	172:	average profit/loss for the periods ... just under £1300 ... ...
PA	173:	Whereas - the competitor by sticking with very middle of the road charcteristics has done very nicely ...
PA	174:	... and he reduced his price quite considerably on the product very close to mine
DS	175:	... so once again I lost out there ... so we are going to have do something quite drastic in terms of price competition ... ...
PA	176:	Share price has gone up dramatically - £3.10
PA	177:	... ... his ROCE the average for the six periods is 19.84% ... ...
		<u>Period 7</u>
DPPS	178:	So period 7 ... I'm going to withdraw and introduce new products ... ...
DPPS	179:	... I'm introducing two new products
DS	180:	- what I'm going to try to do is to keep the characteristics reasonably close to the rival
DS	181:	- but undercut his price ... ...
DPPS	182:	I'm going to withdraw my most expensive product ... and ... my middle range product ... ...
RATIO	183:	Mmm ... my characteristic mix for Product 12 will be ... 6 units of C1 and 3 units of C2 ...
RATIO	184:	and ... for Product 13 ... 3 units of C1 and 7 units of C2 ...
PPW	185:	I'll withdraw both Products 9 and 10 ...

SV	186:	since neither were successful last period ...
SA	187:	So my product porfolio is now ... products with characteristics ... ... with ratios C1 to C2 ... ... 0.4 ... ... 2 ... ... and 0.42 ... but although I've got one with 0.4 and one with 0.42 ... the one with 0.42 has got overall more charcteristics ... that's 2 units of C1 and 5 C2 and 3 C1 and 7 C2 ... ...
DPS	188:	Right - Product 4 - which is my staple product ... I'm going to keep its price ...
SV	189:	because I seem to be earning quite a reasonable return on that product - I'm going to keep it as it is
SA	190:	... variable costs £3.50
PRICE	191:	and price £3.65 ... I see no reason to change it ... ... staple product ...
SA	192:	... My new product - variable costs £4.50 ... ...
PRICE	193:	so ... we're going to make it a price of £5.00 ...
SV	194:	that should just undercut the rival's similar product ... ... by about 10p I suspect ... ...
SA	195:	My next product er ... Product 13 ... a new product ... has variable costs of £5.00 -
PRICE	196:	we'll make it £5.20 for its price ... ...

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PA	197:	Oh dear ... ... mmm ... not very good again ... the two new products were not accepted at all by the market ... ...
PA	198:	Collapse in share price to 50p ... ...
PA	199:	average ROCE for the seven periods is now negative !
PA	200:	Rival ... ... doing very well ... ... share price has risen even further ... ...

END OF TRANSCRIPT

CHAPTER 6 - APPENDIX II

This Appendix contains the fully transcribed protocol for subject S6. The protocol has been coded to reflect the application of the global operators described in Chapter 5.

SUBJECT 6: **TRANSCRIPT OF PROTOCOL**

Topic and Operator Represenatation

Operator

Period 1

PA	1:	... ... Now our competitor has launched a new product and his product did very well for him in the previous period ...
SA	2:	and we can see that it has ratio of 5.
SA	3:	Its characteristics are very different from ours having a 5 to 1 relationship between C2 and C1 - whereas ours has an equal relationship
SA	4:	... therefore, their product is quite different from ours ... we have nothing in that sector ...
DS	5:	perhaps we did ought to change our product protfolio ... yes ... ... we'll launch a new product in this period ...
DPPS	6:	last period ... yes ... same as the case notes ... ok ... entry barriers ... Now if I launch two products ...
SV	7:	that would make me proactive - rather than reactive at the moment and I don't know enough about what he is going to do ... can't predict that at this stage ...
DPPS	8:	so how many products do we intend to launch ? - one - Product 4 ...
RATIO	9:	consumer preferences for any ... ... consumption technology ... what is the characteristic mix going to be? ... ...
SA	10:	now his Product 3 that I'm trying to compete with is ... ... his has a characteristic C1 of 1 ...

RATIO	11:	so I'll go for 1.1 and ... mine wil be marginally better ...
SA	12:	his is ... characteristic 2 is 5 -
RATIO	13:	so I'll go for 5.1 - so mine is marginally better ... that's ok.
DS	14:	Do I intend to withdraw any products ? ... No ...
SV	15:	because he still has got Product 1 ... and my Product 2 ... seemed to compete well with that in the previous periods - so, no I don't intend to do that.
SA	16:	So we now have two products on the market this period - so I'd better make a note of that ... Product 2 and Product 4 ... 3 and 3 ... and ... 1.1 and 5.1 ...
SA	17:	Pricing strategy - would I like to review market price data for the last period ? - yes I would ... now then Product 2 has a C-ratio of 1 ...
SA	18:	... and his price of his new product was £3.75 -
DS	19:	but mine has more characteristics ... but do I need to convince customers ... it is new? ...
DPS	20:	I need to convince customers to buy ... as his was £3.75 - I ought ... so I ought to go in at about £3.75 or just under.
SA	21:	Now we are dealing with Product 2 first of all - now Product 2 last period was £3.60 ...
SA	22:	now that it is coming to the end of its life cycle by the looks of it since we had to drop the price and the volume is coming down ...
DPS	23:	don't want to lose too much money on that - so let's keep at £3.60 and ... see what the volume does ...
SA	24:	Variable cost of product 4 is £3.10 ... oh ... didn't note the variable cost of Product 3 ...
DPS	25:	what price do I want here? I'm competing against £3.75 ... so ...

PRICE 26: let's go in at £3.70 this time ...

27: As a result your ... ... we now a wait the results ... let's calculate the ratios while the machine calculates ... Product 4 ....

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PA 28: Right ... as a result ... Product 2 ... 3 and 3 - £3.60 ... the revenue £21080 ...

PA 29: and the price £3.70 - £28784 ...

PA 30: Unit sales .... and operating profit ... Product 2 £2763 .... £3917 ...

PA 31: Total sales revenue for the period £49864 ... yes ... I could arrive at the figure if I wanted to ... ...

PA 32: The total profit and loss is £10109 ... yes.

PA 33: Market share - oh - 83.5% - he isn't going to like that ...

PA 34: ROCE - 16.72% ...

PA 35: cash ... £45464 ...

PA 36: share price was £2.18 ...

PA 37: Now our competitor results ... Product 1 ... ratio of 4 to 1 ... price of £3.25 ... sales revenue £9835 ...

PA 38: No sales revenue for Product 3 - so I've wiped that out ...

DS 39: but will he retaliate? ... probably he might drop that one and ... a launch a new one or will he go for ...

PA 40: total sales revenue £9835 ...

PA 41: total profit £3307 ...

PA 42: Market share should be the balance - 16.4% ...

PA 43: ROCE is 6.61% ...

PA 44: competitor's cash balance ... £35036

PA 45: share price £1.40.

	46:	Competitor ... ... right ... I've now completed the current decision period ...
		<u>Period 2</u>
SA	47:	Now the competitor - I destroyed his Product 3 last time ...
DS	48:	maybe he his likely to go for - perhaps - launching a brand new product again which ... ... or he could respond by ... withdrawing Product 3 and going above me in terms of C2 ...
DPPS	49:	Now do I want to launch a new product ?
SA	50:	and what effect might that have on my ... I won 83% of the market last time ...
DPPS	51:	difficult decision ... difficult ... I know he is likely to come back at me ... No I think I'm happy enough ... I've got a reasonable product portfolio - so I'm not going to make any changes this time ...
SA	52:	Would you like to review market prices for the last period ... yes I would, to check ... ... Now here we go ... variable cost of Product 2 in period was £3.00 -
SA	53:	the variable cost of Product 1 was £2.50 ... and ...
SA	54:	the variable cost of Product 3 was £3.00.
SA	55:	I need the technology ratios - consumption technology for Product 1 - 0.25 ...
SA	56:	Product 3 ... now that's interesting ... my consumption technology ratio for Product 4 was below ... Product 3
SA	57:	but my price was 20p below and I wiped him out on that ...
SA	58:	so it would appear that price ... on that basis the market appears to be more price sensitive ... than it was sensitive to the quality of the product ...

SA	59:	and similarly ... mmm ... that doesn't appear to hold true though for Products 1 and 2 which appear to be the only other competitor products - although there not really in the same market sector ...
DS	60:	Price in this period ... well we ought to try and get something back in terms of ...
PRICE	61:	I'll see this product out ... ... let's go to £3.70 ... see what ...
DS	62:	The price of the product was £3.70 - he went for £3.90 - he could reduce his price ...
PRICE	63:	I'll go for £3.80 - we'll test for customer loyalty ... ...

****

PA	64:	Oh dear ! - company results for period 2 ... Product 2 - Product 4 ... unit sales - zero ...
PA	65:	operating profit minus £750 ...
PA	66:	total profit for the period £2137.
PA	67:	Revenue for the period - zero.
PA	68:	Company market share - nothing ...
PA	69:	ROCE 3.41% ...
PA	70:	cash balance £47601 ...
PA	71:	share price ...
PA	72:	Performance data to date ... my share price has gone way down ... need to do something about that ....
PA	73:	Average profit ...
PA	74:	Average return ...
PA	75:	Competitor's results ... he really dropped his prices there then ... to respond to mine ... so he wants to have a price war
PA	76:	and ... he's trying a new product ... Product 5 ...
PA	77:	sales revenue for Product 1 ...

PA	78:	sales revenue for Product ...
PA	79:	Total sales revenue for the period £169575 ...
PA	80:	profit/loss £21004 ...
PA	81:	Market share 100% ... ...
PA	82:	ROCE ... 7% ...
PA	83:	cash ...
PA	84:	share price ...
PA	85:	... he's launched a new product.
PA	86:	Summary of his performance ... his share price is increasing ...

<u>Period 3</u>

DPPS	87:	Right period 3 ... Product 5 - do we need to respond to that ? No - I don't think we do ... ... need to change our product portfolio ... No I don't think it's necessary this period ...
SA	88:	We'll review market price data for the last period ... Now we can check what happened ... Product 1 - had a variable cost of £2.50 ...
SA	89:	Product 3 is £3.00 ... ratio is 0.25 -
SA	90:	... and Product 4 was ... prices ...
SA	91:	total market size ... is growing ... ...
DPS	92:	Price of product this period ... well Product 2 really competes with Product 1 ...
SA	93:	yes - Product 1 was £3.14 last period having come down from £3.25 ...
DPS	94:	I think I'll go in ... at ... £3.15 ... a massive reduction in price there ...
SA	95:	... went in at £3.80 - competing with a product that went in at £3.30 last time ...
PRICE	96:	let's go in at £3.25.

DS	97:	Whatever happens we have to get some sales ... Waiting for the results of my decsions ...

****

PA	98:	I'm still sticking with Products 2 and 4 - oh - I've got some sales this time ... great ...
PA	99:	Product 2 and Product 4 ... operating profit ...
PA	100:	unit sales - which of course last time were nil - I've now got 24206 - Product 2
PA	101:	and 22165 for Product 4.
PA	102:	Revenues £76000 ... £72000 ... er ...
PA	103:	operating profits ... mmm ... there quite low ...
PA	104:	Total revenue for the period £148284 ...
PA	105:	profit/loss £9263 ...
PA	106:	Now we have got market share back again ... 78.3% ...
PA	107:	ROCE back up to 12.89% ...
PA	108:	cash continuing to grow - the cash balance - so that's reasonably healthy.
PA	109:	The share price is up to £1.82 but it wants to be ... ...
PA	110:	Competitor firm results period 3 ... profit ...
PA	111:	I've still not succeded in dealing with that Product 1 ... ... Product 1 at a price of £3.14 gives a revenue of £39816 ...
PA	112:	so how much volume is that ... about 12000 units ...
PA	113:	Product 3 and 5 ... haven't done very well at all ...
PA	114:	Yes - market share is only 21.17 % ...
PA	115:	ROCE 12.08% ...
PA	116:	cash ...

PA	117:	share price down ...
PA	118:	No changes in his product strategy - though I expect some change next period ...
PA	119:	Mmm ... the competitor's performance to date ... almost an exact mirror image of ours ... can I continue to be succesful this next period ?
DS	120:	Right just let's take stock of the situation at the moment as I see it then after three periods ... it seems that it is likely for the competitor to retaliate on price
DPPS	121:	and I have set up my Product 4 to compete with his Product 3 and 5
SA	122:	and although he didn't launch - sorry - scrap a product ... he launched a new product in period 2
PA	123:	which so far in either period 2 or 3 has sold nothing ...
SA	124:	My assumption at the beginning that Product 1 and Product 2 were in competition doesn't appear to be correct ...
DPPS	125:	so I think in the next period I need to launch a product that will deal with Product 1 in the competitive arena. So here goes ....

Period 4

DPPS	126:	Yes ... I'll change my firm's product portfolio this period ... yes, I'm going to launch a new product.
SA	127:	Yes - I want to review market data from last period because I want to check on variable costs ... and the ratios.
SA	128:	Let's deal with the ratios first of all - Product 2 - 1 ... Product 4 - 4.63 ... Product 1 - 0.25 - that's the product I've got to compete with. Product 3 was 5 and Product 5 was 2.81.
SA	129:	Variable costs - Product 2 - was £3.00 ... Product 4 was £3.10 ... Product 1 - £2.50; Product 3 - £3.00 and Product 5 - £3.91.

SA	130:	The total market turnover increased again to ... £1810000 ...
SA	131:	I'm not sure whether there is a trend in that ... ... mmm ... yes ... an increase ... is this something beyond our influence or is it the result of our decisions ... in other words is there unlimited potential - more or less?
DS	132:	Now - going back to what I was saying - I want a product to deal with Product 1 ... my competitor's product ... I only want to launch one product ...
DPPS	133:	though I could launch 2 I suppose ... er ... to tackle different segments of the market -
DPPS	134:	no - I'll keep to my original strategy.
DPPS	135:	This will be Product 6 - which I'm going to use to deal with Product 1 ...
SA	136:	Characteristic 1 ... er ... the competitor's product has a C1 of 4 ...
RATIO	137:	I think I'll go slightly below that ... mmm ... 3.75.
SA	138:	Characteristic 2 - the competitor had 1
RATIO	139:	- I want to go slightly above that at ... 1.25 ...
DPPS	140:	I won't withdraw any products this period ...
SA	141:	I'll now consider my pricing strategy ... Right now - let's review the data - the same as I've already seen a while ago ... Product 2 ... well, last period I charged £3.15 ...
PRICE	142:	I regard Product 2 as a 'miscellaneous' product ... it may respond ... I think if I go for £3.20 - I'll not be too far out ...
SA	143:	Product 4 - £3.25 ... he's likely to have spotted ... mmm ... he'll respond ...
DPS	144:	I'd better hold that price the same at £3.25.

DPS 145: Product 6 - I've attempted to deal with Product 1 which went in at £3.14 -

PRICE 146: so we'll put it in at £3.10

SA 147: - so variable cost is only £2.50 ...

now ... let's see how I've done ...

****

PA 148: I've got Products 2,4 and 6 - profits or am I being too optimistic ? ... ... oh dear ... I've sold nothing ... ... in terms of Product 2 and 6 ...

PA 149: So he's obviously responded in some way ... my guess would be is that he has cut his prices - although he may well have launched new products - we'll have to have a look at that.

SA 150: So we've got product 2 - 3 and 3 ... Product 4 ... 1.1 and 5.1 ... Product 6 - 3.8 and 1.3 ...

SA 151: price ... £3.20 - £3.25 - £3.10 ...

PA 152: interesting that, the most expensive product and the only one that has sold any ... ...

PA 153: I bet my share price is going to go down ... ...

PA 154: Total profit for the period is £6955 ... not as good as last period by any means.

PA 155: Oh dear ... 33% of the market ...

PA 156: ROCE - 8.8% ...

PA 157: share price £1.33 again - what a see-sawing share price ...

PA 158: cash - oh - I've actually lost a bit of cash ... £56321 ... ...

PA 159: Come on then let's see what he has done ... Aagh ... now ... he has dropped two products ...

PA 160: he came in with Product 1 and ... Product 7 ... ... Product 7 - again wasn't successful ...

PA 161: Product 1 ... ... price is £2.70

PA 162: and for Product 7 ... £4.23 ...

PA 163: Revenue for Product 1 - £204455 ... so that's the total ... his sales revenue ... ...

PA 164: He still has made a reasonable profit ... more profit than we did ...

PA 165: maybe I'm spending too much time to try and destroy him ... ... without thinking about our own profitability ... though of course the two ought to be reasonably closely related ...

PA 166: £1.42 ... so his share price has fallen slightly ...

PA 167: his cash balance has gone up enormously ...

DS 168: So this next period requires some very careful decision making ... ... some very careful decision making indeed ... ...

PA 169: Ok ... he launched a new product - Product 7

PA 170: and he dropped Products 3 and 5 ... that was in period 4.

PA 171: Mmm - the summary of his performance - good revenue again ...

PA 172: healthy market share again ...

PA 173: marginal drop in profits ...

PA 174: though an increase in ROCE

PA 175: ... share price ...

Period 5

DPPS 176: Do I want to change my firm's product portfolio ?

DPS 177: Now what's the function ... served by Prcducts 2 and 6 ? ... Product 6 still ought to be able to compete with Product 1 if I can get the pricing right ...

SA 178: and I know that the variable cost of Product 1 wasn't much lower ... I can check that in a minute ...

PPW	179:	Product 2 looks to be surplus to requirements - so let's make some changes here ...
DPPS	180:	Do I wish to launch any new products ? No I don't ...
DPPS	181:	Do I wish to withdraw any products ? Yes ... I do.
SA	182:	I'll review the products marketed last period ... here we go ... So in this last period - Product 1 - 4 and 1 ... a ... variable costs of £2.50 - I thought that was correct ...
SA	183:	and ... Product 6 had a variable cost of £2.50 as well.
PPW	184:	Right - I'm beginning to get somewhere here I think ... that has a ratio of ... Product 2, a ratio of 1, this is the product that I'm thinking of scrapping ... a variable cost of £3.00 and a price of £3.20 ...
SA	185:	Product 4 - a variable cost of £3.10 ... and a ratio of 4.6 ...
SA	186:	Product 1 a ratio of 0.25 ...
SA	187:	Product 7 ... 2.8 ... variable cost of Product 7 is ... £3.91 ...
DS	188:	Now the decision .... What would I do if I were in his position ? ...
PA	189:	Product 7 ... that didn't do anything ... that was a further attempt to compete with Product 4... last time he reduced his price .... and his variable cost is £3.91 ...
DS	190:	- my price is below his variable cost, so he has got to launch a new product - I think ... and get out of Product 7.
DPS	191:	So I've got to be careful in terms of what I do in relation to Product 4 ...
DPPS	192:	he'll have to launch his new product dropping characteristic 1 - I think - down a little.
DPS	193:	But I've got Product 6 which I want to compete with Product 1 ...

DPS	194:	again same variable cost - so if I went in slightly above marginal cost simply on the basis of trying to destroy him - provided I get it right with Product 4 - I can eliminate Product 2.
DPPS	195:	A big gamble - but let's try it ... I'll withdraw one product ...
PPW	196:	I'm withdrawing Product 2 ... and as a result I've Products 4 and 6 left in my portfolio ...
SA	197:	Right ... pricing strategy ... let's think carefully here ... Product 4 ... £3.10, £3.25 ... that's the one in competition with Product 7 and ...
DPPS	198:	he ought really be dropping that and going for a new one ...
PA	199:	£3.25 gave me a reasonable revenue last time ...
DPS	200:	I think the market might take a little more on this one ... let's go for £3.30 this time - see what happens.
SA	201:	Er ... Product 6 ... price last ... £3.10
SA	202:	... variable cost £2.50 ... ...
PA	203:	I'm trying to deal with Product 1 ... he sold it at £2.70 and it sold well ...
DPS	204:	might be a bit more aggresive ...
PRICE	205:	I'll come in at £2.65 ... let's see how we do with that ...

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PA	206:	I've got just Products 4 and 6 ... here we go ... oh ... oh ... I've sold a lot of Product 6 ...
PA	207:	though I didn't sell much of Product 4 ...
PA	208:	and I've got quite a healthy profit again there ...
SA	209:	We'll have to see how he did ... Product 4 - 1.1 and 5.1 - price £3.30
SA	210:	Product 6 - 3.8 and 1.3 - price £2.65 ...

PA	211:	unit sales 6658 and 115298.
PA	212:	Revenues - £21970 and £305540 ...
PA	213:	Operating profit - £581 and £16544.
PA	214:	Total revenue for the period £327510 and ...
PA	215:	total profit and loss £16632.
PA	216:	Market share - 82.70% ...
PA	217:	ROCE for the period 17.42% ...
PA	218:	still haven't wiped him out ...
PA	219:	Cash balance ...
PA	220:	Share price £1.73 ... oh ... going up again ... see-saw share price ... the market might be expecting me to dip down next period ...
PA	221:	Trading results of the competitor firm ... he stuck with Product 7 ...
PA	222:	he didn't sell any of Product 1 ...
PA	223:	aagh ... he put his price upto £2.84 ... ... let's have a look at that ... about a 5% increase in price ... mmm ...
PA	224:	Price was £2.84 ... price £4.11 ... and he still sold some ... has he brought his price down ?
DS	225:	I can't get everything ... ... I wonder if I ought to launch a new product ... I can do that ... see whether I get rid of ...
	226:	... Right the next decision period ....

<u>Period 6</u>

DS	227:	Now this is going to require some very careful consideration here ... What would I do if I was in his position ? ...
DS	228:	my revenue had fallen an awful lot ... I'd lost out on Product 1 ... its well above variable cost - I could reduce the price on that ...

PA	229:	Product 7 has some sales ... hasn't done too badly ...
DPPS	230:	Well I think if I was him I would go for a new product to try and compete with my Product 4 ... or try to move to a new segment of the market ...
DPPS	231:	Now I need a new product at the risk of cannibilising my own product range ...
DPPS	232:	one that will compete directly with his Product 7 as it stood and also one that might go for a new range.
SA	233:	Now if we look at ... the c-ratios ... er ... he has one at 0.25 - I have one at 0.3 ... he has one at 2.8 - I have one at 4.6 ...
DPPS	234:	His one at 3 is doing reasonably well ... so he his probably going to go for one in and about the 1.5 range ...
DPPS	235:	so I think I need to launch one ... let's think about this ... I need to launch one at about 1.5 ...
DPPS	236:	and I have to be prepared to launch another one to deal with his ... with his Product 7 ...
DPPS	237:	So - yes I do want to change my product portfolio and yes, I do want to launch a new product.
SA	238:	I'll review last period's data ... ratio of Product 1 was 0.25 ... Product 7 ... variable cost ... ... it doesn't give us operating profit ...
SA	239:	Product 4 ... ratio 4.6 ... Product 6 ... ratio ...
SA	240:	variable cost Product 4 - £3.10 ... ... Sales revenue ...
DPPS	241:	Right let's make our decisions for the period .... I've got to launch two new products this time ... Products 8 and 9.
RATIO	242:	Now then Product 8 ... I've got to get to a ratio of about 1 to 1.5 ...
SV	243:	because I think that is roughly where he is going to be ... he has high C1 values ...

RATIO	244:	so let's go in low ... a Cl of 1.00.
RATIO	245:	Now Product 9 that's got to deal with Product 7 ... so 2.10 and ...
DPPS	246:	I don't wish to withdraw any products this time ... ok ... right ...
PA	247:	Now Product 4 ... the last time for me ... didn't sell particularly well ... ...
DPS	248:	but I'm getting near to the variable costs ... I think I will have to stick with roughly the same price I'll just add a little extra on ...
PA	249:	Product 6 ... that did very well ...
DPS	250:	that's the one that roughly competes with Product 1 - now he's likely to bring his price down on that ... I would - so I'll go in at £2.60 this time ...
SA	251:	Variable cost of Product 8 ... this is the new product that I'm going for ...
PRICE	252:	nothing below that ... so let's go in at a price of £2.00 for that
SA	253:	... Product 9 - has a variable cost of £3.95 ...
SA	254:	his variable cost was £2.91 ...
PRICE	255:	so let's go in £4.00 on that and see how we do ...
	256:	It's calculating again ... I wonder if this will be the last period ... ...

****

PA	257:	Oh ... I did nothing with Product 8 ... nobody is interested in that ... oh dear ...
PA	258:	total sales revenue for the period £465809 ... not bad ...
PA	259:	my profit is not growing anything like the revenue ...
PA	260:	Still only got 81% - the competitor actually did better than me ...
PA	361:	my ROCE went down ...
PA	262:	my cash grew marginally ...

PA	263:	and my share price went up ...
PA	264:	And he stuck with same two products and this time ...
PA	265:	he sold a lot of Product 1
PA	266:	- but yet he sold nothing of Product 7 ...
PA	267:	he went in at a price of £2.63 ... ... and I went in at a price of £2.60 ... but yet he sold very well.
PA	268:	I wiped him out on Product 7 - but I've still got to deal with Product 1 ... it must surely change this time ... ...
DS	269:	Interesting isn't it that I'm going for 100% share of the market
DS	270:	and ... profitability only seems to be a side issue ... ... an indictment of aggressiveness ... ...
PA	271:	Market share ...
PA	272:	cash ... his cash balance is healthier than mine again ...
PA	273:	but his share price is down to 98p ...
PA	274:	and he didn't change any products.
PA	275:	He's got an average ROCE of 14.4% ...
	276:	Now let's get onto the next period ...

Period 7

DPS	277:	Now let's pause a minute and think about this very carefully ... we've got to take out Product 1 ... Product 1 is akin to my Product 6 ...
SA	278:	variable costs are £2.50 each ...
DPS	279:	If I went in at under his price ... ... What effect would that have ?
DPPS	280:	If I scrapped my existing Product 6 and launched a new product ... er ... that was in direct competition with ...
PA	281:	My Product 8 - that I was going for - didn't sell at all ...

SA	282:	It was 75p over variable cost of £1.75 ... so I'll keep Product 8 in.
PA	283:	Product 6 sold very well - so why would I need to change that ? ...
DS	284:	perhaps I should just attempt to launch another product directly equivalent to his Product 1 -
SV	285:	but I could cannibolise my Product 6 then ... anyway we'll try that and see what happens.
DPPS	286:	So we'll go for launching a new product this time ... ...
DPS	287:	So in this period I've got to reduce price for Product 8 ...
DPPS	288:	I've got to launch a new product ... exactly as Product 1 ... ok ...
DPPS	289:	So I'm launching one new product ... ...
RATIO	290:	Characteristic 1 ...
DPPS	291:	Do you wish to withdraw any products ? ... No ...
PA	292:	Price ... Product 4 ... that sold very well ...
SA	293:	that's the one ... £3.91 is the variable cost ...
DPS	294:	I ought to be able to put up price of that one - didn't I? ... ...
SV	295:	unles his new product is going to be close in that area - so I'd better be a bit careful ...
PA	296:	Product 6 - that sold very well ...
SA	297:	Product 8 - we didn't sell anything last time ...
DPS	298:	so we'd better go for a reduced price here ...
DPS	299:	Product 9 - now this is the one that we were trying to deal with Product 7 - and we were successful last time ...
DPPS	300:	now is he going to drop Product 7 ... he could well drop Product 7 ...

DPS	301:	therefore, we could very well go for a price increase on that ...
SA	302:	Product 11 - no previous price history - should have a variable cost of £2.50 ...
DPS	303:	and we are trying to knock-out Product 1
SA	304:	and he came in at £2.63 last time ...
PRICE	305:	so I'll come in £2.60 on that ...
	306:	Here we go ... ...

****

PA	307:	Oh dear ... got two products where we haven't done anything at all ... so .... Product 4 ... Product 6 ... Product 8 ...
PA	308:	Profits up well ... that's good ... that's good ... ...
PA	309:	Total sales revenue £550000 ...
PA	310:	I can't possibly have the whole market on that ... It doesn't stand up ... Oooh - I have - company market share ... 100% ...
SA	311:	er ... the market must becoming down in size then ...
PA	312:	ROCE 22.95% ...
PA	313:	cash ...
PA	314:	share price £2.42.
PA	315:	Competitor results period 7 ... ok ... his prices are £2.63 and £4.10 ...
PA	316:	revenue nil ...
PA	317:	ROCE ...
PA	318:	cash ...
PA	319:	share price down to 61p ... Mmm ...
DS	320:	now I've drawn him out of the market I've got to be very careful about this one ... ...

END OF TRANSCRIPT

CHAPTER 7

SUBJECT S7: A PRODUCTION SYSTEM MODEL OF THE STRATEGIC DECISION MAKING TASK

7.1 INTRODUCTION

The previous two chapters were concerned with the global modelling of subject behaviour. In this chapter we use our protocol data at a much lower level of aggregation with the purpose of modelling the step-by-step decision making processes of an individual subject. In brief, we present a behavioural process model of S7's strategic decision making behaviour. We shall also evaluate this model against S7's decision output data and our description of the procedural characteristics of his behaviour that were presented in Chapter 5.

The analysis of subject behaviour in this and the previous chapters highlights the value of verbal protocol data for this kind of behavioural research. Decision output data alone would have been insufficient for the purpose of explaining and understanding the detailed aspects of our subjects' information processing behaviour. However, we have also seen that protocol data is unlikely to provide a complete picture of a subject's information processing behaviour. There are two reasons for this in our particular experimental setting. First, the limited period over which subject behaviour was observed. Second, despite our attempts to design an experimental setting that satisfied the conditions outlined by Ericsson and Simon (1980), our subjects rarely provided a complete verbal account of their decision making behaviour.

In brief, the PS model presented in this chapter is likely to be a simplistic representation of S7's behaviour when compared with actual statements in his protocol. For example, the PS model does not capture all the detailed procedural aspects of S7's behaviour (notably the sequence application of the problem space operators). It needs to be recognised that information processing behaviour can be modelled at a variety of different levels and that a single protocol transcript is unlikely to capture all aspects of a subject's behaviour for a given task. We have illustrated this in Chapter 5 when distinguishing between knowledge and meta-level knowledge. The limitations of our experimental design did not facilitate the study of S7's application of meta-level knowledge.

The move towards presenting a detailed PS model of S7's behaviour requires the specification of the production rules that define each of the global operators described in Chapters 5 and 6. Our previous discussion provides the basis for the individual rules we specify in this chapter and it should be clear that they are not generated in some ad hoc fashion. In this respect, our earlier description of the generic pricing and product strategies used by our subjects is important in understanding the nature of the production rules that we have defined below for describing S7's behaviour.

In the next section we describe the production rules that specify each of the problem space operators defined in Chapter 5. The following section compares S7's PS model trace with his actual behaviour. This allows us to evaluate the validity of our behavioural process model as an interpretation of S7's actual behaviour. However, it should be noted that we contrast the PS model simulation trace with the actual data that was used in developing S7's PS model. This is clearly unsatisfactory as a basis for testing the predictive content of the model from the orthodox perspective of neoclassical economics. However, our evaluation of S7's PS model emphasises the importance of being able to account for the procedurally rational aspects of our subject's behaviour. In brief, we are able to test (though not rigorously) the ability of our model to explain S7's behaviour in terms of the generic decision making strategies introduced in the previous chapter. While we are only able to do this for a single subject and for one decision making episode, the generality of our interpretation of the problem space operators in terms of a set of generic price and product strategies has been established in the previous chapter.

In the final section of this chapter we consider how S7's PS model could be further tested and developed. In this context it can be seen that the building of detailed PS models of the kind developed in this chapter provide a framework for further hypothesis based testing. However, it is clear from the discussion in this chapter that our PS model for S7 is only the first stage of an iterative modelling process. In this respect our model is unlikely to satisfy any rigorous test in terms of predicting the behaviour of S7 in other decision making tasks.

This limitation of the present research reflects the way we have chosen to conduct our experimental work. Specifically, we have studied the behaviour of a number of different subjects with the purpose of investigating the variety in subject behaviour. Given the ill-structured nature of our decision making task, this has proved valuable for providing a general form to the problem space operators that were introduced in Chapter 5. In this sense the PS model we present in this chapter is general to a number of different subjects. However, this research strategy has had a cost in terms of our ability to develop a PS model that predicts the behaviour of an individual subject in different experimental conditions.

In contrast, a different research strategy (probably more appropriate to well-structured tasks) would have been to observe the behaviour of a single subject for a number of different decision making episodes. This would have limited our capacity to provide a broad interpretation of good and bad decision making strategies for our experimental setting. However, we would have been able to develop a more comprehensive model of an individual subject's information processing behaviour. Such a model might be subject to more rigorous testing in terms of its ability to predict an individual subject's behaviour for different decision making episodes.

In addition to the substantive content of this chapter our discussion will also illustrate the procedural difficulties and problems facing the behavioural researcher conducting this type of analysis. Mostly, this reflects the richness of detail that we have captured in S7's protocol. It can be argued that this is a cost of this type of research method and needs to be off-set against the benefits of an approach that overcomes a fundamental difficulty that has faced behavioural researchers for over 25 years. That is, the absence of a structured approach to the observation and analysis of human decision processes.

7.2 GLOBAL OPERATOR SPECIFICATION: SUBJECT S7

We have described S7's global operators in Chapter 5 and assessed their general validity in terms of describing the behaviour of other subjects in Chapter 6. In this section we specify the knowledge elements that form the input to and output from each operator. The resulting production rules reflect our description of the generic price and product strategies in the previous chapter. At this stage our description of S7's behaviour becomes very detailed since each problem space operator has to be defined in terms of a number of production rules. This is an important aspect of modelling decision making processes within the framework of HIP theory.

In an attempt to overcome some of the difficulties created by incomplete protocol data, we have made use of decision output data to assist in the detailed specification of our subject's production rules. Ultimately, we can test the reasonableness of our inferences by comparing the process characteristics of our model with the actual behaviour of the subject. This highlights the role of multi-method approaches to collecting and analysing behavioural data.

However, even adopting a multi-method approach, the researcher is faced with the need to exercise judgement in determining which elements of the behavioural data are deemed relevant and how this data is to be represented in a formalised PS model.

From the problem space defined for S7 in Chapter 5 we identified:

DS : Determine Strategy
DPPS : Determine Product Portfolio Strategy
DPS : Determine Price Strategy
RATIO : Ratio
PRICE : Price
SA : Strategic Assessment
PA : Performance Assessment
SV : Strategic Evaluation
SF : Strategic Facts

In Chapter 6 we described the behavioural content of these operators in terms of a set of generic price and product strategies. Also of importance for developing a PS model is the sequencing of the various operators applied by our subject. Figure 5.4 provided an insight into the patterns and relationships between the operator codes that described S7's information processing behaviour. This was seen more clearly in the subject's Problem Behaviour Graphs. For example, before the subject made any decisions or formulated any strategies he acquired (as did all other subjects) relevant 'strategic facts'. The SF operator represented the 'housekeeping' operation of the subject collecting and interpreting strategic facts (via the application of the PA and SA operators). These 'strategic facts' formed the Left Hand Side (LHS) conditions for the production rules that we defined as the DS, DPPS, RATIO, DPS and PRICE operators.

This sequential aspect to S7's behaviour is an important process feature of his decision making and needs to be captured to some degree in our PS model. Of course, it is unlikely that we will be able to capture all the sequential features of our subject's behaviour given the limited period over which we observed his behaviour. For this reason the behavioural process model we develop for our subject is likely to be more 'pure' than the actual information processing behaviour of the subject. The task analysis conducted in Chapter 5 provides some basis for placing a structure on S7's sequencing of the information processing operators. However, whilst the general sequencing of S7's problem space operators is important in developing our PS model, there is no evidence in the protocol to suggest that the detailed sequencing of the various operators was significant in terms of providing a greater understanding of S7's actual behaviour.

A good illustration of this latter point is where S7's protocol reveals that the subject does not always identify all the relevant strategic facts before formulating his decision making strategy. In some instances he appears to search for further information or 'recalls' strategic facts that have been alluded to earlier in the protocol (or maybe that he failed to verbalise). Similarly, there are instances of the subject applying the DPS operator to all products sequentially before using the PRICE operator to price each product in turn. In other periods the subject first applies the DPS operator and then the PRICE operator to each product in his portfolio. In other instances S7 does not apply the DPS or PRICE operator to a product or applies these operators prior to applying the DPPS and RATIO operators. There are also examples of where the subject applies the DS operator while applying the RATIO or PRICE operators. It would be wrong to suggest that these idiosyncrasies in S7's application of the various operators were not important. For example, these patterns may have significance in terms of how the subject acquired knowledge. However, this is difficult to assess from observing S7's behaviour for a single decision making episode.

To obtain an overview of the sequential information processing behaviour of S7, Figure 7.1 provides a summary of the number of times each type of problem space operator was followed by each type of operator. In brief, Figure 7.1 gives some indication of the sequential dependencies between the various operators that have been identified from the subject's protocol (with the exception of the SF and SV operators). For reasons discussed below, we have combined the application of the SA and PA operators in Figure 7.1.

<u>Figure 7.1 The Number of Times Each Operator (Row) was Followed by Each Type of Operator (Column)</u>

	SA/PA	DS	DPPS	RATIO	DPS	PRICE
SA/PA	127	14	5	1	10	5
DS	13	11	6	2	3	3
DPPS	8	2	6	3	3	0
RATIO	1	2	3	1	2	0
DPS	4	7	0	1	11	6
PRICE	9	2	1	6	3	5

Figure 7.1 shows that there is no pure firing sequence of the operators used by S7. However, there are some definite patterns that can be used as a basis for representing the sequencing of the operators in our subject's PS model. Clearly, an important determinant of this sequencing behaviour was our experimental design. One consequence of the difficulty in identifying regular patterns in the application of problem space operators is that we can expect to 'observe' the PS model trace being more complete and unambiguous than the actual behaviour of the subject. For example, our PS model will apply all operators in a particular sequence for each period.

In sum, Figure 7.1 highlights aspects of the subject's behaviour for which his protocol transcript does not provide a complete insight. For this reason, our PS model will reflect only the general trends in S7's firing of particular operators.

(a) <u>**SA/PA Operators:**</u> In developing our PS simulation model we have combined the operation of the PA and SA operators. It can be seen from Figure 7.1 that the PA and SA operators performed the bulk (over 50 per cent) of the subject's information processing activity. In both cases, these operators reflect the subject's attempt to extract and interpret features about the competitive and market environment. Moreover, both operators highlight the use of qualitative information by the subject when interpreting trends in the market and assessing his and the competitor firm's performance. S7's protocol supports the interpretation that the subject did not simply use the quantitative information as it was presented to him in the exercise. This is reflected in the way we have defined the production rules below and highlights the behavioural significance of 'chunking' for overcoming the processing constraints of STM [Miller (1956)].

It will be recalled from Chapter 5 that the SA operator refers to the subject identifying trends in the market environment. The PA operator was largely concerned with performance appraisal. While we distinguished between the role of the PA and SA operators in our global model the subject's protocol does not always provide a clear picture as to whether the PA or the SA operator is being applied in a particular set of circumstances. Given that these operators have essentially the same purpose of identifying strategic facts, we have not distinguished between them in our PS model. This suggests that the PA and SA operators may not represent significantly distinct information processing activities for our subject. In sum, a distinction between the SA and PA operators does not appear to be behaviourally significant for the purpose of modelling S7's behaviour.

Given that the output of the SA and PA operators are similar (i.e. the qualitative assessment of particular facts), we have focused our modelling efforts on trying to identify the nature of the mechanisms that relate quantitative data to qualitative assessment e.g. GOOD, BAD, SATISFACTORY, SIGNIFICANT and so on. These qualitative assessment variables were identified from the subject's protocol and included as knowledge elements in the problem space for S7 in Figure 5.1 - specifically, the <performance measures> and <strategy importance> knowledge elements. In some instances, it is relatively straightforward to assign these knowledge elements to particular strategic facts, e.g. when sales revenue has INCREASED or profits have DECREASED. In other cases, it is more difficult since the subject's reasoning is not always fully accounted for in the protocol. For example, under what circumstances does the subject consider market share HIGH or profits LOW? While the protocol provides no evidence that the subject made extensive and overt use of quantitative data or performed sophisticated calculations, it is not always unambiguous as to the subject's use of qualitative terms. Observing regular patterns in the use of certain qualitative terms in conjunction with studying decision output data was a very important part of the process of placing some structure on the subject's qualitative information processing behaviour.

Figure 7.2 presents the detailed specification of the PA/SA operator constructed from S7's protocol. The production rules are coded in the form of IF-THEN rules which were directly translated into the code of our simulation model. The actual program source code (in Fortran) is less transparent because of the abbreviated nature of many of the variable names and the need for definitions to be consistent with our experimental simulation. For the purposes of the discussion in this chapter we define all our production rules in terms of the knowledge elements used to specify the subject's problem space in Chapter 5.

Inevitably, there are a few instances where the precise reasoning for a rule is not immediately apparent from the subject's protocol. For example, we would rarely expect the subject to verbalise the cut-off points for applying some of the percentage criteria identified in our production rules. In this sense we cannot 'prove' the use of these criteria. However, they can be reasonably inferred from the subject's comments (and their timing) and by analysing the decision output data. Knowledge acquisition requires the researcher to monitor closely the context in which particular information processing behaviour takes place. Rather than discuss each rule in detail, we shall illustrate the process by which these rules were constructed and briefly describe the behavioural content of each rule.

Figure 7.2 PA/SA Production Rules

Production Rule 1:

```
IF:
    company market share: > 60%
THEN:
    market share: = 'HIGH'
ELSEIF:
    company market share: < 40%
THEN:
    market share: = 'LOW'
ELSE:
    market share: = 'SATISFACTORY'
```

Production Rule 2:

```
IF:
    product market share: > 30%
THEN:
    product performance: = 'SUCCESSFUL'
ELSEIF:
    product market share: > 10%
THEN:
    product performance: = 'SATISFACTORY'
ELSE:
    product performance: = 'UNSUCCESSFUL'
```

Production Rule 3:

```
IF:
    ROCE: > 14%
THEN:
    ROCE performance: = 'HIGH'
ELSEIF:
    ROCE: < 8%
THEN:
    ROCE performance: = 'LOW'
ELSE:
    ROCE performance: = 'SATISFACTORY'
```

Production Rule 4:

```
IF:
    company profitability: > £6000;    AND
    company profitability: > 1.3*competitor profitability
THEN:
    profit performance: = 'HIGH'
ELSEIF:
    company profitability: < £4000;    OR
    company profitability: < 0.70*competitor profitability
THEN:
    profit performance: = 'LOW'
ELSE:
    profit performance: = 'SATISFACTORY'
```

Production Rule 5:

```
IF:
     company share price: > £2.00
THEN:
     share price performance: = 'HIGH'
ELSEIF:
     company share price: < £1.00
THEN:
     share price performance: = 'LOW'
ELSEIF:
     share price performance: = 'SATISFACTORY'
```

Production Rule 6:

```
IF:
     company cash balance: > £40000
THEN:
     cash balance performance: = 'GOOD'
ELSEIF:
     company cash balance: < £20000
THEN:
     cash balance performance: = 'BAD'
ELSE:
     cash balance performance: = 'SATISFACTORY'
```

Production Rule 7:

```
IF:
     current <knowledge element>: > 1.1*last <knowledge
                                                element>
THEN:
     current <knowledge element>: = 'INCREASE'
ELSEIF:
     current <knowledge element>: < 0.9*last <knowledge
                                                element>
THEN:
     current <knowledge element>: = 'DECREASE'
ELSE:
     current <knowledge element>: = 'UNCHANGED'
```

Production Rule 8:

```
IF:
     product mark-up: < 0.75*average mark-up
THEN:
     product mark-up: = 'LOW'
ELSEIF:
     product mark-up: > 1.20*average mark-up
THEN:
     product mark-up: = 'HIGH'
ELSE:
     product mark-up: = 'COMPETITIVE'
```

Production Rule 9:

```
IF:
     current product price: > last product price
THEN:
     price decision: = 'INCREASE'
ELSEIF:
     current product price: < last product price
THEN:
     price decision: = 'DECREASE'
ELSEIF:
     current product price: = last product price
THEN:
     price decision: = 'HOLD'
ELSE:
     price decision: = 'NEW'
```

Production Rule 10:

```
IF:
     competitor product price: = 'DECREASE'
THEN:
     competitor price strategy: = 'AGGRESSIVE'
ELSE:
     competitor price strategy: = 'NON AGGRESSIVE'
```

Production Rule 11:

```
IF:
    product c-ratio: > competitor product c-ratio;     AND
    product c-ratio: < competitor product c-ratio
THEN:
    competitor product: = 'PINCERED'
ELSE:
    competitor product: = 'NOT PINCERED'
```

Production Rule 12:

```
IF:
    competitor product performance: = 'SUCCESSFUL'     OR
    competitor product performance: = 'SATISFACTORY'
THEN:
    target product: = 'PRODUCT-ID'
    target count: = target count+1;    AND
IF:
    target count: > 1;  AND
    competitor product mark-up: = 'HIGH'
THEN:
    target product: = 'PRODUCT-ID'
    target count: = target count+1;    AND
IF:
    target count: > 1;  AND
    competitor product: = 'NEW'
THEN:
    target product: = 'PRODUCT-ID'
```

For the majority of the rules contained in Figure 7.2 the output is in the form of assigning an interpretative attribute value to many of the knowledge elements consistently used by the subject when making an assessment of his performance or relative strategic position. Typically, attribute values appear to relate to a qualitative assessment of the level of a variable, e.g. GOOD, BAD, SUCCESSFUL, UNSUCCESSFUL and so on or to the degree of change in a variable from one period to the next, e.g. INCREASE, DECREASE and UNCHANGED. The latter type of rule was relatively easy to formulate, while the former involved a more detailed analysis of the protocol and decision output data. Inevitably, these rules are less precisely formulated.

In developing these PA/SA production rules, we have followed the approach adopted by Bouwman (1983). We have analysed both the verbal protocol and decision output data to elicit reference points which appear to capture the boundaries for when a particular qualitative description applies to a given knowledge element. Unlike our PS model, S7's protocol does not illustrate the subject analysing each knowledge element that has been incorporated in the RHS of the production rules for the PA/SA operator. In this respect our PS model is more pure than the actual behaviour of the subject. One implication of this is that it limits our evaluation of the output of S7's PS model trace to those periods in which the subject makes some reference to a particular knowledge element that forms a LHS condition of one of our rules.

An example will illustrate the process we have adopted in developing the PA/SA production rules. With regard to the market share knowledge element, the subject regularly made comments regarding his position and that of the competitor firm. For example:

Period 1 Topic 43

... mmm ... share of the market is high ... 68.16% ... that is encouraging.

Similarly, in Period 3:

Period 3 Topic 142 - 143

I must have a high share of the market unless the market has grown enormously ... I'm beginning to get the feel for the pricing patterns of this market ... My market share has gone up ... 65.62%.

There are other comments in the protocol that demonstrate the subject identifying a company market share in excess of 60% as being "HIGH" or "GOOD". In contrast, when the subject had a broadly similar market share to the competitor firm (see for example the protocol statements for Period 3), this did not appear to elicit any comment from the subject. We have interpreted this situation as the subject viewing market share as SATISFACTORY. When the competitor firm dominated the market (with a market share in excess of 60%) S7 makes a number of overt statements about his "LOW" market share (see for example the topic statements in Period 5) or explicitly states the need to increase market share through the launch of a new product or an aggressive pricing policy.

A similar process was adopted in developing all the other production rules defined in Figure 7.2. It can be seen by comparing the structure of the various rules that some rules capture more fully aspects of our subject's information processing behaviour. For example, the rule regarding share price behaviour is rather general and far less discriminating than the production rule concerned with assessing market share position. This, in turn, reflects the rather limited verbal comments made by the subject with regards share price. It was only towards the end of the simulation that S7 noted significant deviations between his share price and that of the competitor. The increasing significance of the share price knowledge element provided some reference points for defining the necessary production rules.

In sum, we rarely observe explicit comments in the verbal report of S7 that allow us to determine unequivocally the reference points against which he determines the output of applying a rule from the PA/SA operator. It is the subject's comments in his protocol and the context in which they are made (ie. using decision output data) that enable us to place a meaningful interpretation on his behaviour. Ultimately, if we are to develop an operational model we need to make judgements of this type for the purpose of inferring reasonable rules that describe a subject's behaviour. In this context protocol analysis has an important role to play as a research method for minimising the impact of subjectivity in developing behavioural process models.

<u>**Production Rules 1 and 2:**</u> These two rules are reasonably transparent and represent the subject monitoring the overall market share position for a firm and for individual products on the market. An inspection of S7's protocol reveals the extent of the subject's comments on market share knowledge elements. Given the nature of the generic strategies used by S7, market share was an important variable in determining his strategy.

Production Rule 3 and 4: Interpretation of these rules is straightforward. They capture the subject's assessment of his profitability position relative to the competitor firm. While ROCE (Production Rule 3) appears to be of secondary importance when assessing financial performance, the subject appeared to use this knowledge element to reinforce the assessment of his profits position. Production Rule 4 illustrates that it was not just the absolute level of profit that was important but also its level relative to that achieved by the competitor firm.

Production Rules 5 and 6: These two rules capture the subject's interpretation of the remaining two performance variables - share price and cash balance. Neither appeared to have real significance in the exercise for S7 and this is reflected in the subject's comments; for example, in later periods he commented on the inability to activate a takeover strategy or increase the probability of the competitor firm becoming bankrupt. The subject appeared to monitor cash balance (liquidity) for the purpose of determining whether a product should be withdrawn from the market. However, as S7 never withdrew a product, it is difficult to identify a likely trigger point for cash balance at which a product would have been withdrawn by the subject. Share price, as we have suggested, appeared to increase in significance for S7 towards the end of the exercise.

Production Rule 7: This rule monitored the change in a knowledge element from one period to the next. In our PS model it was applied to all the performance variables included in the exercise. The discriminating values in the rule reflect S7's unwillingness to make detailed calculations and comparisons and it required a fairly significant change in a variable to elicit any comment from the subject.

Production Rule 8: This is a rule that appears quite important to understanding the subject's pricing strategy in the early periods of the simulation. The subject's protocol reveals the application of some indicator of 'the level of market prices'. S7 used this to assess whether a product was priced "HIGH"; "LOW" or "COMPETITIVE" in terms of the level of market prices. For the purpose of this rule the PS model compares the price of a product with the average mark-up of products on the market. There is no evidence in the protocol to suggest that the subject employed a more sophisticated trigger mechanism. Equally, there is no real indication that the subject actually calculates the average level of prices on the market.

Production Rule 9: A mechanical production rule that captures the activity of the subject monitoring the price decision for each product in the previous period. This formed an important input to his own pricing strategy and also for interpreting the aggressiveness of the competitor firm's pricing strategy (see Production Rule 10).

Production Rule 10: This rule examines knowledge elements that are output by Production Rule 9 for all the competitor firm's products and makes a general assessment of whether the competitor firm's price strategy is "AGGRESSIVE" or "NON AGGRESSIVE". This rule provided important insight into the price sensitivity of the market and was also a factor in determining whether the subject focused upon developing a price or product strategy in any period. From S7's protocol statements it would appear that an AGGRESSIVE price strategy was associated with occasions where the competitor firm had DECREASED the price for each of its products in the previous period.

Production Rules 11 and 12: These rules are concerned with simulating the subject's behaviour of identifying "PINCERED" and "TARGET" products of the rival firm. These two concepts strongly feature in the subject's verbal comments about his product strategy and reflect the CPS type rules used by the subject. Both of these concepts were used when modelling the competitor firm's strategy module and Production Rules 11 and 12 are modelled on a similar basis. Production Rule 11 is straightforward, with a competitor product being "PINCERED" if S7 had a product with a c-ratio on either side of it. Production Rule 12 is slightly more complex, but simply reflects the subject filtering possible target products until only a single product remains. This product then becomes the focus of the subject's product strategy for the next period. This rule highlights the use of 'competitor focus' based strategies by S7.

Without exception, S7 did not launch a new product unless he had identified a target product. This provided a reference point for determining the c-ratio and price for a new product. S7 appears to have employed three filters in identifying target products. First, the product should be "SUCCESSFUL" or "SATISFACTORY" in terms of its market share performance. Second, if more than one competitor product was trapped by the first filter, the subject then identified those products that were profitable in terms of having a high price mark-up. Finally, if there still remained more than one competitor product as a potential target, the subject then focused upon whether the product had recently been launched (i.e. was "NEW").

The production rules defined above can be interpreted as representing S7's "basic" information processing activities for our decision making task. Each rule is applied every period in our PS model. The model completes the application of the PA/SA rules in a single step before moving onto applying the DS operator. Figure 7.1 provides general support for this sequencing of the PA/SA and DS operators for S7.

As with the other operators defined below, there are alternative ways in which we could have modelled this interpretative aspect of S7's behaviour. For example, we could have defined operators that were more general in application than the conditions of our experimental setting, e.g. an operator to compute a trend, an operator to compare two items and so on. Once again, these operators would be applied to all the knowledge elements defined in S7's problem space. A development of this approach might be to include control mechanisms (e.g. based on our generic strategies) that select an appropriate operator to apply to particular knowledge elements. We could also include an operator to select which RHS outputs were significant for the purposes of the subject's decision making strategy. Whilst the verbal report for S7 does not provide the detail to develop such control mechanisms, it can be appreciated that this may be one approach to capturing the evolutionary features of S7's behaviour. Ultimately, we are of course constrained by the level of information processing detail that is captured in our subject's protocol.

In sum, the PA/SA production rules described above appear to be a reasonable interpretation of subject behaviour given the nature of our decision making task, the protocol data and the decision output information. In essence, the protocol for S7 does not provide us with sufficient information to model a more complex information examination process (even if the subject had used one). However, the rules described in this section do capture an important aspect of S7's interpretative behaviour - notably the use of qualitative information.

(b) <u>DS Operator:</u> Figure 7.3 defines the seven production rules that simulate the application of the DS operator by S7. These rules are presented in terms of the knowledge elements defined in S7's problem space. It will be recalled that the DS operator represents the information processing activity of the subject in determining his overall strategy in terms of the knowledge elements: <strategy type> and <strategic goal> [see Figure 5.1]. The RHS and LHS elements of each rule are straightforward to interpret given our previous discussion of S7's behaviour in Chapter 5.

Formulating a goal and the nature of an appropriate strategy to achieve that goal was an important aspect of our decision making task. This demanded that subjects considered and interpreted available strategic facts (which formed the LHS conditions of the rules for the DS operator) and determine the nature of their strategy and strategic goals (the RHS statements of the rules for the DS operator).

Figure 7.3 DS Production Rules

```
Production Rule 1:

    IF:
        company market share: = 'HIGH';      AND
        company profitability: = 'HIGH'
        OR
        company market share: = 'LOW';       AND
        company profitability: = 'LOW'
    THEN:
        overall strategy: = 'AGGRESSIVE'
    ELSE:
        overall strategy: = 'NON AGGRESSIVE'

Production Rule 2:

    IF:
        overall strategy: = 'AGGRESSIVE'
        OR
        overall strategy: = 'NON AGGRESSIVE';     AND
        company market share: = 'LOW';       AND
        company profitability: = 'HIGH' OR 'SATISFACTORY'
    THEN:
        strategic goal: = 'INCREASE MARKET SHARE'

Production Rule 3:

    IF:
        overall strategy: = 'NON AGGRESSIVE';
        AND
        company market share: = 'SATISFACTORY';          AND
        company profitability: = 'LOW'
        OR
        company market share: = 'HIGH';      AND
        company profitability: = 'SATISFACTORY'
    THEN:
        strategic goal: = '?'

Production Rule 4:

    IF:
        overall strategy: = 'NON AGGRESSIVE';     AND
        company market share: = 'HIGH';      AND
        company profitability: = 'LOW'
    THEN:
        strategic goal: = 'INCREASE PROFITABILITY'

Production Rule 5:

    IF:
        overall strategy: = 'NON AGGRESSIVE';     AND
        strategic goal: = 'INCREASE PROFITABILITY'
    THEN:
        price strategy: = 'NON AGGRESSIVE'
```

Production Rule 6:

```
    IF:
        overall strategy: = 'AGGRESSIVE';  AND
        strategic goal: = 'INCREASE MARKET SHARE'
    THEN:
        price strategy: = 'AGGRESSIVE'
    ELSE:
        price strategy: = '?'
```

Production Rule 7:

```
    IF:
        overall strategy: = 'NON AGGRESSIVE';   AND
        competitor price strategy: = 'NON AGGRESSIVE'
    THEN:
        product strategy: = 'NON AGGRESSIVE'
    ELSE:
        product strategy: = 'AGGRESSIVE'
```

As with the PA/SA operator, S7's protocol transcript does not provide detailed insight into the circumstances (other than at a general level) in which the DS operator was or was not applied by the subject. Moreover, it seems reasonable to infer from the protocol that when the subject does not appear to explicitly "fire" the DS operator this is because there is no clearly obvious strategy to develop or the subject is pursuing a strategy similar to that of the previous period. This is captured in our production rules for the DS operator by the RHS output of "?". Good examples of this situation can be found in the first two periods of the experimental run.

Production Rule 1: This rule determines the overall strategy of the subject. The output of the rule is either an "AGGRESSIVE" or "NON AGGRESSIVE" strategy for the period. During observation of S7's behaviour it appears that he adopted an aggressive strategy when his performance relative to the competitor was either very poor or very good. The latter reflects the attempt by the subject to try to dominate the market (for example, in Period 7). The former set of circumstances captures the subject responding to a highly aggressive strategy of the competitor firm (for example, in Period 5).

Production Rules 2, 3 and 4: These three rules represent the subject formulating a strategic goal. Each rule reflects the circumstances in which different strategic goals are specified. For example, Production Rule 2, captures the conditions when the subject pursues a goal of "INCREASING MARKET SHARE". S7 applied this strategy when either his overall strategy was "AGGRESSIVE" or his market share was "LOW" and his profit position was "SATISFACTORY" or "GOOD". Production Rule 4 was applied when the subject pursued the goal of "INCREASE PROFITABILITY". This was activated when S7's market share was "HIGH" but profitability was "LOW" and his overall strategy was "NON AGGRESSIVE" (see, for example, Period 4).

<u>Production Rules 5, 6 and 7:</u> These three rules capture the nature of S7's overall product and pricing strategies for a period. Some of the LHS conditions for these rules reflect knowledge elements output by Production Rules 1-4 of the DS operator; in particular, those which specify the subject's overall strategy and his strategic goal for the period. Other LHS conditions capture the nature of the competitor firm's strategy.

<u>(c) DPPS Operator:</u> The DPPS operator captures the subject's processing activity of formulating his product strategy. The output of the DPPS operator are the following knowledge elements: <product strategy>, <portfolio change> and <product type>. Since S7 only introduced four new products during the course of the exercise (and did not withdraw any), we have a limited amount of behavioural data from which to elicit the nature of his production rules for the DPPS operator. However, valuable insight can also be gained into the subject's product strategy by examining the periods in which he made no changes to his product portfolio.

In Chapter 6 we distinguished between two types of new product strategy: Market Product Strategy (MPS) and Competitor Product Strategy (CPS). Our discussion suggested that these two types of generic strategy implied the use of different knowledge elements that form the input and output of the production rules that define the

DPPS and RATIO operators (particularly the latter). In Chapter 5 we were able to identify from the protocol that two of the products launched by the subject suggested the application of MPS type rules. The other two new products (launched towards the end of the exercise) reflected the use of a CPS type product strategy. The contrast between these two types of generic product strategy is clearly illustrated by the production rules defined in Figure 7.4 to simulate S7's application of the DPPS operator.

Hopefully, we have identified what appear to be reasonable rules for describing S7's product strategy in the light of his application of both CPS and MPS type rules. The production rules below demonstrate that the output of the DPPS operator is not just in terms of whether to launch a new product but also how many products to launch and the type of new product.

Figure 7.4 DPPS Production Rules

Production Rule 1:

```
IF:
    competitor price strategy: = 'NON AGGRESSIVE';     AND
    competitor target product: = 'PROD-ID'
THEN:
    company product strategy: = 'NEW PRODUCT'
ELSE:
    company product strategy: = 'NO CHANGE'
```

Production Rule 2:

```
IF:
    company product strategy: = 'NEW PRODUCT';    AND
    overall strategy: = 'NON AGGRESSIVE';   OR
    competitor product: = 'NOT PINCERED'
THEN:
    portfolio change: = '+1'
ELSE:
    portfolio change: = '0'
```

Production Rule 3:

```
IF:
    company product strategy: = 'NEW PRODUCT';    AND
    product strategy: = 'NON AGGRESSIVE';   AND
    portfolio: = not 'HIGH VALUE' and 'LOW VALUE' and 'MID
                                                     VALUE'
THEN:
    product type: = 'HIGH/MID/LOW';    AND
    product strategy type: = 'PRODUCT MARKET GAP'
ELSE:
    product type: = 'COMPETING';  AND
    product strategy type: = 'PINCER MOVEMENT'
```

Production Rule 4:

```
IF:
     company cash balance: = 'GOOD';     OR
     company cash balance: = 'SATISFACTORY'
THEN:
     company product strategy: = 'NO CHANGE'
ELSE:
     company product strategy: = 'WITHDRAW PRODUCT'
```

<u>Production Rule 1:</u> This is a straightforward rule that captures S7's reasoning regarding the decision whether and when to launch a new product. The LHS conditions reflect circumstances where the subject has identified a target product in the competitor's product portfolio (see the PA/SA operator) and has also interpreted the competitor firm's price strategy as being "NON AGGRESSIVE". Both of these conditions appear to be important to S7's reasoning when deciding whether to launch a new product. Without a competitor target product, S7 (as evidenced by statements in his protocol) did not have a clear reference point for the purpose of launching a product. This, as we have seen in Chapter 6, was particularly important for a CPS type of product strategy.

In circumstances where S7 assessed the competitor firm's price strategy as being "AGGRESSIVE" (i.e. all competitor products were reduced in price in the previous period) he typically noted the importance of price strategy in his protocol. S7 then proceeded to focus upon pricing rather than product strategy for competing against the competitor firm in the next period.

<u>Production Rule 2:</u> This production rule captures the subject's decision regarding the number of products to launch in a period. This rule effectively fires by default since the subject only ever launched one new product at any point in time. It would appear that the subject might have considered launching two new products if (a) his overall strategy had been "AGGRESSIVE"; and (b) the competitor target product was "NOT PINCERED". However, as the subject never actually made such a decision, we have no supporting evidence for this interpretation. In sum, S7 only ever needed to launch a

single product to achieve the position of pincering a competitor product. However, the evidence in S7's protocol is not particularly informative in terms of providing an insight into this aspect of his behaviour.

<u>**Production Rule 3:**</u> This production rule generates the product strategy type (either PRODUCT MARKET GAP or PINCER MOVEMENT). The rule also outputs the new product type (either HIGH VALUE/LOW VALUE/MID VALUE or COMPETING). The key LHS conditions which determine the output of the rule are the current state of the subject's product portfolio (in terms of existing product type) and the nature of his product strategy (as output by the DS operator discussed above). Interpreting this rule is not difficult if we examine and compare the topic statements in the subject's protocol for the first two products he launched in Periods 1 and 2 and for the products that were launched in Periods 4 and 7.

The PRODUCT MARKET GAP type strategy is a non-aggressive strategy and implies the application of MPS type decision rules by S7. This in turn reflects upon the subject's assessment of the various product types in his portfolio. As with a number of other subjects, S7 first launched a product that was a HIGH VALUE type product. Statements from his protocol suggest that he perceived his initial portfolio as consisting of a product which he described as a MID-VALUE type of product. The subject's launch of a HIGH VALUE product in Period 1 and a LOW VALUE product in Period 2 captures the non-aggressive nature of his product strategy in the earlier periods.

What is not totally clear from S7's protocol is why a HIGH VALUE product was launched first, in preference to a LOW VALUE product - either of which would have improved the perceived balance of his portfolio in terms of product type. Some indication is provided by comments in Period 1 which suggest the subject recognising that a HIGH VALUE product could carry a higher mark-up and, therefore, yield a higher level of absolute profitability. The fact that the competitor firm also launched a relatively high value product in the previous period may also have been significant. This, however, is difficult to verify from the protocol of the subject.

In contrast to the use of a MPS type of product strategy in Periods 1 and 2, S7 adopts a more aggressive product strategy in later periods by launching "COMPETING" products. This forms an important element of what S7 calls his "PINCER MOVEMENT" strategy. This resulted in the launch of products that were focused in terms of how close a new product's c-ratio was to the target product of the competitor firm. S7 appears to have used the concept of a COMPETING product in later periods of the simulation by launching products so that he had a product on either side of a competitor product in terms of c-ratio values. In sum, S7 aimed to have products whose strategy points straddled the competitor firm's products. This would seem to reflect S7's use of the term "PINCER MOVEMENT" and is an example of a CPS type of product strategy.

<u>Product Rule 4:</u> This production rule is straightforward and captures S7's product withdrawal strategy. For reasons noted above, it is based on limited evidence in terms of the subject's protocol statements. Indeed, S7's protocol only contains two instances of where he considers a product withdrawal strategy. In both cases S7 concludes that it was not an acceptable strategy in our experimental setting. In his verbal report the subject makes reference to his liquidity position and the fact that his cash balance is sufficiently healthy not to force the withdrawal of products. A second reason, but which is much more difficult to capture in the form of an operational rule, is that the subject believed that products had market research value. In consequence, it appeared worthwhile to the subject to retain products indefinitely.

<u>(d) RATIO Operator:</u> The RATIO operator captures S7's

information processing behaviour of assigning values to C1 and C2 when launching new products. Once again, the structure of the production rules for RATIO reflect whether the subject is following a CPS or MPS type of product strategy. Determining the c-ratio for new products was a difficult aspect of our decision making exercise. Generally, the protocol transcripts for our subjects are incomplete in terms of revealing the detail of how a new product's c-ratio was determined. Since S7 launched four new products, we are faced with having only a limited amount of protocol data from which to try to explain his reasoning when determining c-ratios for new products. This is particularly problematical since the RATIO operator involved the subject assigning values.

The production rules defined in Figure 7.5 reflect our interpretation of how S7 appeared to determine the C2/C1 ratio for new products. Both production rules are relatively straightforward and were defined after close examination of the protocol and the decision output data for the subject. They make sense when viewed against the generic types of product strategy which we identified in Chapter 6. For example, Production Rule 1 is clearly a MPS type of RATIO rule, while Production Rule 2 is a CPS type of rule. The rules appear simple and capture the fact that the subject did not make extensive calculations or give considerable thought to determining c-values for new products. The reasonableness of our interpretation of this aspect of S7's behaviour can be verified from his protocol statements.

Figure 7.5 RATIO Production Rules

Production Rule 1:

```
IF:
    product strategy type: = 'PRODUCT MARKET GAP';     AND
    product type: = 'HIGH VALUE'
THEN:
    product c-ratio: = 2*product c-ratio[MID VALUE]
ELSE:
    product strategy type: = 'PRODUCT MARKET GAP';     AND
    product type: = 'LOW VALUE'
THEN:
    product c-ratio: = 0.5*product c-ratio[MID VALUE]
```

Production Rule 2:

```
IF:
    product strategy type: = 'PINCER MOVEMENT';    AND
    product type: = 'COMPETING PRODUCT'
THEN:
    product C1/C2: = C1/C2[target product]  OR
    product C1/C2: = C1/C2[target product] + 1
```

<u>**Production Rule 1:**</u> This rule is a MPS based production rule and reflects the subject relating the c-ratios appropriate for HIGH and LOW value type products to the ratio of his (perceived) MID value product (Product 2). In general terms, this is a sensible rule of thumb. We have no evidence from the protocol that S7 used the exact relationship implied by this rule. However, it can be inferred from his actual choice behaviour.

This rule seems very effective for the early product strategy of the subject. A HIGH value product was simply given a C1/C2 characteristic mix of twice the subject's MID value product. A LOW value product was given a C1/C2 characteristic mix profile of half that for the MID value product. This is a MPS type rule as the subject gave little consideration to the competitor firm's c-ratios.

Identifying a MID value product (his existing product) as a reference point was clearly a useful basis for assessing relative product type. In this context, S7's "doubling" and "halving" rule seems both plausible and reasonable. The fact that S7 was consistent for both high and low value products seems to support the use of a simple rule of this type.

<u>**Production Rule 2:**</u> This rule captures a similar heuristic to the one described above except that it is a CPS type RATIO rule. In this case the reference product is the target product of the competitor firm rather than a product in the subject's own portfolio. The rule is straightforward and simulates the subject selecting a c-ratio for a new product that is very close to a competitor product and adding one extra unit of the dominant characteristic.

Production Rule 2 is more easily verified from the protocol transcript than the previous RATIO rule. The subject makes verbal reference to imitating the successful products of the competitor firm (ie. the target product) but marginally increasing the amount of the dominant characteristic. The fact that this rule was applied both times when a PINCER MOVEMENT type of product strategy was used supports our interpretation that the subject may well have been using a simplistic rule of this type. As with Production Rule 1, the information processing requirements of this rule were minimal.

(e) <u>DPS Operator:</u> The DPS operator simulates the behaviour of S7 formulating his price strategy. This involved the subject assigning one of the knowledge elements from <price strategy> [defined in Figure 5.4] to each product in his portfolio, i.e. INCREASE, DECREASE, HOLD or NEW. As with the DPPS operator, it was relatively easy to elicit the production rules that defined S7's broad price strategy by studying his protocol transcript. It was, however, considerably more difficult to identify discriminating rules that captured the subject's implementation of his price strategy via the PRICE operator (see discussion below).

In total, the subject made some 25 different pricing decisions during the decision making episode for which he was observed:

DECREASE	11 decisions
HOLD	6 decisions
INCREASE	4 decisions
NEW	4 decisions

This distribution of pricing decisions reflects the aggressive nature of S7's pricing strategy and his overall objective of increasing market share. To elicit the various rules for the DPS operator we examined each separate pricing decision and identified the significant facts that characterised the circumstances in which a particular price decision was made (using both the subject's verbal report and his decision output data).

These decisions were then studied to identify regularities in the information processing behaviour of the subject and to elicit patterns in the significant facts processed as the LHS conditions of each rule. As we shall see, S7 applied all three types of generic pricing strategy described in the previous chapter, i.e. CBPS (Cost Based Pricing Strategy); MBPS (Market Based Pricing Strategy) and CMBPS (Competitor Based Pricing Strategy).

Figure 7.6 contains the rules that were incorporated into our production system model for simulating S7's DPS problem space operator. The simple structure of each rule allows for ease of association with the generic price strategies described in Chapter 6.

<u>Figure 7.6 DPS Production Rules</u>

Production Rule 1:

IF:
overall strategy: = 'NON AGGRESSIVE'; AND
strategic goal: = 'INCREASE MARKET SHARE' OR '?'; AND
product market share: = 'SUCCESSFUL' OR 'SATISFACTORY'
THEN:
product price strategy: = 'HOLD'

Production Rule 2:

IF:
overall strategy: = 'NON AGGRESSIVE'; AND
strategic goal: = 'INCREASE PROFITABILITY'; AND
product price mark-up: = 'COMPETITIVE' OR 'HIGH'; AND
product market share: = 'SUCCESSFUL' OR 'SATISFACTORY
THEN:
product price strategy: = 'HOLD'

Production Rule 3:

IF:
product market share: = 'UNSUCCESSFUL'
THEN:
product price strategy: = 'DECREASE'

Production Rule 4:

IF:
overall strategy: = 'AGGRESSIVE'; AND
strategic goal: = 'INCREASE MARKET SHARE'; AND
price strategy: = 'AGGRESSIVE'; AND
product market share: = 'SUCCESSFUL' OR 'SATISFACTORY'
THEN:
product price strategy: = 'DECREASE'

Production Rule 5:

IF:
overall strategy: = 'NON AGGRESSIVE'; AND
strategic goal: = 'INCREASE PROFITABILITY' OR '?'; AND
company market share: = 'HIGH'; AND
product price mark-up: = 'LOW'; AND
product market share: = 'SUCCESSFUL' OR 'SATISFACTORY'
THEN:
product price strategy: = 'INCREASE'

Production Rule 6:

IF:
product <new>
THEN:
product price strategy: = 'NEW'

<u>**Production Rule 1 and 2:**</u> These two production rules capture the circumstances under which the subject holds the price of a product constant. The LHS conditions of the rules are self-explanatory and reflect the knowledge elements in the subject's problem space in Figure 5.1. Rule 1 covers the situation where the subject has set (via the DS operator) a strategic goal to INCREASE MARKET SHARE and when his overall strategy is NON AGGRESSIVE. In these conditions, the subject appeared to view a price increase or decrease strategy as being inappropriate as the product would already have a SATISFACTORY or SUCCESSFUL level of market share.

The second production rule copes with a slightly different set of circumstances. As can be seen from the LHS conditions of the rule, it reflects the situation where the subject is considering increasing the price of a product in an attempt to INCREASE PROFITABILITY (the strategic goal). However, despite the product's market share in the previous period suggesting that it is a successful product, its price is considered to be too high (or it would be if it were further increased). In consequence, the subject decides to hold the price of the product constant.

Both of these rules appear to be reasonable for market conditions where the price of a product should be held rather than increased or decreased. The LHS conditions for these rules provide an insight into their origin in terms of our generic pricing strategies identified in the previous chapter. However, the distinction between cost, market and competitor based pricing strategies is more readily apparent in the rules that define the PRICE operator discussed below.

Production Rules 3 and 4: These rules reflect the market conditions in which the subject reduced the price of a product. As we have seen, this type of behaviour dominated the subject's pricing strategy and largely reflected his objective of attempting to increase market share. These two rules were easily identified from the protocol and the decision output data for the subject. The first rule - Production Rule 3 - is purely a market based type of pricing strategy. This captures the subject responding to the strategic fact that a product has been UNSUCCESSFUL in the market in the previous period. Given S7's policy of not withdrawing products, this rule appears to be an obvious response to this set of circumstances.

Production Rule 4 is applied in a quite different set of circumstances and is where the subject adopts a highly aggressive strategy towards the competitor firm (e.g. Periods 5 and 7). In these conditions, the price for a product is reduced even where it has been considered SATISFACTORY in terms of its level of market share in the previous period. As would be expected, the objective here is for the subject to INCREASE MARKET SHARE and his overall strategy is AGGRESSIVE. This is a clear example of a CMBPS type decision rule.

Production Rule 5: This production rule captures the subject increasing the price of a product in his portfolio. The LHS conditions demonstrate the circumstances under which this rule appears to have been applied by the subject and it was fired in total four times. Production Rule 5 reflects the subject attempting to INCREASE PROFITABILITY (for example, in Period 4) and was typically applied to products whose price mark-up was LOW but whose market share was at least SATISFACTORY. Moreover, S7 appears to have pursued this policy when his market share was HIGH, emphasising the fact that he was prepared to sacrifice market share in an attempt to increase profitability. However, as can be observed from his protocol, profitability appears to have been of secondary importance to S7 for most of the exercise.

Understandably, S7 was only prepared to try to increase profits when his market share position was considered to be highly favourable.

Production Rule 6: This is a straightforward rule that captures S7 acknowledging the circumstances where the price strategy for a product is NEW. In these circumstances, the subject has no market information on which to assess the past performance of the product. It is necessary to examine the PRICE operator to gain insight into our interpretation of the subject's pricing strategy for new products.

(e) PRICE Operator: The role of the PRICE operator is to assign price values to each of the subject's products. At this level of information processing activity the verbal protocol of S7 does not always reveal detailed explanations of the reasoning behind the various price decisions he made. It is only by close inspection of the protocol and the decision output data that we can gain insight into the consistency with which particular pricing rules were applied. The reasonableness of our PRICE rules for S7 can be interpreted against the generic pricing strategies described in Chapter 6.

Figure 7.7 suggests that the subject used rather simple rules of thumb in pricing products. These rules did not require excessive information processing or calculation. For example, S7 consistently priced in units of 5p, except when the mark-up on a product reached 5p above variable cost. The basic RHS and LHS knowledge elements that make up these rules are defined in Figure 7.7.

Figure 7.7 PRICE Production Rules

Production Rule 1:

IF:
product price strategy: = 'HOLD'
THEN:
current product price: = last product price

Production Rule 2:

IF:
product price strategy: = 'INCREASE'
THEN:
check: = product type; AND
check: = last product price mark-up; AND
current product price: = variable cost+MBPS mark-up

Production Rule 3:

IF:
product price strategy: = 'DECREASE'; AND
average price mark-up: > 15p; AND
price strategy: = 'AGGRESSIVE'; OR
last product price: > average price mark-up
THEN:
current product price: = variable cost+ relative CBPS mark-up

Production Rule 4:

IF:
product price strategy: = 'DECREASE'; AND
average price mark-up: = < 15p; AND
price strategy: = 'AGGRESSIVE' OR
product price mark-up last: < average price mark-up
THEN:
current product price: = variable cost+absolute CBPS mark-up

Production Rule 5:

IF:
product price strategy: = 'DECREASE'; AND
price strategy: = 'NON AGGRESSIVE'; AND
product price mark-up last: > 1.25*average price mark-up
THEN:
current product price: = variable cost+MBPS mark-up

Production Rule 6:

IF:
product price strategy: = 'NEW'; AND
overall strategy: = 'NON AGGRESSIVE'; AND
product type: = 'HIGH VALUE' OR 'LOW VALUE'
THEN:
check: = product type; AND
current product price: = variable cost+MBPS mark-up

Production Rule 7:

IF:
product price strategy: = 'NEW'; AND
overall strategy: = 'NON AGGRESSIVE'; AND
strategic goal: = 'INCREASE PROFITABILITY'; AND
product type: = 'COMPETING PRODUCT'
THEN:
current product price: = variable cost+CMBPS mark-up

<u>**Production Rule 1:**</u> This rule is very straightforward and requires no further comment. It simply sets the current price for a product equal to last period's price when the subject is adopting a HOLD price strategy.

<u>**Production Rule 2:**</u> This production rule determines the amount by which a product price is increased in any period. The RHS output shows that it is a hybrid of a

CBPS and CMBPS type decision rule. There are two check routines in this rule which assess an individual product's position with respect to: (i) product type; and (ii) its price mark-up last period relative to the average mark-up on the market. This latter check routine captures the subject's comments in his protocol about the level of prices on the market in previous periods. S7 clearly does not calculate an average price mark-up in the market for each period. However, for modelling purposes it is necessary to try to capture the important activity of when S7 makes a comparison between the price of an individual product and prices for other products. This production rule also captures the subject's comments when he considers whether a product was a HIGH, MID or LOW value type product. This was important for determining the price mark-up of a product in the early periods of the exercise.

The mark-up added to a product's variable cost in this rule ensures that it is priced within a narrow range relative to the average price of products already on the market. It is not possible to verify a particular range used by the subject from his protocol statements. We have had to study the context in which the subject made particular pricing decisions. subject's behaviour. For this rule we have specified that a product's price never exceeds the average mark-up on the market by more than 20 per cent. Prices appear to have then been set in increments of 20p, 10p or 5p, depending on product type.

<u>Production Rules 3, 4, and 5:</u> These three rules cope with the circumstances under which the subject decreased the price of a product. All three rules reflect S7 adding a mark-up to the variable cost of a product, though as is clear from the definition of each rule, the basis for these mark-ups are different in each case. Rules 3 and 4 cope with the circumstances when the subject adopts an aggressive price strategy. The subject followed this strategy either in response to an aggressive move by the competitor firm or in an attempt to increase market share.

Rule 5 is essentially applied when an individual product has underperformed in the previous period.

Production Rules 3 and 4 were difficult to identify and reflect the subject's perception about the level of market prices. However, the two rules do appear reasonable when viewed against information relating to trends in market prices and the nature of the subject's overall strategy. Production Rule 3 is a relative percentage mark-up rule - "the 3 per cent rule" - and was consistently used by the subject when average prices were high in the market (ie. mark-ups above 15p). As such, "the 3 per cent rule" depends on the knowledge element <product type>, i.e. HIGH value products can be expected to carry higher margins than LOW value products. The trigger mechanism can only be inferred from statements by the subject. These comments suggest that a 15p mark-up on a HIGH value product was the minimum mark-up before relative prices became a secondary consideration to absolute price levels in the market. There is evidence in S7's protocol that a mechanism of this sort was being used.

When average prices in the market moved to a level where relative price strategies became difficult to adopt (given S7's policy of pricing in 5p units), absolute margins appeared to dominate his reasoning. The "15p price level trigger" appears to capture this change in policy, though we have no detailed explanation or account of the exact level of this trigger mechanism in the subject's protocol statements. For example, it could also be possible that this change in price policy mirrored the shift in product strategy that occurred in the subject's behaviour towards the end of the experimental run.

The adoption of an absolute price strategy reflected the use of a more aggressive price strategy by S7 in which "the 3 per cent rule" was replaced by "the 5p rule". Both "the 3 per cent rule" and "the 5p rule" appear to reflect aggressive CBPS type decision rules. There is one clear exception to "the 5p rule" which we have encoded in our rules for determining absolute mark-up; that is when the mark-up on a product is already at the 5p level (see for example Period 7). In these circumstances, the subject cuts the product price by 1p and reinforces his strategy of being reluctant to go into either break-even or loss-making pricing.

The final decrease price rule is Production Rule 5. This rule is not as aggressive as Production Rules 3 and 4 and one of the LHS conditions reflects the DS operator having output a "NON AGGRESSIVE" price strategy. In these circumstances, the subject appears to simply bring the price of a product in line with the average mark-up on the market (to the nearest 5p below the price level on the market). This is a good example of a price rule that reflects a CMBPS approach to pricing.

<u>Production Rules 6 and 7:</u> These two production rules capture the subject's behaviour of pricing new products. Each rule captures a different approach to the pricing of new products and is a function of the type of product being launched. Production Rule 6 is the pricing rule for a "PRODUCT MARKET GAP" type of product strategy. As with the RATIO operator, the reference product here is the perceived MID value product of the subject (Product 2). This pricing rule reflects similar reasoning to that used by the subject when assigning a c-ratio to a new product.

While Production Rule 6 is quite general, its application is limited to two periods in the exercise and its validity in other market conditions cannot be assessed. The rule is based on S7's focus upon a price penetration policy and his quite deliberate strategy of pricing new products at a discount to existing products in his portfolio. As a decision rule, it can be associated with a MPS type of product strategy. As for the operational structure of Production Rule 6, the subject appears to apply a similar type of heuristic as with the selection of c-ratios for new products: a 10p discount for HIGH value products and a 5p discount for LOW value products.

As with S7's production rules for the RATIO operator, it is difficult to assess the generality and validity of the detailed specification of Production Rule 6. However, what is important is to assess its significance against our discussion of the various types of generic pricing strategy discussed in the previous chapter. Similar comments apply to Production Rule 7 for the PRICE operator. This rule is applied to the pricing of new products that are of the COMPETING PRODUCT type. Again, the rule appears intuitively reasonable because the price is set equal to the variable cost plus a mark-up (to the nearest 5p). This ensured that the price was just below that of the target product for the competitor firm. Given the closeness of the competing products launched by S7 in terms of c-ratio mix, it was necessary (as the subject notes in his protocol) to price competitively relative to the target product. This is a clear example of the subject linking a CPS type product strategy with a CMBPS type pricing rule.

The discussion in this section highlights some of the difficulties facing the researcher using the technique of protocol analysis for modelling human information processes. Given our experimental setting, we were faced with the problem of only being able to observe subject behaviour for a relatively short period of time (about 1 hour). This posed two particular difficulties. First, there is evidence in S7's protocol that the subject's behaviour evolved over the period of the exercise. For example, the shift from reaction to anticipation of competitor moves. This aspect of S7's behaviour is not easily incorporated in our PS model. Following previous applications of protocol analysis we have focused our attention upon observing regular patterns in information processing behaviour as a basis for defining production rules [Newell and Simon (1972)]. For ill-structured tasks that are not characterised by a sequence of independent and repetitive decisions, this approach to the use of protocol analysis is likely to obscure some important aspects of information processing behaviour. This problem has been discussed in the previous chapter.

A second and related problem concerns the 'gaps' in the subject's verbal report. Despite our attempts to satisfy the conditions identified by Ericsson and Simon for validating verbal protocol data, the verbal reports of many of our subjects were typically incomplete. Good examples of this can be found in relation to the PRICE and RATIO operators for subject S7. In this context, it is important to emphasise that protocol analysis should be viewed as complementary to other techniques for studying decision making behaviour (e.g. input-output analysis). In this chapter our combined use of decision outcome data and the subject's verbal report was an important base for increasing our understanding of S7's information processing behaviour. However, even in these circumstances, it has been necessary to exercise our judgement in interpreting S7's behaviour.

Finally, it should be noted that we have not defined any production rules for the SV operator incorporated in S7's problem space. It is difficult to assess the significance of the SV operator in terms of its effect on S7's behaviour. One interpretation of its role is as a confirmation routine that captures the subject's attempts to rationalise the validity of his particular pricing and product strategies. Given our operator coding of S7's protocol (see Chapter 5, Appendix I) the subject fired the SV operator some 33 times. In Chapter 5 we suggested that the SV operator represented the subject's information processing behaviour of assessing alternative strategic options in terms of their feasibility, suitability and acceptability. It appears, therefore, to have the function of a control strategy. The reasons we have not explicitly incorporated the SV operator into our PS model are twofold. First, its application is implicit in the production rules we have already defined for the PA/SA, DS, DPPS, RATIO, DPS and PRICE operators. The strategies that are simulated by our PS model are likely to be those that the subject perceived to be most suitable, acceptable and feasible, given the strategic facts that had been observed from the output of the PA and SA operators. In sum, there appears to have been little need for the subject to make a genuine evaluation of alternative strategies in our experimental setting.

Second, and related to the previous point, it was not clear from the protocol and the actual decisions made by S7 that the SV operator was significant in terms of influencing his choice of strategy. Indeed, it appears that the SV operator was performing a role of summarising the rationale for adopting particular product and price strategies in a period. There are some instances in the subject's protocol where he did formulate alternative strategies that appear to have been considered. However, even in these circumstances, the SV operator had a relatively cosmetic role in terms of determining his final choice. In sum, whilst the SV operator represents an important activity of strategic decision making, in practice it is difficult to identify situations from S7's protocol to suggest that he was applying the SV operator other than for the purpose of summarising his current position with respect to a particular strategy.

The production rules defined above have been coded into our simulation environment as a separate decision module. The structure of this module is general and could easily be adapted to incorporate the production rules for simulating the behaviour of other subjects. Unlike the OPS4 production system language described in Chapter 2, our Fortran simulation environment does not have an explicit control procedure for the firing of rules that operate via the contents of a working memory. In this sense, we do not have the conflict resolution strategies that are incorporated as part of the OPS4 inference engine. In modelling S7's behaviour, the SF operator performs the same housekeeping functions as OPS4's working memory by storing the output knowledge states from the firing of the various operators described above. In consequence, the sequencing of the firing of the various production rules is controlled by the quantitative and qualitative knowledge elements stored by the SF operator in each period.

7.3 TESTING THE VALIDITY OF THE PS MODEL: A COMPARISON OF THE PS TRACE AND S7's ACTUAL DECISIONS

In this section we compare the trace of our PS model with the actual behaviour of subject S7. The nature of our experimental task setting does not facilitate a meaningful statistical analysis of our PS simulation model trace output. However, while there is no underlying statistical basis for our analysis in this section, the discussion should be viewed in the context of the information processing theory of human problem solving introduced in Chapter 2. We shall evaluate our behavioural process model of S7 in terms of the criteria introduced in Chapter 3.

We can identify a number of differences between the output of our PS model and the actual behaviour of S7. Possible explanations for these differences reflect both our experimental design as well as the limitations of the method of protocol analysis. We have noted earlier those operators where it proved difficult to induce production rules from the protocol data alone, i.e. the RATIO and PRICE operators. In contrast, the operators that defined the subject's broad strategy - i.e. the DS, DPS and the DPPS operators - were more easily specified. In this respect, we can expect two types of differences to occur between our PS model and the actual behaviour of S7. First, differences in broad strategy: is our PS model capable of generating the type of behaviour described in Chapter 5? Second, differences in the operational aspects of the subject's decision making: does the PS model generate the same price and product decisions as those made by subject S7? The previous discussion suggests that these latter differences are more likely to be problematical in testing our model.

Figures 7.8 and 7.9 present a comparison between S7's actual decisions and those which were generated by the PS model. The only information that is not contained in these figures are the c-ratios for the new products which were launched on the market. This information can be found in the data contained in the appendices to this chapter. Figure 7.8 summarises the actual decisions of S7 and the competitor firm, while Figure 7.9 is a summary of the PS model output. An asterisk against a decision by the subject indicates a deviation between his actual behaviour and that produced by the behavioural process model. We shall discuss these differences below.

In Appendices I and II to this chapter we present the more detailed data generated by S7 and the PS model. Appendix I contains a summary of all the financial information and results for S7 and the competitor firm in the actual experiment. Appendix II is the PS trace and summarises the firing of the production rules that we have described in the previous section. As can be seen from Appendix II, the PS model generates the type of output that can be compared directly with the subject's actual protocol (though it is not presented in exactly the same format). Inevitably, the PS trace is more rigid in its use of language. However, it generates comparative qualitative reasoning that can be contrasted with the actual statements of the subject in his protocol.

Clearly, the comparison between the behavioural process model for S7 and the subject's actual behaviour can be examined at many different levels. We outlined in Chapter 3 one possible framework based on the work of Payne, Braunstein and Carroll (1978). The first criterion suggested by Payne et al is the sufficiency criterion which requires an assessment of whether our PS model is capable of generating the type of behaviour that we observed from subject S7's protocol. In particular, does our formal representation of S7's problem space in this chapter capture the essential characteristics of the changing knowledge states that we can identify from S7's actual behaviour?

Figure 7.8 Subject S7: Product and Pricing ACTUAL Decisions

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE MARK-UP IN PENCE AND (%) LAST P.	THIS P.
Period 1:				
Subject-				
Product 2	hold	38%	60p (20%)	60p (20%)
Product 4	new	-	-	50p (8%)
Competitor-				
Product 1	increase	31%	70p (28%)	75p (30%)
Product 3	increase	31%	75p (25%)	90p (28%)
Period 2:				
Subject-				
Product 2	decrease	-	60p (20%)	10p (3%)
Product 4	increase	68%	50p (8%)	70p (12%)
Product 5	new	-	-	5p (3%)
Competitor-				
Product 1	decrease	25%	75p (30%)	50p (20%)
Product 3	decrease	7%	90p (28%)	30p (10%)
Period 3:				
Subject-				
Product 2	hold	35%	10p (3%)	10p (3%)
Product 4	decrease	-	70p (12%)	40p (7%)
Product 5	hold	14%	5p (3%)	5p (3%)
Competitor-				
Product 1	decrease	1%	50p (20%)	23p (9%)
Product 3	increase	49%	30p (10%)	47p (16%)
Product 7	new	-	-	20p (9%)
Period 4:				
Subject-				
Product 2	increase	26%	10p (3%)	20p (7%)
Product 4	hold	23%	40p (7%)	40p (7%)
Product 5	increase	17%	5p (3%)	10p (7%)
Product 8	new	-	-	30p (9%)
Competitor-				
Product 1	decrease	17%	23p (9%)	19p (8%)
Product 3	decrease	17%	47p (16%)	23p (8%)
Product 7	decrease	-	20p (9%)	11p (5%)
Period 5:				
Subject-				
Product 2	decrease	-	20p (7%)	5p (2%)
Product 4	decrease	-	40p (7%)	20p (3%)
Product 5	decrease	-	10p (7%)	5p (3%)
Product 8	decrease	5%	30p (9%)	10p (3%)
Competitor-				
Product 1	hold	49%	19p (8%)	19p (8%)
Product 3	hold	10%	23p (8%)	23p (8%)
Product 7	hold	36%	11p (5%)	11p (5%)
Period 6:				
Subject-				
Product 2	increase	22%	5p (2%)	10p (3%)
Product 4	decrease	-	20p (3%)	10p (2%)
Product 5	hold	33%	5p (3%)	5p (3%)
Product 8	hold	10%	10p (3%)	10p (3%)
Competitor-				
Product 1	hold	34%	19p (8%)	19p (8%)
Product 3	decrease	-	23p (8%)	15p (5%)
Product 7	withdrawn	-	11p (5%)	-

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE MARK-UP IN PENCE AND (%) LAST P.	THIS P.
Period 7:				
Subject-				
Product 2	decrease	-	10p (3%)	5p (2%)
Product 4	decrease	19%	10p (2%)	5p (1%)
Product 5	decrease	36%	5p (35)	4p (2%)
Product 8	decrease	24%	10p (3%)	5p (1%)
Product 9	new	-	-	5p (1%)
Competitor-				
Product 1	decrease	20%	19p (8%)	10p (4%)
Product 3	withdrawn	-	15p (5%)	-
Product 10	new	-	-	12p (4%)

Figure 7.9 Subject S7: Product and Pricing PS Model Decisions

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE MARK-UP IN PENCE AND (%) LAST P.	THIS P.
Period 1:				
Subject-				
Product 2	hold	38%	60p (20%)	60p (20%)
Product 4	new	-	-	50p (8%)
Competitor-				
Product 1	increase	31%	70p (28%)	75p (30%)
Product 3	increase	31%	75p (25%)	90p (28%)
Period 2:				
Subject-				
Product 2	decrease	-	60p (20%)	10p (3%)
Product 4	increase	68%	50p (8%)	70p (12%)
Product 5	new	-	-	5p (3%)
Competitor-				
Product 1	decrease	25%	75p (30%)	50p (20%)
Product 3	decrease	7%	90p (28%)	30p (10%)
Period 3:				
Subject-				
Product 2	hold	35%	10p (3%)	10p (3%)
Product 4	decrease	-	70p (12%)	*30p (5%)
Product 5	hold	14%	5p (3%)	5p (3%)
Competitor-				
Product 1	decrease	1%	50p (20%)	23p (9%)
Product 3	increase	49%	30p (10%)	47p (16%)
Product 7	new	-	-	20p (9%)
Period 4:				
Subject-				
Product 2	increase	23%	10p (3%)	20p (7%)
Product 4	hold	28%	30p (5%)	30p (5%)
Product 5	increase	17%	5p (3%)	10p (7%)
Product 8	new	-	-	30p (9%)
Competitor-				
Product 1	decrease	17%	23p (9%)	19p (8%)
Product 3	decrease	15%	47p (16%)	21p (7%)
Product 7	decrease	-	20p (9%)	11p (5%)
Period 5:				
Subject-				
Product 2	decrease	-	20p (7%)	*10p (3%)
Product 4	decrease	9%	30p (5%)	20p (3%)
Product 5	decrease	-	10p (7%)	5p (3%)
Product 8	decrease	4%	30p (9%)	10p (3%)
Competitor-				
Product 1	hold	49%	19p (8%)	19p (8%)
Product 3	hold	9%	21p (7%)	21p (7%)
Product 7	hold	29%	11p (5%)	11p (5%)

PRODUCTS	PRICE DECISION	MKT. SHARE LAST PERIOD	PRICE MARK-UP IN PENCE AND (%) LAST P.	THIS P.
Period 6:				
Subject-				
Product 2	*decrease	-	10p (3%)	5p (2%)
Product 4	decrease	-	20p (3%)	10p (2%)
Product 5	hold	52%	5p (3%)	5p (3%)
Product 8	hold	13%	10p (3%)	10p (3%)
Product 9	*new	-	-	5p (1%)
Competitor-				
Product 1	hold	35%	19p (8%)	19p (8%)
Product 3	decrease	-	21p (7%)	15p (5%)
Product 7	withdrawn	-	11p (5%)	-
Product 10	new	-	-	13p (4%)
Period 7:				
Subject-				
Product 2	decrease	27%	5p (2%)	4p (1%)
Product 4	decrease	16%	10p (2%)	5p (1%)
Product 5	decrease	-	5p (35)	4p (2%)
Product 8	decrease	24%	10p (3%)	5p (1%)
Product 9	*decrease	33%	5p (1%)	4p (1%)
Competitor-				
Product 1	withdrawn	-	19p (8%)	-
Product 3	withdrawn	-	15p (5%)	-
Product 10	decrease	-	13p (4%)	3p (1%)
Product 11	new	-	-	10p (3%)

Given the complex and unstructured nature of our experimental task, we required our PS model to capture the following aspects of S7's behaviour to satisfy the sufficiency criterion:

(i) the subject's qualitative assessment of his performance and the trends in the competitive market environment (the PA/SA operator)

(ii) the subject's formulation of his goals and broad strategy (the DS operator)

(iii) the subject's formulation of product strategy for each period (the DPPS operator) and, where appropriate, the determination of the characteristic mix of new products (the RATIO operator)

(iv) the subject's formulation of his price strategy for each period (the DPS operator) and the implementation of this strategy into specific price decisions (the PRICE operator).

Without further discussion it is clear from the PS trace in Appendix II to this chapter that our PS model does capture the general characteristics of S7's information processing behaviour for our decision making task. Albeit in a more pure form, S7's PS model generates the type of strategic decisions required of subjects in our experimental setting. Moreover, in modelling the production rules for each of the operators defined in S7's problem space, we have kept the framework of our model sufficiently robust and general so as to allow it to be easily modified. For this reason it is relatively straightforward to incorporate the equivalent rules for the operators of other subjects who participated in our experiment.

A second, and more demanding criterion, is to assess the power of our PS model in terms of its ability to match (predict) the actual decisions made by the subject. Given the limited period of subject observation, a statistical assessment of "goodness of fit" is inappropriate here; however, what is valuable is to contrast in some detail the decision output data for S7's PS model with the decisions actually made by the subject. This predictive criterion [Payne et al (1978)] is clearly a less rigorous predictive test of model validity than that which is conventionally applied to orthodox models in economics. Specifically, we are evaluating our PS model against data that was used to develop the model. Given our previous analysis, it might be considered appropriate to view this as a test of the PS model's explanatory power rather than its predictive content. However, this should not understate the importance of this kind of test of the validity of a behavioural process model.

In comparing the decision output data of our PS model with the actual decisions of S7, we are not generating predictions of the form that characterise neoclassical economics. There are a number of reasons for this in the present study. However, this problem highlights a more general weakness of protocol analysis as a methodology for studying and modelling decision processes. There is a clear lack of widely accepted summary measures for evaluating PS trace data and this limits the ability to draw inferences about the generality of a particular set of results. One rather obvious reason for this is the focus of information processing theory upon the detailed study of individual behaviour. The previous discussion suggests that the researcher will, at most, be able to study and analyse the behaviour of a few individual subjects. In addition, the importance of internal validity in an experimental setting and the need to avoid problems created by having too much behavioural data, will typically restrict the researcher to studying subject behaviour for a short period of time.

In a sense, our PS model of S7 can be viewed as a single data point or a 'microtheory' [Newell and Simon (1972)] for which a more general theory (not yet precisely formulated) will be developed and tested in future research. From this perspective we can view one role for PS simulation models as a formalism that forces the researcher to be more precise in the description and interpretation of subject behaviour. Indeed, PS models can be viewed as an approach to testing the researcher's analysis and interpretation of the behavioural data collected from verbal reports. Bouwman's work on the diagnostic behaviour of financial analysts appears to reflect this interpretation of the use of PS modelling techniques [see Bouwman (1983); Bouwman et al (1987)].

The previous argument highlights some rather obvious limitations in the predictive content of our basic PS model for S7 when evaluated against the criteria of orthodox economics. In the last section of this chapter we consider how our basic model could be further extended and tested. However, it is worth stressing two points. First, this problem characterises a major difference between inductive and deductive research methods in general. Second, we should view our prototype model of S7 as an initial step towards developing a more general model of subject behaviour for our decision making task.

In summary, our ability to identify a minimal set of production rules that capture the nature of S7's generic strategies indicates that our PS model does have predictive content. The production rules that define each global operator are not simply a replication of the decision making conditions that faced the subject in each period of our experimental simulation. Instead, they are intended to reflect reasonable inferences about patterns in the subject's information processing behaviour. In this respect, it should not be surprising that our PS model will not simply be able to replicate the decisions made by our subject. It is also important to recognise that these production rules are not context free. This highlights an important aspect of AI and expert systems research in the 1970's and 1980's. Knowledge and expertise for complex decision making tasks is highly domain specific and the search for general problem solving strategies has remained an elusive goal for research on human problem solving [Hayes-Roth, Waterman and Lenat (1983)].

We shall now assess the similarity between the output of our PS model and S7's observed decisions. The first major difference occurs in Period 3 and results from the PS model applying the PRICE operator to Product 4. The DPS operator fired by the model generated the correct price strategy for Product 4 given that it had been UNSUCCESSFUL in the previous period with zero market share. The DPS operator fired Production Rule 3 with the output of DECREASE for the price of Product 4. The difference between model and subject occurred when the PRICE operator was subsequently fired.

The PRICE operator generated a price for Product 4 of £6.30, whereas the subject's actual decision was to set a price of £6.40. The production rule fired by the PS model was PRICE rule 5 which, we can recall from Figure 7.7, prices a product in relation to its variable cost and a mark-up based on an MBPS type of generic strategy (i.e. the level of prices in the market). From the subject's protocol transcript we observe him comment:

Period 3 — Topic 131 -133

Product 4 at £6.70 did disastrously ... let me ... my competitor's dropping his price ... his margins ... mmm ... I'm going to put that down to £6.40 - 40p - roughly in line with the competitor's margins ...

This extract from the subject's protocol suggests the use of a CMBPS type strategy for pricing Product 4. The impact of the PS model employing an MBPS type pricing rule is to reduce the price of Product 4 by more than the subject's actual decision. As we have seen, the different types of generic price strategy focus upon different knowledge elements. The consequence of this difference is that Product 4 captures a higher percentage of market share at the expense of the two products with which it competes, i.e. Product 2 and Product 3. Production Rule 5 of the PRICE operator captures the activity of the subject monitoring prices in the market and his adjustment of product prices to be competitive with the prices of other products. We discussed in the previous section that the indicator for the level of prices in the market was taken to be the average mark-up on all products. We argued that it was difficult to justify modelling a more sophisticated or discriminating rule on the basis of S7's comments in his protocol. However, the protocol extract above indicates that S7 may have been adopting a more discriminating rule in this particular case. Specifically, he seems to focus only upon the competitor firm's margins when recognising (as evidenced in the LHS conditions of rule 5) that his product is overpriced. As a result, the subject went for a higher price margin on Product 4 than that selected by the PS model.

One possible rationalisation of the 40p margin selected by the subject for Product 4 is that it is a simple average of the margins on both of the competitor firm's products. However, there is no real evidence in the protocol that the subject carried out such a calculation. This might be viewed as a special case of rule 5, though we have not adapted the rule to fit this particular set of circumstances. However, the more likely rationalisation of this difference is that the subject was employing a CMBPS type rule for the pricing of this product.

The DECREASE rules for the PRICE operator (i.e. rules 4, 5 and 6) consist of two different types of CBPS rules and one MBPS type rule. In the circumstances that arose in Period 3, the presence of a CMBPS type PRICE rule in our rule base would have presented an instance where conflict resolution would have been necessary, since both rules could have fired. We would then have been left with the task of trying to infer from the protocol a mechanism used by the subject for resolving this conflict of rules. However, S7 provides no indication in the protocol of where serious conflict resolution appears to have taken place. In consequence, we have avoided this as a modelling issue by both the ordering of the rules and their specificity. This is clearly one area where the present research could be extended by a more extensive period of observing S7's behaviour. For example, this might result in the incorporation of stochastic production rules or the use of confidence factors to indicate the likelihood of different rules firing in a particular set of circumstances. Clearly, a more comprehensive information processing model of S7's behaviour requires the development of a task specific interpreter (inference engine) to represent the control strategies used by S7. This, however, demands observing S7's behaviour over a large number of decision episodes.

A second difference between the PS model trace and the actual decisions of S7 occurs in Period 5. Once again, it concerns the application of the PRICE operator. The reason for this difference is partly because of the difference in pricing that we observed for Product 4 in Period 3, though in the main it might be interpreted as a possible idiosyncrasy in the behaviour of the subject. The simulated price strategy of S7 is the same as his actual decision (via the DPS operator) and is in response to a very low market share in Period 4. This, in turn, reflected a highly aggressive price strategy by the competitor firm with all product prices for the competitor being reduced.

In these circumstances, we have seen that S7 appeared to apply one of two CBPS type rules. As both rules are based on cost information, they can be distinguished in terms of the mechanism that captures the subject's determination of price mark-up. We have previously differentiated between S7's "3 per cent rule" and the "5p rule". The 3 per cent and 5p rules are not arbitrary mechanisms but reflect the subject's general approach to cost-based pricing using both absolute and relative measures of price mark-up. The conflict between which type of rule to select is resolved in the rules themselves, according to the level of prices on the market. In Period 5, margins were perceived by the subject to be sufficiently high in the market to make a relative cost based pricing rule feasible (i.e. higher margins for more expensive products). In consequence, PRICE rule 3 was fired for all products in the subject's portfolio.

Extracts from the subject's protocol for Period 5 (see Appendix I, Chapter 5: Topic Statements 223 - 235) support the view that the subject is applying some consistent rule in relation to cost - similar (as the subject notes) to the PRICE rule applied in Period 2. The only deviation from this rule appears to be with regard to Product 2, when the subject states:

<u>Period 5</u> <u>Topic 224</u>

Product 2 ... we'll go in at £3.10 ... er ... no £3.05 ...

This statement is not untypical of subjects in our experiment when applying the PRICE operator and highlights the lack of depth of explanation provided by our subjects at this level of information processing activity. In this particular case, it appears that the subject was going to apply exactly the same basis for pricing Product 2 as for all the other products (i.e. the 3 per cent rule). In fact, it can be seen that the subject opts for a marginally lower price of £3.05 by applying the 5p rule in preference to the 3 per cent rule.

There is no obvious rationale for this switch given market and competitive conditions. One possible explanation might be that the subject was employing a very sophisticated conflict resolution strategy (for which there is no insight in his protocol). However, a more likely reason is that his behaviour at this level of detail was on occasions stochastic. This contrasts with the structure of the rules we have developed to simulate the PRICE operator in our PS model. It could also be partly explained by the design of our experimental setting and the fact that subjects did not have access to detailed market research data. However, S7's behaviour was similar to other subjects in that more time (or at least it appears from comments in the protocol) was devoted to considering broad strategic issues rather than to detailed calculation and analysis, e.g. pricing products or determining the c-ratios of new products. This highlights an important point. Given the nature of our decision making task, it is possible to evaluate our PS model trace against the actual behaviour of S7 at a number of different levels. In this respect, we are able to offer a much richer insight into decision making strategy than would be available by focusing only on decision output data. Clearly, our protocol data and the technique of protocol analysis provides detailed insight into some aspects of S7's information processing behaviour but not others.

In Period 6 we can observe two differences between the decisions of S7 and the PS model. Both are predominantly at the level of the DPS and DPPS operators and suggest that the PS model deviates in overall strategy from the subject's actual behaviour at this stage of the task. The first difference can be accounted for purely as a result of the difference in application of the PRICE operator in Period 5. Due to the high degree of price sensitivity in our task setting, particularly where margins on products are falling, Product 2 (priced at £3.10 by the PS model in Period 5) achieved no market share. The PS model interpreted the product's performance as being

UNSUCCESSFUL (the output of the PA/SA operator). This contrasts with the product's SATISFACTORY performance when viewed by the subject at this stage in the actual experimental task. In consequence, the PS model generates a different decision strategy for Product 2 in Period 6 from that actually made by the subject (though clearly the response was consistent with the subject's own decision rules). The DPS operator in the model generates a DECREASE price strategy against an INCREASE strategy applied by the subject. To the extent that our PS model is a reasonable representation of the subject's decision rules, we can only infer that the subject would have adopted a similar price strategy in these circumstances.

The second and more fundamental difference in Period 6 is that the PS model simulates the launch of a new product. In fact, the subject actually launched a new product in Period 7. As the target product identified by the subject and the PS model were the same (though in different decision periods), the decision output data generated by the model via the DPS, RATIO and PRICE operators was the same as the subject's decisions in Period 7. This difference in the timing of the launch of a new product is reflected in the output of the DPPS operator. Once again, if we refer to the subject's protocol we can find a possible explanation of the difference between the PS model and the subject's actual behaviour:

<u>Product 6</u> <u>Topic 253; 258</u>

So ... I can't out-manoeuvre him in terms of introducing new products since I've already got enough I feel and ... and I don't think I want to follow that strategy ... Well, I'm now committed to a definite pricing strategy ... even though ... what I'll do is hold the price for Product 5 constant ...

Whilst the subject is quite positive in his protocol (topic statement 253) that he will not launch a new product in Period 6, there is some suggestion in topic statement 258 that he may have reconsidered his decision. We cannot determine the exact moment that the statement was made in terms of the timing of the exercise. In particular, whether it had been after the point at which

S7 needed to decide his product strategy (in which case it would have been too late to reverse his decision given the design of our experiment). This suggests that the subject may have made a mistake or reconsidered his strategy given that he notes that there was a highly successful competitor product on the market (Product 1). Indeed, both the subject (see topic statement 244 in Period 5) and the PS model identified Product 1 as a target product. This, of course, is the basis for the PS model launching a new product since Product 1 was SUCCESSFUL and was NOT PINCERED.

Further comments made by S7 when analysing his performance in Period 6 suggest that he may have made a mistake or an error of judgement in Period 6. For example:

<u>Period 6</u> <u>Topic Statement 283 - 284</u>

The interesting thing is that he has priced his Product 1 at £2.69 and got a huge revenue. That now really is ... yes, I should definitely have "gone under" Product 1 ... I was quite right in my intuition there ... no, it's not intuition, it's knowledge ...

It is difficult to see how we might have captured this aspect of S7's decision making in Period 6 (if we are to retain consistency in the modelling of S7's other decisions). The suggestion from S7's protocol is that, in hindsight, he should have launched a product in Period 6 to counter the successful product of the competitor firm. The consequence of this mismatch between the PS model and S7's actual behaviour is that the simulation model resulted in 'S7' acquiring a 100 per cent share of the market one period prior to that actually achieved by S7 during the exercise proper. In brief, the PS model recognised that conditions for a successful product launch had been satisfied at the the end of Period 5.

A final difference that we can observe in Figure 7.9 is in Period 7 and relates to the pricing strategy for Product 9. This is easily explained away in terms of our discussion about the differences observed in Period 6. Product 9 was a new product for the subject's actual decision making exercise but was an established product in the PS simulation trace. In this context it can be seen why different pricing rules would be fired. The simulation model introduced this product early and hence the DPS operator generates a decision which is consistent with the overall strategy of the subject in Period 7: an aggressive price strategy to maintain domination of the market. The subject actually priced Product 9 as a new product.

A third criterion for evaluating our PS model is the process criterion and refers to the capacity of the model to capture the sequential aspects of our subject's information processing behaviour [Payne, Braunstein and Carroll (1978)]. One approach to examining the process validity of our PS model for S7 is to contrast the actual protocol trace of the subject with the simulated protocol from our behavioural model. The PS model does not produce a protocol trace in the same format as the transcribed protocol of our subject. However, we can, without distorting our interpretation, present the PS model trace side by side with the verbal protocol of the subject to illustrate the model's "goodness of fit" in terms of its reasoning capacity.

Figure 7.10 illustrates how one might gain an overall qualitative assessment of the validity of a behavioural simulation model in process terms. Inevitably, there are differences since the PS model's "verbal" report is complete, unambiguous and stylised; this is not true for the subject's actual protocol. For the purpose of our evaluation we have re-ordered some of the statements output by the PS model to make the comparison more meaningful. This reflects a previous argument that the subject's sequencing of the application of the various operators was not as pure as that incorporated in our PS model. It should also be remembered that the operators and knowledge elements that define the problem space for S7 have been derived from analysing the full protocol for the subject. In consequence, our PS model reflects the knowledge state terminology defined in the problem space and is more linguistically rigid than the subject's actual protocol transcript.

That apart, Figure 7.10 demonstrates that our production system model captures, albeit in a stylised manner, the reasoning portrayed by the actual decision making behaviour of subject S7. Clearly, our PS model trace simply reflects the knowledge states that are the output of the production rules which define each of our global operators. Our model clearly does not satisfy the Turing Test of imitating subject behaviour to such a degree that we cannot distinguish between subject and model [Turing (1963)]. However, it can be seen that the PS model is capable of generating reasoned behaviour that closely mirrors (in general terms) the information processing activity of our subject.

The content of Figure 7.10 is an illustration of how we might apply this process test. It would be relatively straightforward to extend this comparison between the subject's protocol and the PS trace to all decision periods. Some periods would show a higher degree of similarity than others largely because the subject's actual protocol does not always provide a full account of his information processing behaviour. Moreover, Figure 7.10 does not reproduce all the trace output from the PS model but only that which has meaning in terms of a direct comparison with the subject's actual protocol. Further, our PS model generates identical output from one period to the next and is a "pure" behavioural process model when compared with the actual behaviour of S7. In sum, while our PS model generates a more comprehensive protocol, it lacks the subtlety of reasoning displayed in the subject's own verbal report.

Figure 7.10 Protocol and Model Trace for Subject S7: A Comparison for Period 5 of the Strategic Decision Making Task

SUBJECT S7 VERBAL PROTOCOL TRACE	BEHAVIOURAL SIMULATION MODEL TRACE
... Ah well ... that exploded into some sort of disaster ...	Product 2: UNSUCCESSFUL Product 4: UNSUCCESSFUL Product 5: UNSUCCESSFUL Product 8: UNSUCCESSFUL
it can't be my actions, it must be my competitor's actions. He must have hit me on price - I've shaded up and he has gone down I guess - that was predictable.	Competitor Price Strategy: AGGRESSIVE
Mmm! ... Market share must be virtually a write-off ... down to 5% ...	Market Share: LOW DECREASE
ROCE is a disaster;	ROCE: LOW DECREASE
cash balance is Ok;	Cash Balance: SATISFACTORY
share price understandably has dropped.	Share Price: LOW DECREASE
What has the competitor done ? ... Yes, just as I thought ... a pricing war on our hands. In a sense I've walked into this - I should not have shaded my prices up at the same time I expected him to shade his prices down ...	Competitor Price Policy: Product 1: DECREASE Product 3: DECREASE Product 7: DECREASE Overall Price Strategy: AGGRESSIVE
but I'd not realised how sensitive the market was to price ... The "pincer" theory still holds good ... but there is a lot of sensitivity on price.	Product 3: PINCERED Product 7: PINCERED
There is only one way I can go this period - my strategy is quite clear ... it won't do much for profitability, but it will allow me to capture market share.	Strategic Goal : INCREASE MARKET SHARE
So ... aggressive pricing is the only way out given I've walked right into this ...	Price Strategy: AGGRESSIVE
it was bad strategy, I should have introduced my new product without shading up my prices. That should have been an obvious mistake - in hindsight.	
No change in product portfolio strategy this period ...	Product Strategy: NO CHANGE
while my strategy appears to be a bit incremental ... but there has been a clear policy that has emerged very easily ... this is a market share capturing and pricing penetration policy.	Strategic Goal : INCREASE MARKET SHARE Price Strategy: AGGRESSIVE

SUBJECT S7 VERBAL PROTOCOL TRACE	BEHAVIOURAL SIMULATION MODEL TRACE
In a sense deviating from this last period was a mistake - I should have stayed where I was ... ... I guess.	
How is he going to read it? If he is very sharp he will reckon I will come back at him hard ... he'll hardly think I will extrapolate the trend given that my prices are up ...	
So, ... it's going to have to be some very keen prices indeed - virtually selling at cost again ...	Overall Strategy: AGGRESSIVE
Product 2 ... we'll go in at £3.10 ... er ... no ... £3.05 ...	Price for Product 2: £3.10
I don't have a cash flow problem and even though my share price doesn't look good ... I'm not in any liquidity problems, so I can afford to be aggressive ... as I was in period 2 ... a similar policy I think ...	Cash Balance: SATISFACTORY Share Price: LOW Overall Strategy: AGGRESSIVE
Product 4 ... last period £6.40 - it didn't do very well ...	Product 4: UNSUCCESSFUL Relative Price: HIGH
that is interesting since I held that one steady ... I wonder why that one went down ? ...	Product 4 Price Policy: HOLD
because he dropped the price of a ... product close in c-ratio I guess -	Competitor Price Strategy AGGRESSIVE
... £6.20	Price for Product 4: £6.20
Product 5 - £1.60 ... not much I can given away on that one ...	Product 5 Relative Price: LOW
... £1.55	Price for Product 5: £1.55
There is, of course, the possibility of going into loss making pricing -	
but seeing as I don't see any possibility of squeezing him out of the market ... there is little point in trying to do that.	
Product 8 ... that one did sell something at £3.80 -	Product 8 Relative Price: HIGH
but nonetheless it's coming down to £3.60 ...	Price for Product 8: £3.60

Figure 7.10 also highlights gaps in the PS model trace when compared with the subject's actual protocol. This

obviously reflects the limitations of our protocol analysis for S7 and our inability to replicate all aspects of our subject's information processing behaviour. For example, we can note from the protocol that the subject repeats information processing activity from time to time or recalls a prior knowledge state that had previously been noted. We are unable to capture this level of behavioural detail in our model. On the other hand, it is not clear that any attempt to have done so would have improved the process output of our PS model for the purpose of increasing our understanding of subject S7's strategic behaviour.

The line between what is left in or left out of a behavioural process model reflects the researcher's judgement, the aims of the research and, of course, the depth of behavioural detail captured in the subject's verbal protocol. In many instances, the researcher is likely to find it necessary to apply a far higher level of interpretation in the PS modelling phase than that required for the coding and analysis of a subject's actual protocol. A problem facing researchers conducting this type of research is that there does not appear to be any widely recognised criterion that defines a satisfactory level of achievement in process terms. For example, Figure 7.10 suggests that there is scope for incorporating more process detail about S7's behaviour. However, it is difficult to assess exactly how far one needs to go in this respect and in the case of subject S7 we would require substantially more behavioural data to develop the model further. The iterative process of refining and testing a PS model is likely to be a high cost research activity. The benefits are: increased understanding into the nature of human decision processes and the development of more general process models. However, this highlights what may appear to be an unattractive feature of this type of inductive behavioural research.

Another approach to assessing the process validity of a model is to examine the sequential correspondence of operator application between subject and PS model. An obvious construct to use for this purpose is the Problem Behaviour Graph. So far, we have simply introduced the use of Problem Behaviour Graphs as a means for the researcher to summarise a subject's movement through his/her problem space. There are, however, other advantages of using a PBG for analysing a subject's protocol. First, it allows the protocol data to be easily compared (where appropriate) with more aggregate forms of process data, e.g. search statistics. Second, and more relevant here, is that PBG's can be used to test information processing models. An example of the use of PBG's for this purpose can be found in Bouwman (1983). PBG's provide a summary of the relative frequency with which particular operators are applied and also the sequencing of the operators that reflect the information processing activity of the subject for a particular task domain.

In the present experimental setting we presented our subjects with a large amount of information and in a form that increased the perceived significance of uncertainty. Despite the ill-structured nature of this decision making task, our experimental design did impose a structure on the way each subject considered their product and price decisions. Specifically, each subject was first required to outline their product strategy before considering their price strategy. Finally, each subject examined the financial results of their performance relative to the competitor firm. To some extent, these steps were a logical way to design the experiment; however, they did nonetheless impose a structure on each subject's pattern of information processing behaviour. This in itself is not unrealistic as many real world tasks provide a structure to guide behaviour.

In Chapters 5 and 6 we interpreted our subject's behaviour within the framework of a conceptual model of the strategic decision making process. For example, we were able to observe subjects formulating goals and strategies and evaluating alternative courses of action. These activities had implications for the sequencing and application of the various problem space operators. For the purpose of developing our PS model for S7, we have used the following sequencing of problem space operators.

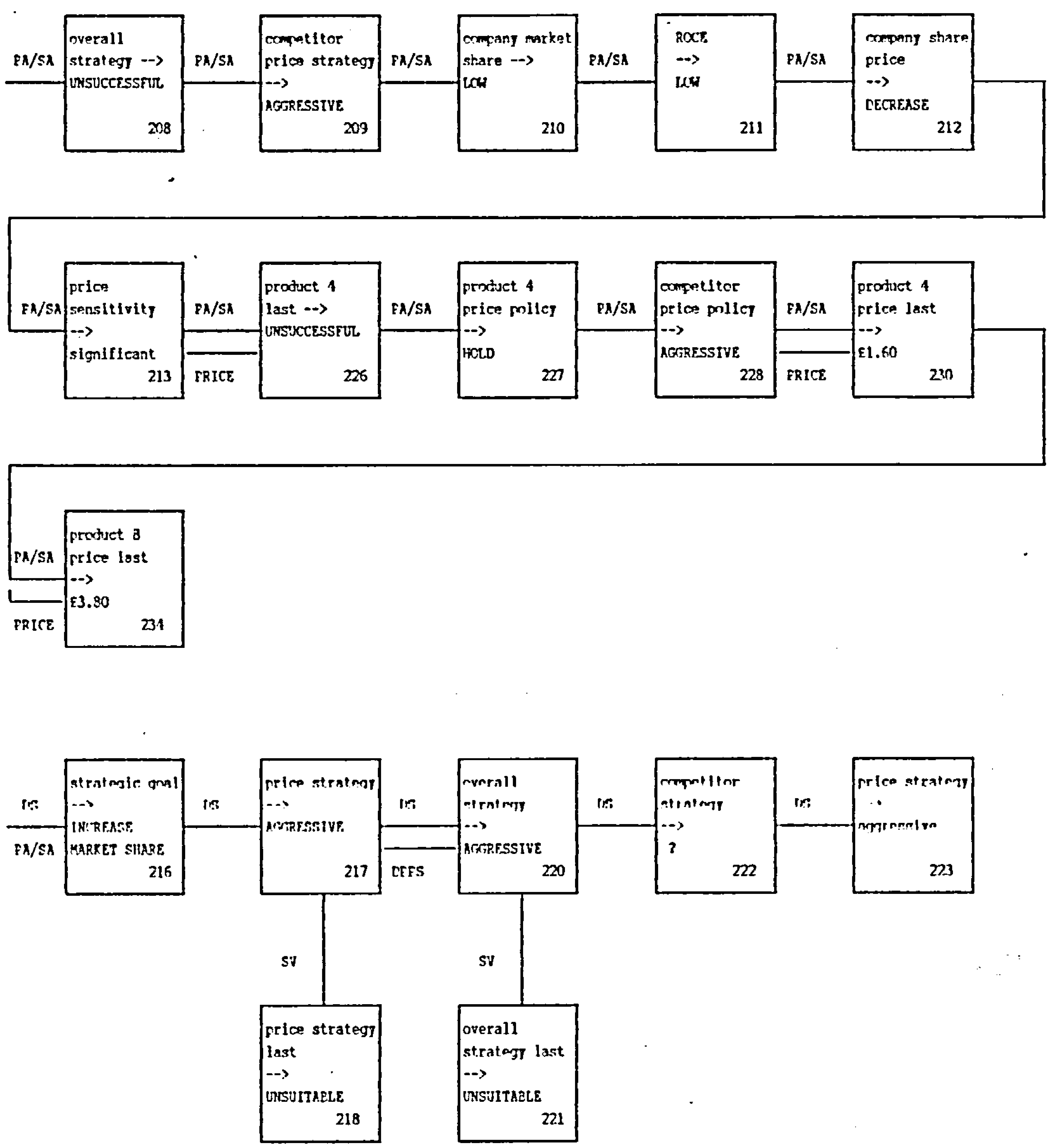
```
SA/PA ------> DS ------> DPPS --------> DPS ----->
                          ^               ^
                          |               |
                        RATIO           PRICE
```

Figure 7.1 provides support for this "pure" sequencing model of S7's application of his global operators. This is also supported by a close examination of the significance of the application of operators outside this pure sequence. From studying S7's protocol, the identification of the various information processing operators was relatively straightforward. However, identifying patterns in the actual sequencing of these operators was a much more ambiguous and difficult task. Clearly, the more ambitious are the research objectives in terms of capturing process detail, the greater the need for a more extensive period of observing subject behaviour. This will allow the development of more refined models of the application and sequencing of problem space operators.

Illustration of the difficulties in placing a structure on the sequencing of information processing activities can be found in S7's protocol. For example, when formulating a price or product strategy (ie. applying the DPS and DPPS operators), the subject often applied the SA/PA operator out of the 'normal' sequence of assessing his performance. It becomes difficult to assess whether this activity represented the subject noting something for the first time or whether he was merely recalling some previously noted information. Given the design of our experiment, we are not able to study the subject's diagnostic behaviour at this level of detail. This in turn has influenced the way in which we have recorded our subject's information processing behaviour. In consequence, we are cannot assess from the protocol data the significance of the firings of the various operators outside our pure sequence model. We can, however, see from the protocol that the subject's topic statements which correspond to our PS trace output for the SA/PA operator do, in general terms, occur in the sequence we have used as the basis of our PS model. That is, the evaluative and interpretive output produced by the SA/PA operator was generated before the subject applied the DS operator.

The validity of the above assessment can best be illustrated by comparing the following two PBG's - one reflecting S7's actual protocol and the other the trace generated by the output of our PS model. As with our comparison of S7's protocol and the PS trace in Figure 7.10, the assessment is only qualitative for the purpose of assessing "goodness of fit". The criterion is not that we are trying to imitate every aspect of S7's behaviour - but instead that we are able to capture the main information processing activities of the subject and their sequencing, as far as they are pertinent to this decision making task. For example, we can observe that the subject formulated goals and the general nature of his strategy before he determined his detailed product and price strategies. Similarly, the subject assessed his and the competitor firm's performance before attempting to formulate his goals and strategy for the next period. The PS model needs to be able to capture these general characteristics of S7's sequencing in his information processing behaviour (ie. the firing of problem space operators). Clearly, for more diagnostic type tasks the sequencing of information processing activities could be important to developing a behavioural process model of subject behaviour.

Figure 7.11 Problem Behaviour Graph: Subject S7 Period 5 ACTUAL Behaviour



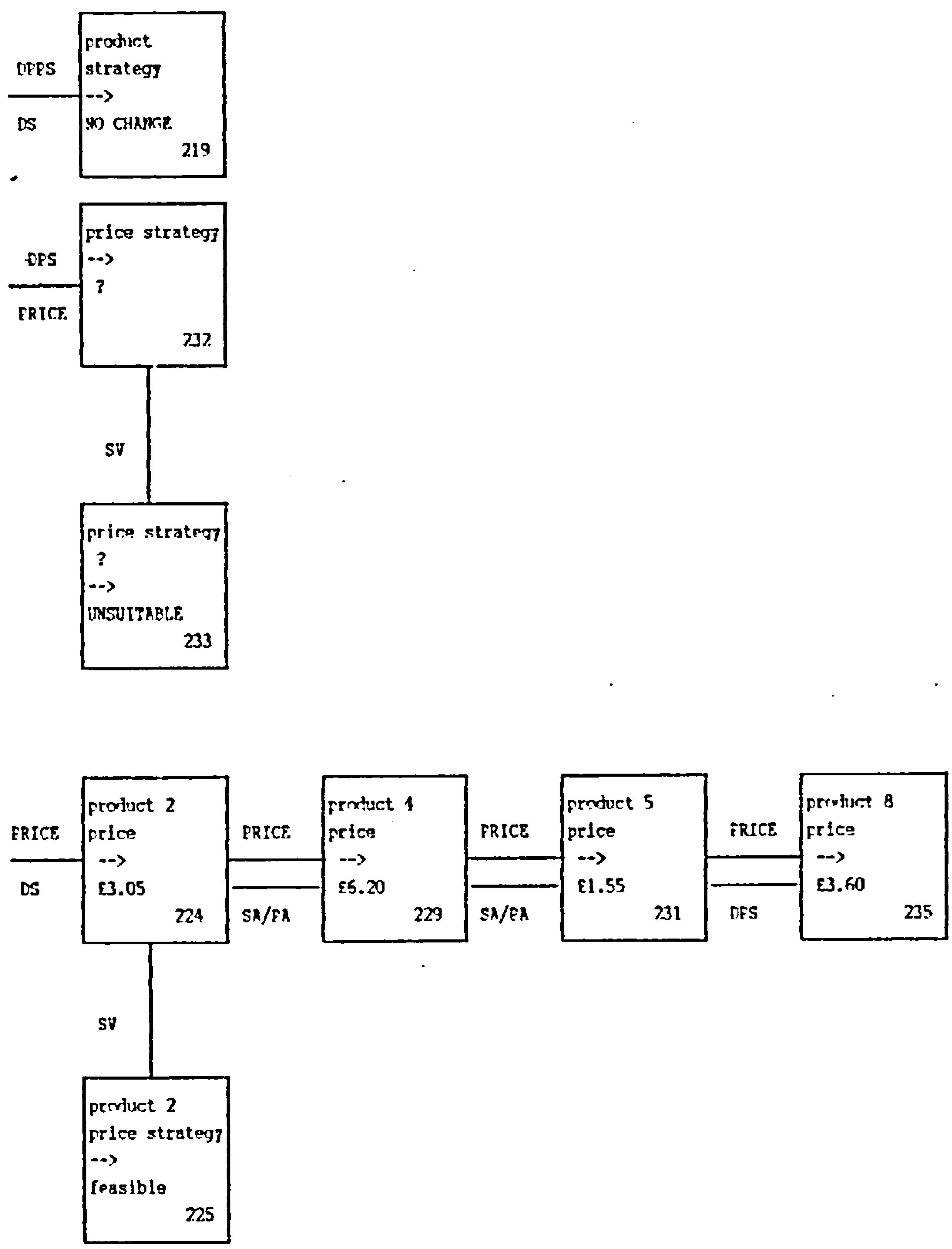
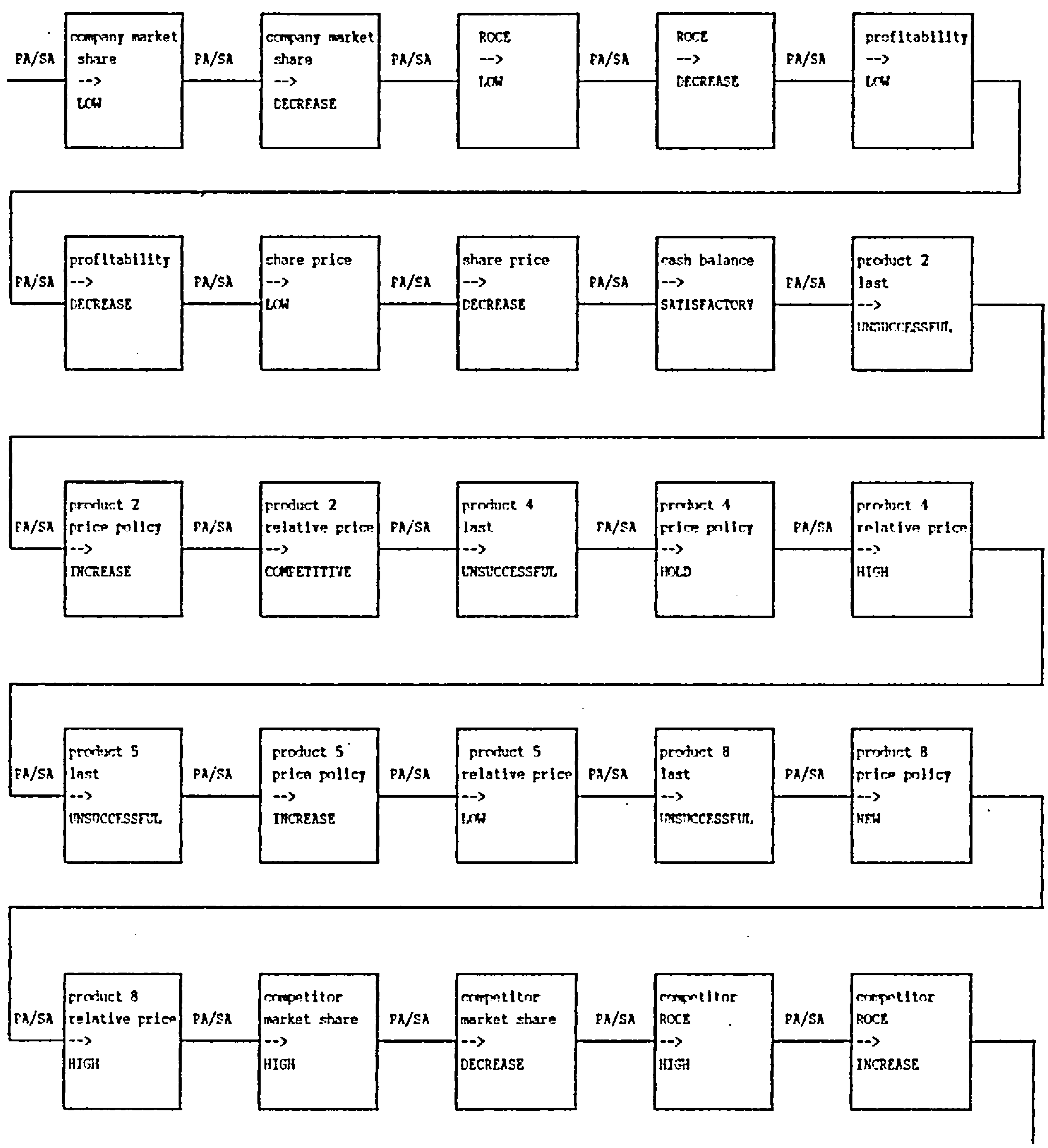
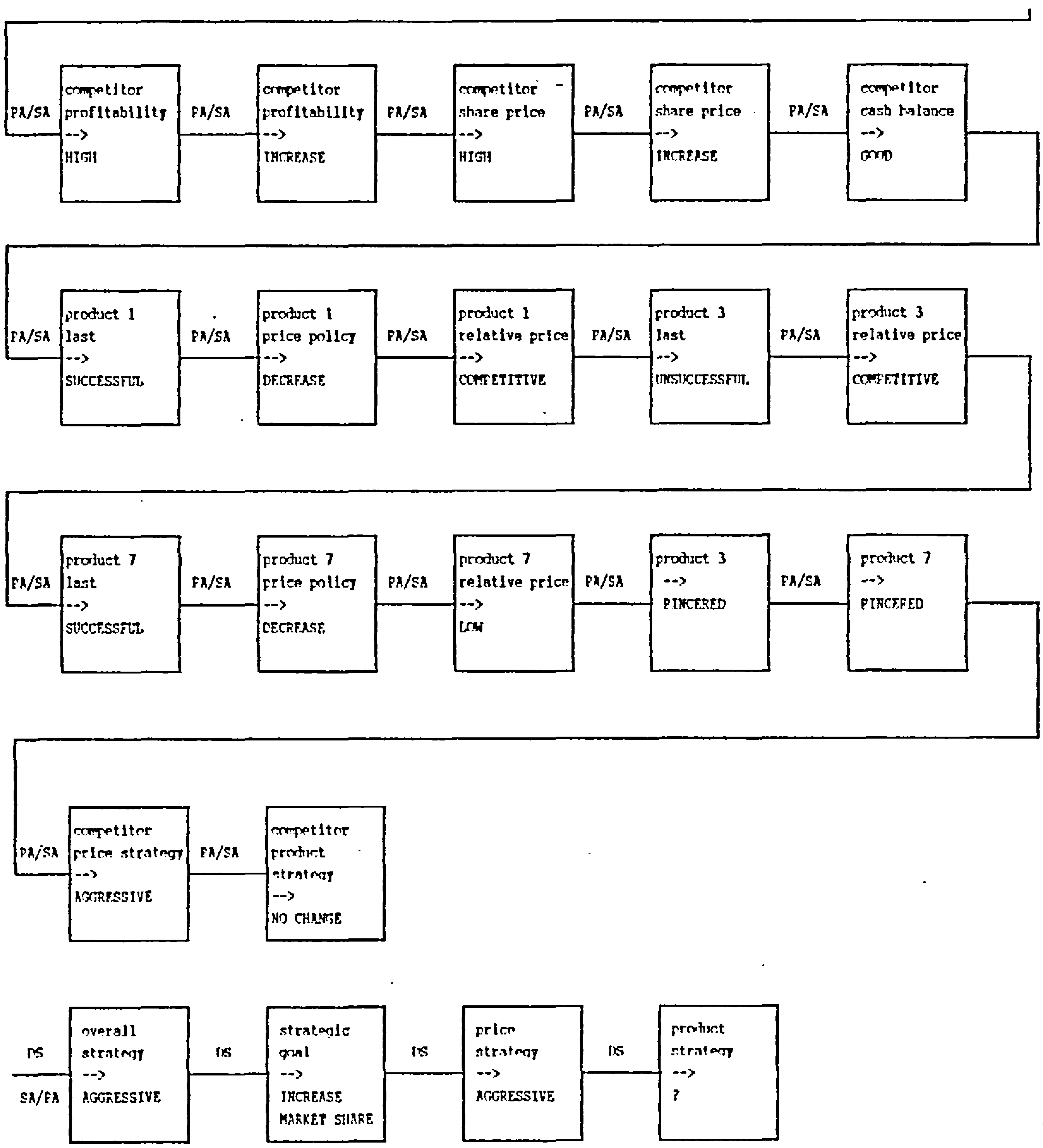
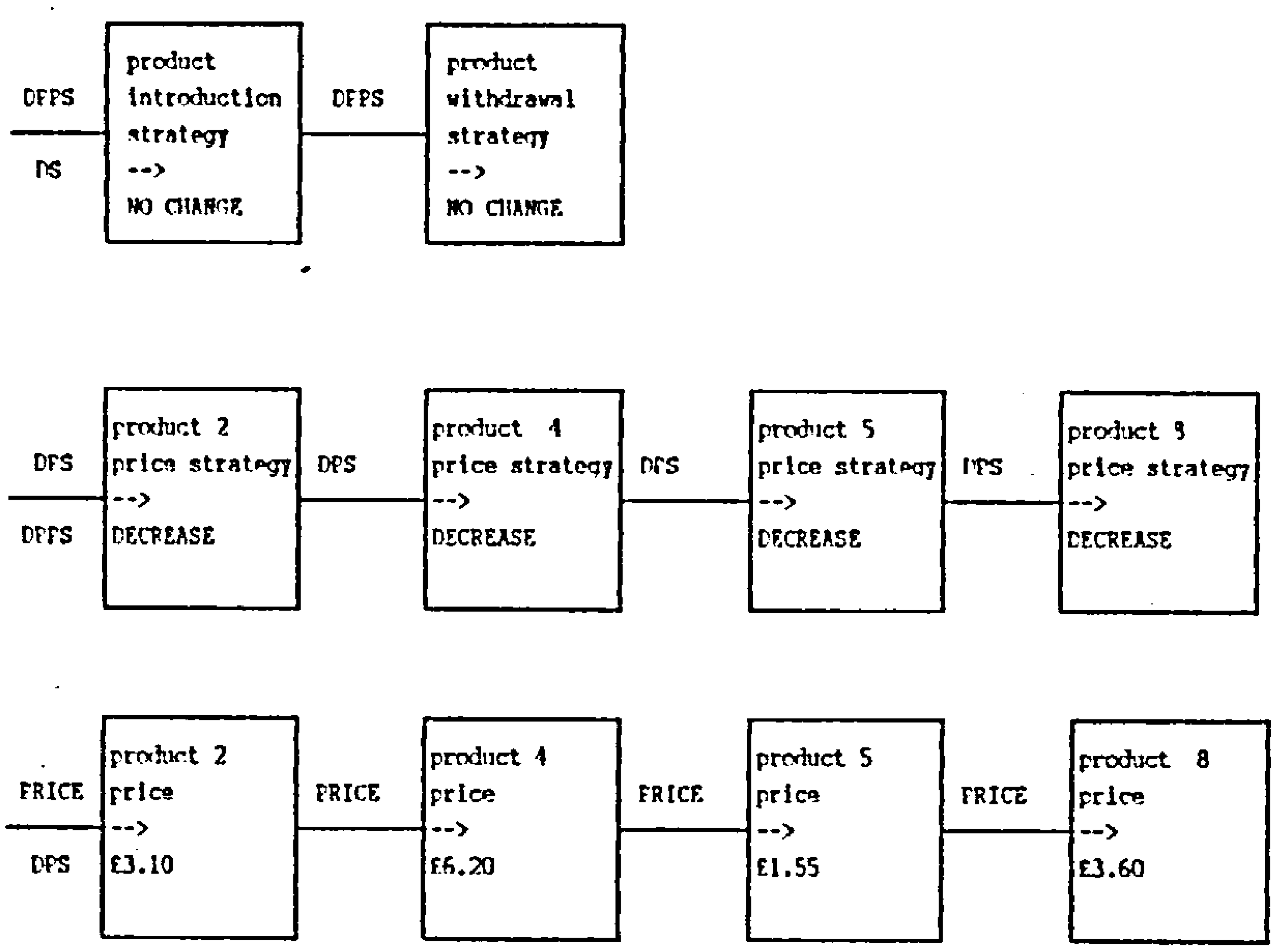

DPPS
DS
product strategy --> NO CHANGE 219
DPS
PRICE
price strategy --> ? 232
SV
price strategy ? --> UNSUITABLE 233
PRICE
DS
product 2 price --> £3.05 224
PRICE
SA/PA
product 4 price --> £6.20 229
PRICE
SA/PA
product 5 price --> £1.55 231
PRICE
DPS
product 8 price --> £3.60 235
SV
product 2 price strategy --> feasible 225

Figure 7.12 Problem Behaviour Graph: Subject S7 Period 5 SIMULATED Behaviour




PA/SA
competitor profitability --> HIGH
PA/SA
competitor profitability --> INCREASE
PA/SA
competitor share price --> HIGH
PA/SA
competitor share price --> INCREASE
PA/SA
competitor cash balance --> GOOD
PA/SA
product 1 last --> SUCCESSFUL
PA/SA
product 1 price policy --> DECREASE
PA/SA
product 1 relative price --> COMPETITIVE
PA/SA
product 3 last --> UNSUCCESSFUL
PA/SA
product 3 relative price --> COMPETITIVE
PA/SA
product 7 last --> SUCCESSFUL
PA/SA
product 7 price policy --> DECREASE
PA/SA
product 7 relative price --> LOW
PA/SA
product 3 --> PINCERED
PA/SA
product 7 --> PINCERED
PA/SA
competitor price strategy --> AGGRESSIVE
PA/SA
competitor product strategy --> NO CHANGE
DS
SA/PA
overall strategy --> AGGRESSIVE
DS
strategic goal --> INCREASE MARKET SHARE
DS
price strategy --> AGGRESSIVE
DS
product strategy --> ?


DFPS
DS
product
introduction
strategy
-->
NO CHANGE
DFPS
product
withdrawal
strategy
-->
NO CHANGE
DPS
DFPS
product 2
price strategy
-->
DECREASE
DPS
product 4
price strategy
-->
DECREASE
DPS
product 5
price strategy
-->
DECREASE
DPS
product 8
price strategy
-->
DECREASE
PRICE
DPS
product 2
price
-->
£3.10
PRICE
product 4
price
-->
£6.20
PRICE
product 5
price
-->
£1.55
PRICE
product 8
price
-->
£3.60

Figures 7.11 and 7.12 present two PBG's. Their purpose is illustration and the comparison could be extended to cover all periods of the simulation. Figure 7.11 is a summary of the actual behaviour of S7 in Period 5 and Figure 7.12 summarises the simulated behaviour of the PS model. The interpretation of these PBG's follows the description in Chapter 5. Each PBG is divided up in terms of the various operators that define the subject's problem space so as to allow for ease of comparison. A double branch indicates a break in the sequence of an operator and we highlight the previous operator below the second branch. As with the comparison made in Figure 7.10, it is clear that the PS model is limited in terms of its ability to capture the subtlety of S7's information processing behaviour. Thus, the phases of the strategic decision making process are more pronounced and distinct in the PS model trace than they are in the subject's actual protocol. Despite these rather obvious differences, Figures 7.11 and 7.12 also highlight the similarity between the PS model's search path through the problem space and S7's actual behaviour.

Inevitably, without a more detailed investigation of S7's behaviour for different decision making tasks, our PS simulation model is more "pure" in a process sense than the actual behaviour of our subject. In this sense the PS model defined in the previous section can be viewed as a prototype model of S7's behaviour for our decision making task. Moreover, it is difficult to assess the behavioural significance of these differences between our PS model trace and S7's behaviour. It appears that S7's deviation from the general sequencing of the operators incorporated in our PS model reflects either stochastic aspects of his behaviour or the result of our incomplete application of an operator sequence that started earlier in a decision period. The difficulty in observing sequential trends in information processing activity for strategic decision making problems has also been noted in the management literature by Mintzberg et al (1976).

It is not difficult to see how a more rigorous form of process criterion for evaluating PS simulation models could be developed by extending the kind of analysis described above. For example, further study might include a detailed examination of the exact information being searched and evaluated at each point in the decision making task in both the protocol and the PS model trace. We could, as a result, generate summary statistics for comparing the relative use of knowledge and operator elements. Of course, the design of the experimental setting and the process of behavioural observation would need to reflect the adoption of a more rigorous process criterion. However, we would be able to develop a more sophisticated HIP model to simulate S7's examination of all the information presented in the exercise. From this we would be able to identify (via the subject's protocol) significant facts and key relations that were the focus of the subject's attention at each stage of the task. Clearly, this would involve studying the behaviour of subject S7 for a considerably longer period of time in other, but similar, decision making tasks. We have, albeit rather crudely, incorporated these types of mechanisms into our behavioural model of S7 in the way we have defined the production rules for the subject's global operators. However, it would be naive to suggest that this represents the full detail of the actual mechanisms used by the subject.

The discussion above highlights that the methodology of protocol analysis has a number of limitations in terms of allowing the researcher to satisfy rigorous model evaluation criteria. For this reason, some authors advocate the use of multi-method approaches to the study of human decision processes [see for example Einhorn, Kleinmuntz and Kleinmuntz (1979)]. In brief, despite the wide use of protocol tracing techniques in cognitive research, there has not emerged a consensus as to how PS simulation models should be evaluated and assessed. One explanation of this is the extensive use of protocol analysis in exploratory studies of decision making in ill-structured task environments [Payne (1982)]. Arguably, this is the area where the technique of protocol analysis has major advantages. For this reason, computer models developed as a result of protocol analysis have largely been tested in terms of whether they validate the researcher's interpretation of a subject's information processing behaviour [see for example Bouwman (1985) and Bouwman et al (1987)]. This focus upon the explanatory power of a model rather than its predictive content is a distinguishing characteristic of PS modelling. Clearly, more hypothesis driven research remains an important direction for future applications of HIP theory. However, there still remains the painstaking task of developing models that provide descriptive insight into the behaviour of complex and poorly understood information processing systems [Simon (1980)]. Business decision making is one such area where greater descriptive insight is required.

One particular problem with our use of protocol analysis for developing S7's PS model is the relatively few periods over which we observed subject behaviour. This is both a strength and a weakness of information processing methodology. While the protocol transcript for S7 reveals a high density of behavioural data, we are only able to infer consistency in information processing activities from a small number of observations. In this context, the systematic rules that we have defined to describe S7's behaviour could, in fact, conceal inconsistencies in judgement. The concern with this problem was the reason for our discussion about the behaviour of other subjects in the previous chapter.

The lack of aggregate statistics to validate the output of our PS model for S7 reflects two important aspects of the present research. First, our research method and its focus upon modelling the detailed information processing behaviour of individual subjects. For this reason we need to qualify the generality of our model in terms of its capacity to predict S7's decision making behaviour and the behaviour of other subjects.

The second aspect relates to the nature of our particular experimental setting. For example, a simpler and well-structured task would have allowed the opportunity to observe subject behaviour for a longer number of repetitive decisions. However, such tasks do not highlight the strengths of protocol analysis as a research technique for studying and modelling human decision processes [Bouwman et al 1987)]. An important objective of the present research has been to demonstrate the value of HIP theory as a framework for the study of decision making behaviour in complex and uncertain task domains. This we view as the high ground of research in behavioural economics and also the area where the limitations of orthodox economic analysis are most evident.

We shall now conclude this chapter with a discussion of how the prototype PS model for S7 could be further tested and developed.

7.4 S7's PS MODEL: GENERALITY AND FURTHER TESTING

The building of a PS model of the type presented for S7 illustrates the role of HIP theory in providing a structured approach to the modelling of human decision processes in behavioural research. The detailed account of our approach in the last three chapters provides a guide for those who might follow a similar methodology in future research. Of course, broader methodological principles will emerge as economists gain a wider experience in the use of these techniques of process modelling.

The previous discussion has highlighted that S7's PS model is a highly particular model of subject behaviour. Before examining how we might further test S7's PS model it is useful to consider the level of generality and predictive content that is likely to characterise the type of process model presented in this chapter. In departing from the research methods of orthodox economics we have focused our attention on the study of actual decision making processes. This highlights the inductive approach of our research method and emphasises that the normative/descriptive distinction becomes blurred for many decision problems that are likely to be of interest to behavioural economists.

Thaler (1987) has challenged the dual role of neoclassical models in economics (ie as normative and descriptive models) for the purpose of modelling choice under conditions of complexity and uncertainty. It is argued that inductive methodology has a role in its own right when studying complex economic behaviour. Of course, behavioural process models may not be as general in their predictions as the normative models of neoclassical economics. Indeed, it is likely that their focus will be on the descriptive and explanatory content of the model. However, this is a reflection of the type of decision problems being studied (and the cognitive psychology of economic agents) rather than simply a limitation of inductive research methods used by behavioural economists. Moreover, it is still possible to generalise and make predictions about decision making behaviour in complex and uncertain task domains [Heiner (1983)]. From the perspective of our own experimental setting and using the technique of protocol analysis, we have shown how it is possible to observe and model patterns in information processing behaviour that reflect the demands of the task domain and the cognitive constraints of the decision maker. Systematic patterns in behaviour across subjects emerged in the form of a number of generic decision making strategies.

It is these systematic elements of a subject's information processing activity that we can generalise and predict. In using protocol analysis to identify these systematic elements of human behaviour we are seeking to discover a subject's problem solving strategies and represent them in the form of production rules. The concept of a strategy is central to our argument and we have discussed the use of the term 'strategy' from the perspectives of both the business policy and cognitive psychology literatures. For good reason (see Chapter 2), the characteristics of strategic decisions are absent from neoclassical models of decision making. The term "problem solving strategy" implies that a task can be carried out in several different ways, depending on the subject's perception of a particular task (ie. there is no optimal solution to the task). Which strategy should be adopted in a given task situation is typically unknown beforehand and specification of all available strategies is likely to be impossible.

The particular nature of strategic decisions raises two important considerations regarding the generality and predictive content of behavioural process models. First, studying differences in behaviour is important to gaining an insight into the general characteristics of decision making strategies. This was demonstrated in Chapter 6. In this sense, adopting a methodology that generalises away differences between the behaviour of decision makers will reduce the level of our understanding of problem solving behaviour in a particular task domain. For example, it will limit our ability to distinguish between good and bad decision strategies and examine the nature of expertise for a particular decision making task.

Second, many complex and uncertain decision making situations represent unique events that are unlikely to be repeated in terms of a specific set of circumstances. This, however, does not mean that general patterns in decision processes (procedural rationality) cannot be observed. For example, the research of Grinyer and Spender (1979) in the management field illustrates the use of inductive research methods for finding patterns and generalisations (recipes) about the strategies used by firms in particular industrial settings. It does suggest, however, that a strategy applied in one set of circumstances is unlikely to be used in exactly the same way in a totally different set of circumstances. It then becomes an issue as to the level at which one can generalise problem solving strategies. The task perspective emphasised in the cognitive psychology literature and the market or industry perspective highlighted in the management literature suggest a common base for the purpose of studying and modelling expertise in business decision making. Of course, the ability of decision makers to adapt and generalise their behaviour to similar environmental conditions that they have previously experienced is also an important aspect of expertise.

In brief, the detailed production rules that define S7's PS model reflect his strategic thinking for the particular decision episode for which his behaviour was observed. However, we have been able to interpret these detailed production rules in terms of a number of generic strategies used by all our subjects. This has allowed us to generalise and contrast S7's behaviour with other subjects and identify the circumstances in which a particular generic strategy might be successful or unsuccessful.

The previous discussion highlights the different levels at which subject behaviour can be modelled within a PS rule framework. Three such levels have been studied in Chapters 5, 6 and 7 and each has implications for the ability to draw general conclusions about information processing behaviour. For example, the different generic pricing and product strategies described in Chapter 6 have validity in terms of research in the business policy and corporate strategy literatures [see, for example, Porter (1980)]. The broad distinction between competitor focus and product differentiation strategies in Chapter 6 can be used to interpret the detailed production rules presented in this chapter. Clearly, for different market and competitive conditions, competitor focus and product differentiation are likely to have advantages and disadvantages as competitive strategies. However, the analysis in this chapter suggests a more general approach to assessing the effectiveness of different strategies. In particular, what is important is the knowledge that is used rather than the application of any sophisticated mechanism for information processing.

This latter point is important within the HIP theory perspective we have adopted. Problem space operators (ie strategies) can usefully be decomposed in terms of the knowledge used and how it is processed. In complex and uncertain tasks a critical problem facing the decision maker is determining what is the appropriate knowledge upon which to focus. Problem perception is an important element of HIP theory and it was the basis for distinguishing between the behaviour of our subjects in Chapter 6 (specifically via the problem space operators). For example, S7's behaviour was characterised by the occasional use of control mechanisms (eg confirmation routines) which emphasise the significance of the build up and modification of his knowledge. This is reflected in S7's interpretation and reasoning about our decision making task. This emphasis upon the strategic significance of knowledge is supported by the general direction of research in the AI and expert systems literature. In particular, knowledge (and expertise) is regarded as highly task specific and it is recognised that the emergence of general problem solving strategies as a basis for distinguishing between good and bad decision makers is a long term research objective.

In sum, the prototype nature of S7's PS model does not allow us to predict the behaviour of other subjects or S7's decisions in other task domains. Moreover, given the nature of our experimental design we were unable to study and model all the different levels of S7's information processing behaviour. For example, the subject's application of deep knowledge and the application and processing of more surface knowledge e.g. the use of the

PRICE and RATIO operators. This highlights what is a recognised problem of the information processing systems view of studying human decision processes in complex and uncertain tasks. As Simon [1980, p 45] has argued:

> "A science of intelligent systems has to be a science of adaptive systems, with all that entails for the difficulty of finding genuine invariants".

Further testing of the PS for S7 could take a number of directions. However, the prototype nature of S7's PS model needs to be highlighted for the purpose of how we might interpret any results. In particular, generalising and predicting from our model is difficult given the single decision episode upon which our model is based and the nature of our experimental setting. It is clear that our PS model could be tested at two levels: (i) a similar task environment and (ii) a different but related task environment. Evidence from research in cognitive psychology [Newell and Simon (1972)] suggests that a large proportion of human behaviour can be accounted for in terms of the behaviour that is demanded by the task. For this reason, it would be unreasonable at this stage to test S7's PS model against the behaviour of the subject in other task environments.

In limiting any testing of our prototype PS model for S7 to a similar task setting, we are faced with various possibilities. For example, we could test our model in modified competitive and market conditions and compare the PS trace with the actual behaviour of the subject. Alternatively, we could simulate the PS model against a variety of different market and competitive conditions and evaluate the robustness of S7's strategies that he used in our actual experimental run. The former approach would require a further period of subject observation. One possibility with this approach would be to simulate the PS model beyond the end period of the experimental run and compare the PS trace with the actual behaviour of S7. Similarly, a development of the second approach could be to run S7's PS model against a number of benchmark strategies. This could be done either for the competitor firm or for comparison with S7's actual strategies.

One problem with conducting these types of tests with S7's PS model is the dynamic and evolving nature of our experimental setting. The difficulty is that S7's protocol reveals that his knowledge was changing from period to period and reflects the fact that our experimental task was not characterised by a finite set of decision outcomes. One implication of this is that our PS model will have limited predictive power in terms of say, for example, individual price values set by S7 in particular decision periods. However, the detailed pricing decisions generated by the PS model reflect both the broad generic strategies used by our subject and the characteristics of the decision episode for which S7's behaviour was observed. We can thus distinguish between decision output and decision process predictions. For example, our PS model would generate broad predictions about strategy, eg. the circumstances in which S7's decisions would reflect a CMBPS type of generic price strategy. Thus, the invariant is unlikely to be a sophisticated pricing rule but the use and processing of certain problem space knowledge elements (ie. the structure of the subject's operators). This, in turn, reflects the way we have defined and evaluated the various generic strategies described in Chapter 6.

The previous argument also emphasises that the kind of predictions generated from testing our PS model will reflect the nature of the experimental task setting. For example, Rae and Reynolds (1987) developed a highly structured experimental task based on a fractional factorial design. This was a simple acquisition decision making task for which there consisted a finite set of decision situations [64 in total, given 6 decision criteria and 2 outcomes for each criterion]. An experiment was conducted on the basis of observing subject behaviour for task situations for a one-quarter replicate.

A protocol transcript was then analysed and a PS model developed. A further quarter replicate was used as data for testing the predictive content of the prototype PS model. The experimental design used in developing our PS model for S7 is not appropriate for conducting this type of analysis. In particular, the Rae and Reynolds study involved presenting subjects with a series of independent and identically structured cases.

Another difficulty with conducting the tests outlined above concerns the need to observe subject behaviour. There are practical difficulties associated with the time costs imposed upon subjects. However, these aside, we face the problem of observing subject behaviour in a similar, though not identical task situation. For example, familiarity with the task structure could reduce the researcher's access (via protocol data) to the decision processes used by the subject [see Ericsson and Simon (1980)]. More importantly, we face the problem that our task domain is dynamic and S7's strategy was evolutionary. This is supported by evidence in the protocol, eg. S7's shift from a differentiation to competitor focus based strategy. In this sense, the knowledge base of our basic PS model for S7 is incomplete and further observation of the subject's behaviour would result in both more refined and additional production rules.

This highlights an important aspect regarding the testing of PS models for the kind of decision making task simulated in our experiment. Developing behavioural process models within a PS framework is an iterative process as expertise for a particular task is rarely, if ever, once and for all defined. As new knowledge emerges or becomes important, an individual adapts their behaviour. The subject's knowledge becomes more extensive and refined as generalised rules begin to emerge. To capture these more generalised rules (as with our attempts to generalise across subjects in terms of a set of generic strategies) requires a lengthy period of subject observation and PS model refinement.

Another approach to testing S7's PS model is to evaluate its capacity to improve our interpretation and understanding of actual firm behaviour. In this respect, our experimental work can be seen as the basis of an approach to capturing the nature of the decision strategies that characterise the behaviour of firms in a specific market setting. One possibility is to present a small sample of practising managers with our experimental task and analyse their behaviour to verify the reasonableness of the generic strategies we identified as being used by our subjects.

This type of test requires us to identify a particular industrial setting that has similar characteristics to our experimental design. One possibility might be the UK package tour market as this could be considered to have many similar features to the competitive and market environment simulated in our experiment. With relatively minor modifications (mostly reflecting aspects of mundane realism), we could present subjects with a realistic task. For example, subjects would be required to price and offer a number of different package holidays (each defined in terms of characteristics C1 and C2, eg. location and climate) to the market each period. The UK package tour market is dominated by a small number of large companies and casual empiricism suggests that the type of behaviour observed of our subjects would not be too dissimilar from the strategies that appears to have reflected actual management practice in that industry during the 1980's.

In summary, given the nature of our decision making task and the limited period over which subject behaviour was observed, the PS model developed in this chapter can be viewed as a prototype. The process of PS modelling is iterative and involves incremental development by further observation of subject behaviour. The problems we have highlighted in the further testing of S7's PS model emphasises both the task specific aspect of human expertise and its adaptive nature. It remains, through further observation and testing, to generalise our PS model and the application of our various generic strategies to particular industrial and market settings.

7.5 CONCLUSION

In this chapter we have presented a PS model for S7. This has involved specifying a number of different production rules that define each global operator in the subject's problem space. While the basic PS model for S7 is incomplete for the purpose of explaining certain features of S7's behaviour, it is not idiosyncratic or the result of incorporating ad hoc rules. Specifically, the reasonableness of our interpretation of S7's strategic behaviour can be examined against the framework provided by the generic pricing and product strategies introduced in the previous chapter.

It is clear that the technique of protocol analysis has focused our attention on the regular patterns in our subject's information processing behaviour. For this reason there are interesting aspects of S7's behaviour (and also other subjects) that we have not been able to incorporate in our PS model. Particularly difficult, given the single decision episode for which S7's behaviour was observed, was capturing his use of meta-level knowledge and control mechanisms. We also faced difficulties in modelling the PRICE and RATIO operators because of 'gaps' in the subject's protocol.

We have suggested how our prototype model could be further tested to verify invariants in S7's behaviour for similar decision making tasks. This would increase the generality and predictive content of our model. In this context, the discussion in this chapter has highlighted the limitations of our experimental design and the technique of protocol analysis. While many of the elements of our PS model for S7 are task specific, they do have generality in terms of the generic strategies used by all the subjects in our experiment. The prototype nature of our PS model also highlights that the inductive nature of our research method is painstakingly slow and general predictions will emerge only after extensive and varied experiments to observe subject behaviour in a wide range of decision making tasks. Of course, these problems reflect the nature of studying human decision processes per se and also the characteristics of many real world tasks and not just the limitations of human information processing methodology.

SUBJECT S7: Production System Model Simulation Trace

This Appendix contains the decision output data for the PS model simulation run of subject S7. This data can be compared with that in Appendix II of this chapter which presents the peformance information for the actual behaviour of S7 and the competitor firm. Inevitably our PS model trace is linguistically more rigid than the protocol transcript of S7.

PS SIMULATION MODEL FOR SUBJECT S7

Decision Period 1 *

Subject S7's Decisions for the Period :

* PA and SA Operators : Period - 1

The following 'significant facts' have been output as a result of simulating S7's PA and SA operators. These form the input to the DS, DPPS, RATIO, DPS and PRICE operators.

Subject S7 - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	LOW	DECREASE
ROCE :	SATISFACTORY	DECREASE
Profitability :	SATISFACTORY	DECREASE
Share Price :	SATISFACTORY	DECREASE
Cash Balance is :	GOOD	

Subject's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
2	SUCCESSFUL	DECREASE	COMPETITIVE

Competitor - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	HIGH	INCREASE
ROCE :	HIGH	DECREASE
Profitability :	HIGH	INCREASE
Share Price :	SATISFACTORY	INCREASE
Cash Balance is :	GOOD	

Competitor's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
1	SUCCESSFUL	DECREASE	COMPETITIVE
3	SUCCESSFUL	NEW	COMPETITIVE

Competitor Target Product is : 3

Competitor's Overall Price Strategy : NON AGGRESSIVE

*DS Operator : Period - 1

The following production rules were 'fired' to simulate the application of the DS operator by subject S7 :

DS Rule 1 - Fired : Output is ...
Overall Strategy --> NON AGGRESSIVE

DS Rule 2 - Fired : Output is ...
Strategic Goal --> INCREASE MARKET SHARE

DS Rule 6 - Fired : Output is ...
Price Strategy --> ?

DS Rule 7 - Fired : Output is ...
Product Strategy --> NON AGGRESSIVE

*DPPS Operator : Period - 1

The following production rules were 'fired' to simulate the application of the DPPS operator by subject S7 :

STEP 1: New Product Introduction.

DPPS Rule 1 - Fired : Output is ...
Product Strategy --> NEW PRODUCT

DPPS Rule 2 - Fired : Output is ...
Portfolio Change --> +1

DPPS Rule 3 - Fired : Output is ...
New Product Type --> HIGH VALUE
Product Strategy Type --> PRODUCT MARKET GAP

STEP 2: Product Withdrawal.

DPPS Rule 4 - Fired : Output is ...
Product Strategy --> NO CHANGE

*RATIO Operator : Period - 1

The following production rules were 'fired' to simulate the application of the RATIO operator by subject S7 :

RATIO Rule 1 - Fired : Output is ...
New Product C-ratio --> C1 = 4.00
--> C2 = 8.00

*DPS Operator : Period - 1

The following production rules were 'fired' to simulate the application of the DPS operator by subject S7 :

DPS Rule 1 - Fired : Output is ...
Price Strategy for Product 2 : HOLD

DPS Rule 6 - Fired : Output is ...
Price Strategy for Product 4 : NEW

*PRICE Operator : Period - 1

The following production rules were 'fired' to simulate the application of the PRICE operator by subject S7 :

PRICE Rule 1 - Fired : Output is ...
Price for Product 2 is 3.60

PRICE Rule 6 - Fired : Output is ...
Price for Product 4 is 6.50

SUBJECT S7 - RESULTS :PERIOD 1

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.60	0.	.00	-750.00
4	4.0	8.0	6.50	6260.	40691.71	2380.13

Total sales revenue for period :	40691.71
Total profit/loss (incl. int.& depcn) for period :	5058.54

Company share of market revenue for period(%) :	68.16
ROCE for period(%):	9.13
Cash balance of company at end of period :	40413.62
Share price at end of period :	1.63

The following summarises S7's performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63

Average profit/loss per period :	5058.54
Average ROCE per period (%) :	9.13

***COMPETITOR FIRM RESULTS: PERIOD 1 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	3.25	14903.21
3	1.00	5.00	3.90	4105.07

Total sales revenue for the period :	19008.29
Total profit/loss (incl. int. & depcn.) for period :	5424.83
Competing firm's share of market revenue for period (%):	31.84
Competitor ROCE for period(%):	10.40
Cash balance of competitor at end of period :	37153.64
Competitor share price at end of period :	1.56

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56

Average profit/loss per period :	5424.83
Average ROCE per period (%):	10.40

Decision Period 2 *

Subject S7's Decisions for the Period :

* PA and SA Operators : Period - 2

The following 'significant facts' have been output as a result of simulating S7's PA and SA operators. These form the input to the DS, DPPS, RATIO, DPS and PRICE operators.

Subject S7 - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	HIGH	INCREASE
ROCE :	SATISFACTORY	DECREASE
Profitability :	SATISFACTORY	UNCHANGED
Share Price :	SATISFACTORY	UNCHANGED
Cash Balance is :	GOOD	

Subject's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
2	UNSUCCESSFUL	HOLD	COMPETITIVE
4	SUCCESSFUL	NEW	LOW

Competitor - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	LOW	DECREASE
ROCE :	SATISFACTORY	DECREASE
Profitability :	SATISFACTORY	DECREASE
Share Price :	SATISFACTORY	DECREASE
Cash Balance is :	SATISFACTORY	

Competitor's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
1	SUCCESSFUL	INCREASE	COMPETITIVE
3	UNSUCCESSFUL	INCREASE	HIGH

Competitor Target Product is : 1

Competitor's Overall Price Strategy : NON AGGRESSIVE

Competitor's Overall Product Strategy : NO CHANGE

*DS Operator : Period - 2

The following production rules were 'fired' to simulate the application of the DS operator by subject S7 :

DS Rule 1 - Fired : Output is ...
Overall Strategy --> NON AGGRESSIVE

DS Rule 3 - Fired : Output is ...
Strategic Goal --> ?

DS Rule 6 - Fired : Output is ...
Price Strategy --> ?

DS Rule 7 - Fired : Output is ...
Product Strategy --> NON AGGRESSIVE

*DPPS Operator : Period - 2

The following production rules were 'fired' to simulate the application of the DPPS operator by subject S7 :

STEP 1: New Product Introduction.

DPPS Rule 1 - Fired : Output is ...
Product Strategy —> NEW PRODUCT

DPPS Rule 2 - Fired : Output is ...
Portfolio Change —> +1

DPPS Rule 3 - Fired : Output is ...
New Product Type —> LOW VALUE
Product Strategy Type —> PRODUCT MARKET GAP

STEP 2: Product Withdrawal.

DPPS Rule 4 - Fired : Output is ...
Product Strategy —> NO CHANGE

*RATIO Operator : Period - 2

The following production rules were 'fired' to simulate the application of the RATIO operator by subject S7 :

RATIO Rule 1 - Fired : Output is ...
New Product C-ratio —> C1 = 2.00
—> C2 = 1.00

*DPS Operator : Period - 2

The following production rules were 'fired' to simulate the application of the DPS operator by subject S7 :

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 2 : DECREASE

DPS Rule 5 - Fired : Output is ...
Price Strategy for Product 4 : INCREASE

DPS Rule 6 - Fired : Output is ...
Price Strategy for Product 5 : NEW

*PRICE Operator : Period - 2

The following production rules were 'fired' to simulate the application of the PRICE operator by subject S7 :

PRICE Rule 3 - Fired : Output is ...
Price for Product 2 is 3.10

PRICE Rule 2 - Fired : Output is ...
Price for Product 4 is 6.70

PRICE Rule 6 - Fired : Output is ...
Price for Product 5 is 1.55

SUBJECT S7 - RESULTS :PERIOD 2

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.10	19345.	59969.52	1184.50
4	4.0	8.0	6.70	0.	.00	-750.00
5	2.0	1.0	1.55	15881.	24616.18	44.07

Total sales revenue for period : 84585.70

Total profit/loss (incl. int.& depcn) for period : 3711.65

Company share of market revenue for period(%) : 49.88

ROCE for period(%): 6.28

Cash balance of company at end of period : 36625.27

Share price at end of period : 1.19

The following summarises S7's performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19

Average profit/loss per period : 4385.10

Average ROCE per period (%) : 7.70

***COMPETITOR FIRM RESULTS: PERIOD 2 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	3.00	1777.10
3	1.00	5.00	3.30	83212.20

Total sales revenue for the period : 84989.30

Total profit/loss (incl. int. & depn.) for period : 9331.68

Competing firm's share of market revenue for period (%): 50.12

Competitor ROCE for period(%): 15.18

Cash balance of competitor at end of period : 46485.32

Competitor share price at end of period : 1.98

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98

Average profit/loss per period : 7378.26

Average ROCE per period (%): 12.79

Decision Period 3 *

Subject S7's Decisions for the Period :

* PA and SA Operators : Period - 3

The following 'significant facts' have been output as a result of simulating S7's PA and SA operators. These form the input to the DS, DPPS, RATIO, DPS and PRICE operators.

Subject S7 - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	SATISFACTORY	DECREASE
ROCE :	LOW	DECREASE
Profitability :	LOW	DECREASE
Share Price :	SATISFACTORY	DECREASE
Cash Balance is :	SATISFACTORY	

Subject's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
2	SUCCESSFUL	DECREASE	LOW
4	UNSUCCESSFUL	INCREASE	HIGH
5	SATISFACTORY	NEW	LOW

Competitor - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	SATISFACTORY	INCREASE
ROCE :	HIGH	INCREASE
Profitability :	HIGH	INCREASE
Share Price :	SATISFACTORY	INCREASE
Cash Balance is :	GOOD	

Competitor's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
1	UNSUCCESSFUL	DECREASE	HIGH
3	SUCCESSFUL	DECREASE	COMPETITIVE

Competitor's Overall Price Strategy : AGGRESSIVE

Competitor's Overall Product Strategy : NO CHANGE.

*DS Operator : Period - 3

The following production rules were 'fired' to simulate the application of the DS operator by subject S7 :

DS Rule 1 - Fired : Output is ...
Overall Strategy —> NON AGGRESSIVE

DS Rule 3 - Fired : Output is ...
Strategic Goal —> ?

DS Rule 6 - Fired : Output is ...
Price Strategy —> ?

DS Rule 7 - Fired : Output is ...
Product Strategy —> ?

*DPPS Operator : Period - 3

The following production rules were 'fired' to simulate the application of the DPPS operator by subject S7 :

STEP 1: New Product Introduction.

DPPS Rule 1 - Fired : Output is ...
Product Strategy —> NO CHANGE

STEP 2: Product Withdrawal.

DPPS Rule 4 - Fired : Output is ...
Product Strategy --> NO CHANGE

*DPS Operator : Period - 3

The following production rules were 'fired' to simulate the application of the DPS operator by subject S7 :

DPS Rule 1 - Fired : Output is ...
Price Strategy for Product 2 : HOLD

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 4 : DECREASE

DPS Rule 1 - Fired : Output is ...
Price Strategy for Product 5 : HOLD

*PRICE Operator : Period - 3

The following production rules were 'fired' to simulate the application of the PRICE operator by subject S7 :

PRICE Rule 1 - Fired : Output is ...
Price for Product 2 is 3.10

PRICE Rule 5 - Fired : Output is ...
Price for Product 4 is 6.30

PRICE Rule 1 - Fired : Output is ...
Price for Product 5 is 1.55

SUBJECT S7 - RESULTS :PERIOD 3

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.10	13777.	42708.29	627.68
4	4.0	8.0	6.30	8411.	52988.40	1773.26
5	2.0	1.0	1.55	20218.	31338.62	260.92

Total sales revenue for period : 127035.30

Total profit/loss (incl. int.& depcn) for period : 5591.89

Company share of market revenue for period(%) : 67.54

ROCE for period(%): 8.64

Cash balance of company at end of period : 42217.16

Share price at end of period : 1.40

The following summarises S7's performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	127035.30	67.54	5591.89	8.64	1.40

Average profit/loss per period : 4787.36

Average ROCE per period (%) : 8.02

***COMPETITOR FIRM RESULTS: PERIOD 3 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.73	32359.76
3	1.00	5.00	3.47	28704.93
7	2.00	2.30	2.35	.00

Total sales revenue for the period :	61064.70
Total profit/loss (incl. int. & depn.) for period :	8072.89
Competing firm's share of market revenue for period (%):	32.46
Competitor ROCE for period(%):	11.61
Cash balance of competitor at end of period :	47058.21
Competitor share price at end of period :	1.61

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**New product launched by competitor this period :

PRODUCT	C1	C2	PRICE
7	2.00	2.30	2.35

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	61064.70	32.46	8072.89	11.61	1.61

Average profit/loss per period :	7609.80
Average ROCE per period (%):	12.39

Decision Period 4 *

Subject S7's Decisions for the Period :

* PA and SA Operators : Period - 4

The following 'significant facts' have been output as a result of simulating S7's PA and SA operators. These form the input to the DS, DPPS, RATIO, DPS and PRICE operators.

Subject S7 - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	HIGH	INCREASE
ROCE :	SATISFACTORY	INCREASE
Profitability :	LOW	INCREASE
Share Price :	SATISFACTORY	INCREASE
Cash Balance is :	GOOD	

Subject's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
2	SATISFACTORY	HOLD	LOW
4	SATISFACTORY	DECREASE	HIGH
5	SATISFACTORY	HOLD	LOW

Competitor - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	LOW	DECREASE
ROCE :	SATISFACTORY	DECREASE
Profitability :	HIGH	DECREASE
Share Price :	SATISFACTORY	DECREASE
Cash Balance is :	GOOD	

Competitor's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
1	SUCCESSFUL	DECREASE	COMPETITIVE
3	SUCCESSFUL	INCREASE	HIGH
7	UNSUCCESSFUL	NEW	COMPETITIVE

Competitor Target Product is : 3

Competitor Product 7 is PINCERED

Competitor's Overall Price Strategy : NON AGGRESSIVE

*DS Operator : Period - 4

The following production rules were 'fired' to simulate the application of the DS operator by subject S7 :

DS Rule 1 - Fired : Output is ...
Overall Strategy —> NON AGGRESSIVE

DS Rule 4 - Fired : Output is ...
Strategic Goal —> INCREASE PROFITABILITY

DS Rule 5 - Fired : Output is ...
Price Strategy —> NON AGGRESSIVE

DS Rule 7 - Fired : Output is ...
Product Strategy —> AGGRESSIVE

*DPPS Operator : Period - 4

The following production rules were 'fired' to simulate the application of the DPPS operator by subject S7 :

STEP 1: New Product Introduction.

DPPS Rule 1 - Fired : Output is ...
Product Strategy —> NEW PRODUCT

DPPS Rule 2 - Fired : Output is ...
Portfolio Change —> +1

DPPS Rule 3 - Fired : Output is ...
New Product Type —> COMPETING PRODUCT
Product Strategy Type —> PINCER MOVEMENT

STEP 2: Product Withdrawal.

DPPS Rule 4 - Fired : Output is ...
Product Strategy —> NO CHANGE

*RATIO Operator : Period - 4

The following production rules were 'fired' to simulate the application of the RATIO operator by subject S7 :

RATIO Rule 2 - Fired : Output is ...
New Product C-ratio --> C1 = 1.00
--> C2 = 6.00

*DPS Operator : Period - 4

The following production rules were 'fired' to simulate the application of the DPS operator by subject S7 :

DPS Rule 5 - Fired : Output is ...
Price Strategy for Product 2 : INCREASE

DPS Rule 2 - Fired : Output is ...
Price Strategy for Product 4 : HOLD

DPS Rule 5 - Fired : Output is ...
Price Strategy for Product 5 : INCREASE

DPS Rule 6 - Fired : Output is ...
Price Strategy for Product 8 : NEW

*PRICE Operator : Period - 4

The following production rules were 'fired' to simulate the application of the PRICE operator by subject S7 :

PRICE Rule 2 - Fired : Output is ...
Price for Product 2 is 3.20

PRICE Rule 1 - Fired : Output is ...
Price for Product 4 is 6.30

PRICE Rule 2 - Fired : Output is ...
Price for Product 5 is 1.60

PRICE Rule 7 - Fired : Output is ...
Price for Product 8 is 3.80

SUBJECT S7 - RESULTS :PERIOD 4

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.20	0.	.00	-750.00
4	4.0	8.0	6.30	4541.	28608.74	612.32
5	2.0	1.0	1.60	0.	.00	-750.00
8	1.0	6.0	3.80	2842.	10799.89	102.62

Total sales revenue for period : 39408.63

Total profit/loss (incl. int.& depcn) for period : 2592.32

Company share of market revenue for period(%) : 12.91

ROCE for period(%): 3.85

Cash balance of company at end of period : 37309.47

Share price at end of period : .97

The following summarises S7's performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	127035.30	67.54	5591.89	8.64	1.40
4	39408.63	12.91	2592.32	3.85	.97

Average profit/loss per period : 4238.60

Average ROCE per period (%) : 6.97

***COMPETITOR FIRM RESULTS: PERIOD 4 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.68	150427.90
3	1.00	5.00	3.21	27799.89
7	2.00	2.30	2.26	87713.52

Total sales revenue for the period : 265941.30

Total profit/loss (incl. int. & depm.) for period : 17359.91

Competing firm's share of market revenue for period (%): 87.09

Competitor ROCE for period(%): 19.97

Cash balance of competitor at end of period : 64418.11

Competitor share price at end of period : 2.09

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	61064.70	32.46	8072.89	11.61	1.61
4	265941.30	87.09	17359.91	19.97	2.09

Average profit/loss per period : 10047.33

Average ROCE per period (%): 14.29

Decision Period 5 *

Subject S7's Decisions for the Period :

* PA and SA Operators : Period - 5

The following 'significant facts' have been output as a result of simulating S7's PA and SA operators. These form the input to the DS, DPPS, RATIO, DPS and PRICE operators.

Subject S7 - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	LOW	DECREASE
ROCE :	LOW	DECREASE
Profitability :	LOW	DECREASE
Share Price :	LOW	DECREASE
Cash Balance is :	SATISFACTORY	

Subject's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
2	UNSUCCESSFUL	INCREASE	COMPETITIVE
4	UNSUCCESSFUL	HOLD	HIGH
5	UNSUCCESSFUL	INCREASE	LOW
8	UNSUCCESSFUL	NEW	HIGH

Competitor - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	HIGH	INCREASE
ROCE :	HIGH	INCREASE
Profitability :	HIGH	INCREASE
Share Price :	HIGH	INCREASE
Cash Balance is :	GOOD	

Competitor's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
1	SUCCESSFUL	DECREASE	COMPETITIVE
3	UNSUCCESSFUL	DECREASE	COMPETITIVE
7	SUCCESSFUL	DECREASE	LOW

Competitor Product 3 is PINCHED

Competitor Product 7 is PINCHED

Competitor's Overall Price Strategy : AGGRESSIVE

Competitor's Overall Product Strategy : NO CHANGE

*DS Operator : Period - 5

The following production rules were 'fired' to simulate the application of the DS operator by subject S7 :

DS Rule 1 - Fired : Output is ...
Overall Strategy --> AGGRESSIVE

DS Rule 2 - Fired : Output is ...
Strategic Goal --> INCREASE MARKET SHARE

DS Rule 6 - Fired : Output is ...
Price Strategy --> AGGRESSIVE

DS Rule 7 - Fired : Output is ...
Product Strategy --> ?

*DPPS Operator : Period - 5

The following production rules were 'fired' to simulate the application of the DPPS operator by subject S7 :

STEP 1: New Product Introduction.

DPPS Rule 1 - Fired : Output is ...
Product Strategy --> NO CHANGE

STEP 2: Product Withdrawal.

DPPS Rule 4 - Fired : Output is ...
Product Strategy --> NO CHANGE

*DPS Operator : Period - 5

The following production rules were 'fired' to simulate the application of the DPS operator by subject S7 :

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 2 : DECREASE

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 4 : DECREASE

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 5 : DECREASE

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 8 : DECREASE

*PRICE Operator : Period - 5

The following production rules were 'fired' to simulate the application of the PRICE operator by subject S7 :

PRICE Rule 3 - Fired : Output is ...
Price for Product 2 is 3.10

PRICE Rule 3 - Fired : Output is ...
Price for Product 4 is 6.20

PRICE Rule 3 - Fired : Output is ...
Price for Product 5 is 1.55

PRICE Rule 3 - Fired : Output is ...
Price for Product 8 is 3.60

SUBJECT S7 - RESULTS :PERIOD 5

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.10	0.	.00	-750.00
4	4.0	8.0	6.20	0.	.00	-750.00
5	2.0	1.0	1.55	131789.	204273.70	5839.47
8	1.0	6.0	3.60	14210.	51155.34	670.98

Total sales revenue for period : 255429.00

Total profit/loss (incl. int.& depcn) for period : 7995.23

Company share of market revenue for period(%) : 64.50

ROCE for period(%): 10.62

Cash balance of company at end of period : 45304.70

Share price at end of period : 1.20

The following summarises S7's performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	127035.30	67.54	5591.89	8.64	1.40
4	39408.63	12.91	2592.32	3.85	.97
5	255429.00	64.50	7995.23	10.62	1.20

Average profit/loss per period : 4989.92

Average ROCE per period (%) : 7.70

***COMPETITOR FIRM RESULTS: PERIOD 5 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.68	140571.00
3	1.00	5.00	3.21	.00
7	2.00	2.30	2.26	.00

Total sales revenue for the period : 140571.00

Total profit/loss (incl. int. & depn.) for period : 12106.51

Competing firm's share of market revenue for period (%): 35.50

Competitor ROCE for period(%): 12.23

Cash balance of competitor at end of period : 76524.63

Competitor share price at end of period : 1.53

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	61064.70	32.46	8072.89	11.61	1.61
4	265941.30	87.09	17359.91	19.97	2.09
5	140571.00	35.50	12106.51	12.23	1.53

Average profit/loss per period : 10459.16

Average ROCE per period (%): 13.88

Decision Period 6 *

Subject S7's Decisions for the Period :

* PA and SA Operators : Period - 6

The following 'significant facts' have been output as a result of simulating S7's PA and SA operators. These form the input to the DS, DPPS, RATIO, DPS and PRICE operators.

Subject S7 - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	HIGH	INCREASE
ROCE :	SATISFACTORY	INCREASE
Profitability :	LOW	INCREASE
Share Price :	SATISFACTORY	INCREASE
Cash Balance is :	GOOD	

Subject's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
2	UNSUCCESSFUL	DECREASE	COMPETITIVE
4	UNSUCCESSFUL	DECREASE	LOW
5	SUCCESSFUL	DECREASE	COMPETITIVE
8	SATISFACTORY	DECREASE	COMPETITIVE

Competitor - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	LOW	DECREASE
ROCE :	SATISFACTORY	DECREASE
Profitability :	HIGH	DECREASE
Share Price :	SATISFACTORY	DECREASE
Cash Balance is :	GOOD	

Competitor's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
1	SUCCESSFUL	HOLD	COMPETITIVE
3	UNSUCCESSFUL	HOLD	LOW
7	UNSUCCESSFUL	HOLD	COMPETITIVE

Competitor Target Product is : 1

Competitor Product 3 is PINCERED

Competitor Product 7 is PINCERED

Competitor's Overall Price Strategy : NON AGGRESSIVE

Competitor's Overall Product Strategy : NO CHANGE

*DS Operator : Period - 6

The following production rules were 'fired' to simulate the application of the DS operator by subject S7 :

DS Rule 1 - Fired : Output is ...
Overall Strategy —> NON AGGRESSIVE

DS Rule 4 - Fired : Output is ...
Strategic Goal —> INCREASE PROFITABILITY

DS Rule 5 - Fired : Output is ...
Price Strategy —> NON AGGRESSIVE

DS Rule 7 - Fired : Output is ...
Product Strategy —> AGGRESSIVE

*DPPS Operator : Period - 6

The following production rules were 'fired' to simulate the application of the DPPS operator by subject S7 :

STEP 1: New Product Introduction.

DPPS Rule 1 - Fired : Output is ...
Product Strategy —> NEW PRODUCT

DPPS Rule 2 - Fired : Output is ...
Portfolio Change —> +1

DPPS Rule 3 - Fired : Output is ...
New Product Type —> COMPETING PRODUCT
Product Strategy Type —> PINCER MOVEMENT

STEP 2: Product Withdrawal.

DPPS Rule 4 - Fired : Output is ...
Product Strategy —> NO CHANGE

*RATIO Operator : Period - 6

The following production rules were 'fired' to simulate the application of the RATIO operator by subject S7 :

RATIO Rule 2 - Fired : Output is ...
New Product C-ratio —> C1 = 5.00
—> C2 = 1.00

*DPS Operator : Period - 6

The following production rules were 'fired' to simulate the application of the DPS operator by subject S7 :

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 2 : DECREASE

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 4 : DECREASE

DPS Rule 2 - Fired : Output is ...
Price Strategy for Product 5 : HOLD

DPS Rule 2 - Fired : Output is ...
Price Strategy for Product 8 : HOLD

DPS Rule 6 - Fired : Output is ...
Price Strategy for Product 9 : NEW

*PRICE Operator : Period - 6

The following production rules were 'fired' to simulate the application of the PRICE operator by subject S7 :

PRICE Rule 4 - Fired : Output is ...
Price for Product 2 is 3.05

PRICE Rule 5 - Fired : Output is ...
Price for Product 4 is 6.10

PRICE Rule 1 - Fired : Output is ...
Price for Product 5 is 1.55

PRICE Rule 1 - Fired : Output is ...
Price for Product 8 is 3.60

PRICE Rule 7 - Fired : Output is ...
Price for Product 9 is 3.05

SUBJECT S7 - RESULTS :PERIOD 6

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.05	51162.	156044.20	1808.09
4	4.0	8.0	6.10	14656.	89402.98	715.63
5	2.0	1.0	1.55	0.	.00	-750.00
8	1.0	6.0	3.60	38427.	138338.80	3092.73
9	5.0	1.0	3.05	62431.	190414.00	2371.55

Total sales revenue for period : 574200.00

Total profit/loss (incl. int.& depcn) for period : 10862.38

Company share of market revenue for period(%) : 100.00

ROCE for period(%): 12.61

Cash balance of company at end of period : 48667.07

Share price at end of period : 1.42

The following summarises S7's performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	127035.30	67.54	5591.89	8.64	1.40
4	39408.63	12.91	2592.32	3.85	.97
5	255429.00	64.50	7995.23	10.62	1.20
6	574200.00	100.00	10862.38	12.61	1.42

Average profit/loss per period : 5968.67

Average ROCE per period (%) : 8.52

***COMPETITOR FIRM RESULTS: PERIOD 6 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.68	.00
3	1.00	5.00	3.15	.00
10	1.50	4.88	3.32	.00

Total sales revenue for the period : .00

Total profit/loss (incl. int. & depn.) for period : -1128.03

Competing firm's share of market revenue for period (%): .00

Competitor ROCE for period(%): 3.96

Cash balance of competitor at end of period : 75396.59

Competitor share price at end of period : .95

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**New product launched by competitor this period :

PRODUCT	C1	C2	PRICE
10	1.50	4.88	3.32

**Products withdrawn by competitor this period :

PRODUCT	C1	C2
7	2.00	2.30

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	61064.70	32.46	8072.89	11.61	1.61
4	265941.30	87.09	17359.91	19.97	2.09
5	140571.00	35.50	12106.51	12.23	1.53
6	.00	.00	-1128.03	3.96	.95

Average profit/loss per period : 8527.96

Average ROCE per period (%): 12.22

Decision Period 7 *

Subject S7's Decisions for the Period :

* PA and SA Operators : Period - 7

The following 'significant facts' have been output as a result of simulating S7's PA and SA operators. These form the input to the DS, DPPS, RATIO, DPS and PRICE operators.

Subject S7 - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	HIGH	INCREASE
ROCE :	SATISFACTORY	INCREASE
Profitability :	HIGH	INCREASE
Share Price :	SATISFACTORY	INCREASE
Cash Balance is :	GOOD	

Subject's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
2	SATISFACTORY	DECREASE	LOW
4	SATISFACTORY	DECREASE	HIGH
5	UNSUCCESSFUL	HOLD	LOW
8	SATISFACTORY	HOLD	LOW
9	SUCCESSFUL	NEW	COMPETITIVE

Competitor - Performance :

	LEVEL LAST PERIOD	CHANGE LAST PERIOD
Market Share :	LOW	DECREASE
ROCE :	LOW	DECREASE
Profitability :	LOW	DECREASE
Share Price :	LOW	DECREASE
Cash Balance is :	GOOD	

Competitor's Product Performance Last Period :

Product No.	Market Share	Price Policy	Relative Price
1	UNSUCCESSFUL	HOLD	LOW
3	UNSUCCESSFUL	DECREASE	HIGH
10	UNSUCCESSFUL	NEW	LOW

Competitor Target Product is : 0

Competitor Product 1 is PINCERED

Competitor's Overall Price Strategy : NON AGGRESSIVE

Product Withdrawn :

PRODUCT 7

*DS Operator : Period - 7

The following production rules were 'fired' to simulate the application of the DS operator by subject S7 :

DS Rule 1 - Fired : Output is ...
Overall Strategy --> AGGRESSIVE

DS Rule 2 - Fired : Output is ...
Strategic Goal --> INCREASE MARKET SHARE

DS Rule 6 - Fired : Output is ...
Price Strategy --> AGGRESSIVE

DS Rule 7 - Fired : Output is ...
Product Strategy --> ?

*DPPS Operator : Period - 7

The following production rules were 'fired' to simulate the application of the DPPS operator by subject S7 :

STEP 1: New Product Introduction.

DPPS Rule 1 - Fired : Output is ...
Product Strategy --> NO CHANGE

STEP 2: Product Withdrawal.

DPPS Rule 4 - Fired : Output is ...
Product Strategy --> NO CHANGE

*DPS Operator : Period - 7

The following production rules were 'fired' to simulate the application of the DPS operator by subject S7 :

DPS Rule 4 - Fired : Output is ...
Price Strategy for Product 2 : DECREASE

DPS Rule 4 - Fired : Output is ...
Price Strategy for Product 4 : DECREASE

DPS Rule 3 - Fired : Output is ...
Price Strategy for Product 5 : DECREASE

DPS Rule 4 - Fired : Output is ...
Price Strategy for Product 8 : DECREASE

DPS Rule 4 - Fired : Output is ...
Price Strategy for Product 9 : DECREASE

*PRICE Operator : Period - 7

The following production rules were 'fired' to simulate the application of the PRICE operator by subject S7 :

PRICE Rule 4 - Fired : Output is ...
Price for Product 2 is 3.04

PRICE Rule 4 - Fired : Output is ...
Price for Product 4 is 6.05

PRICE Rule 4 - Fired : Output is ...
Price for Product 5 is 1.54

PRICE Rule 4 - Fired : Output is ...
Price for Product 8 is 3.55

PRICE Rule 4 - Fired : Output is ...
Price for Product 9 is 3.04

SUBJECT S7 - RESULTS :PERIOD 7

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.04	0.	.00	-750.00
4	4.0	8.0	6.05	31990.	193539.60	849.52
5	2.0	1.0	1.54	0.	.00	-750.00
8	1.0	6.0	3.55	14384.	51063.70	-30.79
9	5.0	1.0	3.04	83723.	254519.20	2598.94

Total sales revenue for period : 499122.50

Total profit/loss (incl. int.& depcn) for period : 5810.99

Company share of market revenue for period(%) : 90.75

ROCE for period(%): 6.32

Cash balance of company at end of period : 54478.07

Share price at end of period : 1.14

The following summarises S7's performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	127035.30	67.54	5591.89	8.64	1.40
4	39408.63	12.91	2592.32	3.85	.97
5	255429.00	64.50	7995.23	10.62	1.20
6	574200.00	100.00	10862.38	12.61	1.42
7	499122.50	90.75	5810.99	6.32	1.14

Average profit/loss per period : 5946.14

Average ROCE per period (%) : 8.21

***COMPETITOR FIRM RESULTS: PERIOD 7 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
10	1.50	4.88	3.22	50877.51
11	4.00	2.40	3.30	.00

Total sales revenue for the period :	50877.51
Total profit/loss (incl. int. & depm.) for period :	-4964.54
Competing firm's share of market revenue for period (%):	9.25
Competitor ROCE for period(%):	5.42
Cash balance of competitor at end of period :	77932.05
Competitor share price at end of period :	.69

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**New product launched by competitor this period :

PRODUCT	C1	C2	PRICE
11	4.00	2.40	3.30

**Products withdrawn by competitor this period :

PRODUCT	C1	C2
1	4.00	1.00
3	1.00	5.00

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	61064.70	32.46	8072.89	11.61	1.61
4	265941.30	87.09	17359.91	19.97	2.09
5	140571.00	35.50	12106.51	12.23	1.53
6	.00	.00	-1128.03	3.96	.95
7	50877.51	9.25	-4964.54	5.42	.69

Average profit/loss per period :	6600.46
Average ROCE per period (%):	11.25

****END OF PS MODEL SIMULATION TRACE FOR SUBJECT S7****

CHAPTER 7 - APPENDIX II

This Appendix contains a summary of the financial performance for subject S7 and the competitor firm in the actual decision making task. The decision output data can be compared with S7's PS model trace in Appendix I of this chapter.

SUBJECT S7 RESULTS :PERIOD 1

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.60	0.	.00	-750.00
4	4.0	8.0	6.50	6260.	40691.71	2380.13

Total sales revenue for period : 40691.71

Total profit/loss (incl. int.& depcn) for period : 5058.54

Company share of market revenue for period(%) : 68.16

ROCE for period(%): 9.13

Cash balance of company at end of period : 40413.62

Share price at end of period : 1.63

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63

Average profit/loss per period : 5058.54

Average ROCE per period (%) : 9.13

***COMPETITOR FIRM RESULTS: PERIOD 1 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	3.25	14903.21
3	1.00	5.00	3.90	4105.07

Total sales revenue for the period : 19008.29

Total profit/loss (incl. int. & depcn.) for period : 5424.83

Competing firm's share of market revenue for period (%): 31.84

Competitor ROCE for period(%): 10.40

Cash balance of competitor at end of period : 37153.64

Competitor share price at end of period : 1.56

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56

Average profit/loss per period : 5424.83

Average ROCE per period (%): 10.40

SUBJECT S7 RESULTS :PERIOD 2

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.10	19345.	59969.52	1184.50
4	4.0	8.0	6.70	0.	.00	-750.00
5	2.0	1.0	1.55	15881.	24616.18	44.07

Total sales revenue for period : 84585.70

Total profit/loss (incl. int.& depcn) for period : 3711.65

Company share of market revenue for period(%) : 49.88

ROCE for period(%): 6.28

Cash balance of company at end of period : 36625.27

Share price at end of period : 1.19

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE (%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19

Average profit/loss per period : 4385.10

Average ROCE per period (%) : 7.70

***COMPETITOR FIRM RESULTS: PERIOD 2 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	3.00	1777.10
3	1.00	5.00	3.30	83212.20

Total sales revenue for the period : 84989.30

Total profit/loss (incl. int. & depcn.) for period : 9331.68

Competing firm's share of market revenue for period (%): 50.12

Competitor ROCE for period(%): 15.18

Cash balance of competitor at end of period : 46485.32

Competitor share price at end of period : 1.98

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98

Average profit/loss per period : 7378.26

Average ROCE per period (%): 12.79

SUBJECT S7 RESULTS :PERIOD 3

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.10	15828.	49067.88	832.84
4	4.0	8.0	6.40	6722.	43021.16	1938.82
5	2.0	1.0	1.55	20218.	31338.62	260.92

Total sales revenue for period : 123427.70

Total profit/loss (incl. int.& depcn) for period : 5962.61

Company share of market revenue for period(%) : 65.62

ROCE for period(%): 9.16

Cash balance of company at end of period : 42587.88

Share price at end of period : 1.40

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	123427.70	65.62	5962.61	9.16	1.40

Average profit/loss per period : 4910.93

Average ROCE per period (%) : 8.19

***COMPETITOR FIRM RESULTS: PERIOD 3 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.73	32359.76
3	1.00	5.00	3.47	32312.57
7	2.00	2.30	2.35	.00

Total sales revenue for the period :	64672.34
Total profit/loss (incl. int. & depcn.) for period :	8557.03
Competing firm's share of market revenue for period (%):	34.38
Competitor ROCE for period(%):	12.22
Cash balance of competitor at end of period :	47542.35
Competitor share price at end of period :	1.70

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**New product launched by competitor this period :

PRODUCT	C1	C2	PRICE
7	2.00	2.30	2.35

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	64672.34	34.38	8557.03	12.22	1.70

Average profit/loss per period :	7771.18
Average ROCE per period (%):	12.60

SUBJECT S7 RESULTS :PERIOD 4

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.20	0.	.00	-750.00
4	4.0	8.0	6.40	0.	.00	-750.00
5	2.0	1.0	1.60	0.	.00	-750.00
8	1.0	6.0	3.80	4023.	15288.17	456.96

Total sales revenue for period :	15288.17
Total profit/loss (incl. int.& depcn) for period :	1613.99
Company share of market revenue for period(%) :	5.01

ROCE for period(%): 2.42

Cash balance of company at end of period : 36701.87

Share price at end of period : .92

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	123427.70	65.62	5962.61	9.16	1.40
4	15288.17	5.01	1613.99	2.42	.92

Average profit/loss per period : 4086.70

Average ROCE per period (%) : 6.75

***COMPETITOR FIRM RESULTS: PERIOD 4 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.69	149064.20
3	1.00	5.00	3.23	31682.36
7	2.00	2.30	2.26	109315.30

Total sales revenue for the period : 290061.80

Total profit/loss (incl. int. & depcn.) for period : 19490.64

Competing firm's share of market revenue for period (%): 94.99

Competitor ROCE for period(%): 21.77

Cash balance of competitor at end of period : 67032.98

Competitor share price at end of period : 2.21

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	64672.34	34.38	8557.03	12.22	1.70
4	290061.80	94.99	19490.64	21.77	2.21

Average profit/loss per period : 10701.04

Average ROCE per period (%): 14.89

SUBJECT S7 RESULTS :PERIOD 5

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.05	28722.	87602.35	686.10
4	4.0	8.0	6.20	0.	.00	-750.00
5	2.0	1.0	1.55	85627.	132721.80	3531.34
8	1.0	6.0	3.60	11191.	40289.21	369.14

Total sales revenue for period : 260613.40

Total profit/loss (incl. int.& depcn) for period : 6772.73

Company share of market revenue for period(%) : 65.81

ROCE for period(%): 9.22

Cash balance of company at end of period : 43474.59

Share price at end of period : 1.08

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP. (%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	123427.70	65.62	5962.61	9.16	1.40
4	15288.17	5.01	1613.99	2.42	.92
5	260613.40	65.81	6772.73	9.22	1.08

Average profit/loss per period : 4623.90

Average ROCE per period (%) : 7.24

***COMPETITOR FIRM RESULTS: PERIOD 5 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.69	135386.60
3	1.00	5.00	3.23	.00
7	2.00	2.30	2.26	.00

Total sales revenue for the period : 135386.60

Total profit/loss (incl. int. & depcn.) for period : 12649.28

Competing firm's share of market revenue for period (%): 34.19

Competitor ROCE for period(%): 12.38

Cash balance of competitor at end of period : 79682.27

Competitor share price at end of period : 1.61

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Competitor didn't withdraw any products this period .

The following is a summary of competitor performance
to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	64672.34	34.38	8557.03	12.22	1.70
4	290061.80	94.99	19490.64	21.77	2.21
5	135386.60	34.19	12649.28	12.38	1.61

Average profit/loss per period : 11090.69

Average ROCE per period (%): 14.39

** SUBJECT S7 RESULTS :PERIOD 6***

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.10	0.	.00	-750.00
4	4.0	8.0	6.10	18604.	113487.40	1110.44
5	2.0	1.0	1.55	135554.	210108.20	6027.69
8	1.0	6.0	3.60	38427.	138338.80	3092.73

Total sales revenue for period : 461934.40

Total profit/loss (incl. int.& depcn) for period : 12958.84

Company share of market revenue for period(%) : 80.45

ROCE for period(%): 14.99

Cash balance of company at end of period : 56433.44

Share price at end of period : 1.37

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	123427.70	65.62	5962.61	9.16	1.40
4	15288.17	5.01	1613.99	2.42	.92
5	260613.40	65.81	6772.73	9.22	1.08
6	461934.40	80.45	12958.84	14.99	1.37

Average profit/loss per period : 6013.06

Average ROCE per period (%) : 8.53

***COMPETITOR FIRM RESULTS: PERIOD 6 ***

The following data summarises the trading results of
the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.69	112265.70
3	1.00	5.00	3.15	.00

Total sales revenue for the period :	112265.70
Total profit/loss (incl. int. & depcn.) for period :	7782.58
Competing firm's share of market revenue for period (%):	19.55
Competitor ROCE for period(%):	11.62
Cash balance of competitor at end of period :	94964.84
Competitor share price at end of period :	1.24

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**Competitor didn't introduce any new products this period.

**Products withdrawn by competitor this period :

PRODUCT	C1	C2
7	2.00	2.30

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	64672.34	34.38	8557.03	12.22	1.70
4	290061.80	94.99	19490.64	21.77	2.21
5	135386.60	34.19	12649.28	12.38	1.61
6	112265.70	19.55	7782.58	11.62	1.24

Average profit/loss per period :	10539.34
Average ROCE per period (%):	13.93

SUBJECT S7 RESULTS :PERIOD 7

The following data summarises your trading results :

PRODUCT	C1	C2	PRICE	UNIT SALES	SALES REVENUE	OPERATING PROFIT
2	3.0	3.0	3.05	0.	.00	-750.00
4	4.0	8.0	6.05	35684.	215885.70	1034.20
5	2.0	1.0	1.54	0.	.00	-750.00
8	1.0	6.0	3.55	22760.	80796.42	387.97
9	5.0	1.0	3.05	83055.	253317.90	3402.73

Total sales revenue for period :	550000.10
Total profit/loss (incl. int.& depcn) for period :	7839.61
Company share of market revenue for period(%) :	100.00
ROCE for period(%):	8.32
Cash balance of company at end of period :	56773.05
Share price at end of period :	1.13

The following is a summary of performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	40691.71	68.16	5058.54	9.13	1.63
2	84585.70	49.88	3711.65	6.28	1.19
3	123427.70	65.62	5962.61	9.16	1.40
4	15288.17	5.01	1613.99	2.42	.92
5	260613.40	65.81	6772.73	9.22	1.08
6	461934.40	80.45	12958.84	14.99	1.37
7	550000.10	100.00	7839.61	8.32	1.13

Average profit/loss per period : 6274.00

Average ROCE per period (%) : 8.50

***COMPETITOR FIRM RESULTS: PERIOD 7 ***

The following data summarises the trading results of the competitor firm :

PRODUCT	C1	C2	PRICE	SALES REVENUE
1	4.00	1.00	2.60	.00
10	3.00	3.75	3.50	.00

Total sales revenue for the period : .00

Total profit/loss (incl. int. & depcn.) for period : 1097.19

Competing firm's share of market revenue for period (%): .00

Competitor ROCE for period(%): 5.49

Cash balance of competitor at end of period : 96062.03

Competitor share price at end of period : .77

PRODUCT STRATEGY OF COMPETITOR THIS PERIOD*

**New product launched by competitor this period :

PRODUCT	C1	C2	PRICE
10	3.00	3.75	3.50

**Products withdrawn by competitor this period :

PRODUCT	C1	C2
3	1.00	5.00

The following is a summary of competitor performance to date :

PERIOD	REVENUE	MKT SHARE REVENUE(%)	PROFIT	RETURN ON CAP.EMP.(%)	SHARE PRICE
1	19008.29	31.84	5424.83	10.40	1.56
2	84989.30	50.12	9331.68	15.18	1.98
3	64672.34	34.38	8557.03	12.22	1.70
4	290061.80	94.99	19490.64	21.77	2.21
5	135386.60	34.19	12649.28	12.38	1.61
6	112265.70	19.55	7782.58	11.62	1.24
7	.00	.00	1097.19	5.49	.77

Average profit/loss per period : 9190.46

Average ROCE per period (%): 12.72

****END OF SIMULATION RUN FOR S7****

CHAPTER 8

SUMMARY AND CONCLUSION

8.1 INFORMATION PROCESSING THEORY AND BEHAVIOURAL ECONOMICS

The central purpose of this research has been to present a comprehensive statement of a methodology for studying and modelling human decision processes in economics. This focus upon decision processes highlights the concern of behavioural economists with the need to observe actual decision making behaviour. However, human behaviour in complex tasks cannot be understood by simply conducting a structural analysis of the choice outcomes for a decision problem. At best this will only provide a surface description of the decision processes being used. Unfortunately, we still only have a limited understanding of individual decision making processes [Simon et al (1987)]. It is, therefore, surprising that there are few examples in the economics literature of empirical studies of decision making processes using the type of techniques introduced in this thesis.

The work of Herbert Simon has promoted an interdisciplinary approach to the study of decision making and problem solving. In this research we specifically draw from work in the fields of artificial intelligence and cognitive psychology. In this respect, many of the concepts and techniques we have introduced in the early chapters of this thesis are not original. However, the synthesis of these ideas into a coherent framework for behavioural research in economics is novel and will hopefully stimulate further research.

Human information processing (HIP) theory is the dominant psychological research paradigm. It is a methodology for the study and modelling of human decision processes which overcomes a number of the difficulties that have constrained behavioural research in economics. In particular, the problems associated with observing actual behaviour and the absence of a well established theoretical language for modelling decision processes. The former difficulty characterises the difference between the well established deductive methodology of the neoclassical economist and the rather limited use of inductive research methods by behavioural economists.

The second problem regarding the lack of a theoretical language for process modelling reflects two related factors. First, technological difficulties that have now largely been overcome because of the availability of powerful and less costly computer hardware and software. Developments in computer modelling techniques that allowed Newell and Simon (1972) to link verbal protocol analysis with computer simulation programs was a significant event for behavioural research method. Early behavioural research [eg. Clarkson's computer based process model of an investment trust officer] provides some good examples of the technological constraints that faced the behavioural researcher in the 1960's and 1970's. Second, the language problem referred to by Cyert and March (1963) has been totally neglected in subsequent behavioural research. Specifically, Cyert and March identified computer simulation as an appropriate language for modelling decision processes. However, they did not present a general form for computer simulation models as an approach to representing observed behavioural phenomena. Research in the cognitive psychology literature has resulted in PS models becoming the well established formalism for modelling human decision processes. As models of information processing systems, PSs are relatively easily transformed into computer models given the programming and modelling techniques that have been the output of research in the artificial intelligence and expert systems literatures.

Approaches to behavioural research in economics are varied and it is difficult to integrate research methods and results. In consequence, three decades of behavioural research has not resulted in a wide range of general and novel conclusions about economic behaviour. In this research we focus attention on what we see as the distinguishing feature between the neoclassical and behavioural research paradigms. Notably, the study of actual behaviour for the purpose of modelling decision processes. Simon (1980) has argued that an important direction for behavioural research in economics is the discovery of the important invariants of human decision processes across a variety of different task domains. As with early behavioural studies of over 30 years ago, we see the study of firm behaviour remaining as a priority research area.

The previous argument suggests that recognition of the exploratory role of behavioural research in economics is long overdue. There may be many reasons for this. The present study has highlighted that behavioural research of this type is painstakingly slow and costly and is unlikely to satisfy the demand for economic models that produce rapid and general predictions. There is, however, a great need to understand and explain the wide variety of human behaviour that characterises many real world tasks. As general models of human decision processes emerge the need for the detailed type of analysis of decision processes that we have presented in this thesis will be reduced. However, developing these empirically founded general theories about the behaviour of intelligent systems will only emerge from the extensive observation of human problem solving behaviour. As the present study illustrates, the type of models that will initially result from this kind of research are likely to be task or subject specific. Research in artificial intelligence and expert systems supports this interpretation.

In summary, information processing theory is a descriptive paradigm that is primarily concerned with how individuals make decisions. Combined with the technique of protocol analysis it provides a general framework for modelling decision processes in terms of a set of problem space operators (which can be defined as production rules). Problem space operators have an important psychological base in terms of Newell and Simon's elementary information processes (eips). However, our analysis has emphasised the interpretation of operators in the context of a particular task domain. In this way we have been able to identify regularity in information processing behaviour across our sample of subjects in terms of a set of generic decision strategies. Each of these strategies had requirements in terms of the type of information that was processed. In brief, they reflected an implicit priority ordering of the various knowledge elements that defined our subjects' problem spaces. The important role of protocol analysis was to provide an approach to discovering the nature of the operators (cognitive processes) used by the subjects in our experimental setting.

8.2 LIMITATIONS OF THE INFORMATION PROCESSING PARADIGM

The integration of HIP theory into disciplines outside the field of cognitive psychology is still in its infancy. While the fundamental concepts of HIP theory are well established in the psychology literature, the ability to build computer models that behave intelligently at a level that provides a meaningful approach to modelling human behaviour in complex tasks is a relatively recent phenomena. Indeed, it is only in the last decade that we have seen the feasibility of being able to generate information processing models in the form that we have presented earlier. This has largely followed from the recognition that computers are not limited to numerical analysis but are general purpose symbol processing systems.

The previous argument suggests that it is the combined developments of research on human thinking and computer modelling that is likely to be a major factor in the building of information processing models by behavioural researchers in economics. However, technological constraints do remain important in terms of limiting the development of HIP models, since there are still many tasks that humans can perform which computers cannot carry out efficiently (compare serial and parallel processing). That said, technological constraints on HIP modelling are diminishing rapidly with the result that modelling opportunities are being created for the behavioural researcher, eg. the modelling of learning and conflict resolution.

The particular application of HIP theory in this research does, however, highlight other limitations to this approach to modelling human decision processes. The descriptive nature of the research paradigm emphasises the need to observe behaviour and it is for this reason that we introduced the combined use of laboratory experimentation and protocol analysis in Chapter 3. These are important elements of our approach to capturing and translating decision processes into a HIP model. However, both our laboratory setting and the use of the technique of protocol analysis constrained our ability to model certain aspects of our subjects' decision processes.

The choice between a field and a laboratory setting is a difficult one and the researcher is required to balance the advantages and disadvantages of each setting in terms of control and realism. The literature on the use of experiments in social science research presents a variety of conflicting views as to whether the laboratory or the field setting is likely to yield results that are more general to other situations. In this study we were concerned with linking the use of protocol analysis with the control that can be achieved in an experimental setting. This was an attempt to validate the use of protocol data for the purpose of developing behavioural process models [Ericsson and Simon (1980)].

The discussion in previous chapters has highlighted some difficulties in using laboratory experiments to study behaviour in complex tasks. For example, the short decision episode over which subject behaviour was observed limited our ability to model important evolutionary aspects of S7's information processing behaviour. Equally, we were concerned to study the behaviour of our subjects in a realistic task when viewed against the type of generalisations about strategic behaviour that were the focus of this research (ie. broad strategy). Of course, a thorough test of the external validity of our experiment requires repetition with different subjects and using different experimental procedures. We have tentatively suggested how we might use external validity evidence to support the broad findings about decision making strategies from our experimental setting.

Clearly, more attention is required to acquiring expertise in the design and running of experiments for behavioural research of this type. It is, however, important to stress that the application of the information processing paradigm is not restricted to developing theoretical models of individual subjects in experimental settings. Indeed, the techniques we have presented in this thesis can also be viewed as providing a methodology for the development of expert systems - that is, models that have a decision support role in a real world setting [see Slatter (1987)].

Within the framework of HIP theory, detailed knowledge of human decision processes is an essential requirement for building behavioural process models. We have used protocol analysis as a vehicle for collecting and analysing a large amount of behavioural data about the information processing that takes place during decision making. Despite the methodological limitations of protocol analysis, the work of Ericsson and Simon (1980; 1984) provides guidelines that underpin the careful use of concurrent verbal reports as behavioural data. Under certain controlled conditions for observing behaviour, protocol analysis provides a rich and accessible source of behavioural data.

As with many other research methods, the judgement and interpretation of the researcher plays an important part in the coding of protocols and the identification of production rules that describe a subject's knowledge operators. As the application of protocol analysis outside the domain of cognitive psychology increase, more general principles will emerge that will increase the validity of using this technique. Moreover, protocol analysis should be viewed as one of a range of techniques available to the behavioural researcher. Wherever possible, protocol data should be cross-validated with other sources of behavioural data. Analysing verbal protocols is expensive in terms of research time and effort and protocol data is inevitably incomplete for the purpose of capturing a subject's information processing behaviour. However, we would argue that protocol analysis is a robust technique. If carefully used, it provides an important basis for conducting behavioural research that is concerned with opening up the 'black box' to study human decision processes.

The analysis and discussion in this thesis suggests a number of directions for further research in the application of human information processing models in economics. First, there is the the need for behavioural researchers to devote considerable effort to collecting empirical evidence on how decision makers cope with ill-structured and knowledge rich task domains. The study of expert behaviour in both laboratory and field settings is vital to increasing our understanding of how the complex and uncertain tasks that characterise the activities of real economic agents are solved in practice. We have illustrated the application of techniques from artificial intelligence and cognitive psychology that provide the framework for conducting this type of research.

Of equal importance is the further development and refinement of the behavioural research methodology introduced in this thesis. In addition to the problems surrounding the application of laboratory experiments and protocol analysis, we have noted the task specific nature of production systems as a theoretical modelling language. For example, the structure of our PS model in Chapter 7 largely reflected the observed variables that characterised our decision making task. This, of course, is a strength of computer simulation languages for studying behaviour in tasks that are characterised by rich and qualitative knowledge. However, it is also a weakness when evaluated in terms of the general and powerful language of formal mathematics used in neoclassical economics. As we observe invariants in human behaviour across a variety of decision making tasks, this may result in more general representations of PS models of economic behaviour.

The previous argument emphasises the need for more research directed towards establishing the validity and generality of the human information processing paradigm for research in economics. This study provides some guidelines as to how we might proceed. Inevitably, we are left with the hope that this thesis will have served to stimulate others to examine further the approach we have presented for studying and modelling human decision processes in economics.

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