# THE USE OF EXPERT SYSTEMS FOR DECISION MAKING IN ORGANIZATIONS

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## THESIS SUMMARY

The research described in this thesis investigates three issues related to the use of expert systems for decision making in organizations. These are the effectiveness of ESs when used in different roles, to replace a human decision maker or to advise a human decision maker, the users' behaviour and opinions towards using an expert advisory system and, the possibility of organization-wide deployment of expert systems and the role of an ES in different organizational levels. The research was based on the development of expert systems within a business game environment, a simulation of a manufacturing company. This was chosen to give more control over the "experiments" than would be possible in a real organization.

An expert system (EXGAME) was developed based on a structure derived from Anthony's three levels of decision making to manage the simulated company in the business game itself with little user intervention. On the basis of EXGAME, an expert advisory system (ADGAME) was built to help game players to make better decisions in managing the game company. EXGAME and ADGAME are thus two expert systems in the same domain performing different roles; it was found that ADGAME had, in places, to be different from EXGAME, not simply an extension of it.

EXGAME was tested several times against human rivals and was evaluated by measuring its performance. ADGAME was also tested by different users and was assessed by measuring the users' performance and analysing their opinions towards it as a helpful decision making aid.

The results showed that an expert system was able to replace a human at the operational level, but had difficulty at the strategic level. It also showed the success of the organization-wide deployment of expert systems in this simulated company. The expert advisory system enabled novices to perform much better than unaided experienced people and improved the performance of experienced people to the "expert" level. It was seen as most useful early on and in difficult situations and good as a "second opinion" to check proposed decisions. Surprisingly it was found that users did not perceive that an expert system can improve their management skills, although learning is often stated as a benefit in the literature. Conversely users thought an expert system could save their time, but in fact it did not. The survey and implementation experience revealed strong user reluctance towards using an expert system, especially amongst the worst users who ought to need it the most. The reluctance from the worst users suggests a further problem for expert system developers related to the expert systems' usability. The results also shed light on issues related to expert system validation, user involvement and user interface design.

Finally the limitations of this research and future work are identified, especially the extent to which this research can provide guidelines for the successful use of expert systems in real organizations.

**Keywords:** Business Game, Evaluation.

*To my family*

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| ABS | Aston Business School |
| AI | Artificial Intelligence |
| DSS | Decision Support System |
| DP | Data Processing |
| ES | Expert System |
| ESS | Expert Support System |
| KA | Knowledge Acquisition |
| KB | Knowledge Base |
| KBS | Knowledge Based Systems |
| MIS | Management Information System |
| PC | Personal Computer |
| R & D | Research and Development |

# Chapter One

## INTRODUCTION

Expert Systems (ESs) or Knowledge Based Systems (KBSs) have been in existence for over thirty years, but only during the last ten years have they moved from the research laboratory into the commercial environment. In a recent report, Touche Ross (1992) indicates that the number of companies using KBSs has gradually risen worldwide throughout the 1980s. From 30 prototype systems reported in 1982 to 1510 applications in 1990 with "more than a suspicion" that there were many more. "Indeed, KBS is no longer a 'hot' research topic in the universities now that the centre of interest has moved to the commercial sphere" (Touche Ross 1992, Page 12). In the same study, the tasks supported by ESs/KBSs were reported to vary over a wide range from fault-finding/diagnosis to decision support and planning. Indeed, most of the earliest ESs/KBSs were developed either for medical diagnosis or fault-finding in machinery or devices. Although these traditional ES applications are still popular, there is a growing awareness of the use of ESs for other tasks, such as organizational decision making. It is well-recognised that design decision making would be one of the most difficult types of task to simulate with computers, as decision making within an organization is a complex process and design know-how is hard to analyze and replicate (Touche Ross 1992).

Bramer (1990) argues that the ES field can be characterized as having a wide range of theoretical viewpoints, but an absence of generally accepted theory in many important areas. This is particularly true when discussing the use of ESs in the decision making area. There are numerous publications and reports available on the subject, but there are still several important points which have not been clarified and need further investigation. For example, opinions on the use of ESs in organizations vary from 'ESs are best in routine and repetitive tasks in the operational level" (Lin 1986) to " ESs are most useful in supporting strategic planning" (Beerel 1987, Mockler 1989); and from "ESs are only intended to be a support tool for humans and are not designed to replace them; ESs can only recommend and management remains responsible for any decision made" (Krebs 1989) to "ESs can be used as a replacement of humans" (Cheng and Bizruchak 1991). The practical evidence for these varying views is weak and based more on prejudice or *ad hoc* experience than on experimental evidence. The effectiveness of ESs for organizational decision making still needs further investigation, since many people still do not feel confident with using ESs to make decisions. Compared with the huge number of papers addressing ES development from the technical point of view, attention and research on the user's aspect is still insufficient and inadequate. The ignorance of user's viewpoint can be seen as one of the no-technical issues contributing to the ES application failure. Additionally, most decision problems tackled by an expert system are restricted to a specific area or organizational level, but since ESs are penetrating into every area of an organization and are able to deal with various tasks, it is inevitable that one company will use several expert systems for its management. Research into the problem of building this organization-wide ES deployment becomes an important issue which, however, has not received any attention from ES researchers.

Therefore, this research is concerned with the use of expert systems for decision making in organizations. It aims to investigate the following issues which are believed so far not to have been fully addressed:

1. The effectiveness of ESs when used in different roles, to replace a human decision maker or to advise a human decision maker.
2. The users' behaviour and opinions towards using an expert advisory system.
3. The possibility of organization-wide deployment of expert systems and the role of an ES in different organizational levels.

This research examines the above questions by developing two expert systems with different roles. One expert system (EXGAME) was designed to replace a human in decision making, and the other (ADGAME) was to advise a human decision maker. The two expert systems were developed to mimic the expert decision making in a simulated organization and their effectiveness was measured by looking at their performance: mainly in terms of profits they made. Users' behaviour and opinions towards the expert system as a advisory system were examined by conducting user surveys. It is hoped that this study can provide a more systematic view and a better understanding of ESs for decision making with different roles and different organizational levels, and the ES users' opinions and behaviour.

The expert system EXGAME and the expert advisory system ADGAME were developed in a business game environment which simulates a manufacturing company. The steps taken to investigate the above issues were:

1. Analysing the decisions required within the game.
2. Constructing several sub-expert-systems for different functional divisions in the game company to replace the game players.
3. Linking them together as an organization-wide expert system (EXGAME) and developing an expert advisory system (ADGAME) which was based on EXGAME.
4. Testing EXGAME and ADGAME with different experimental designs according to the assumptions and expectations formulated after the literature review.
5. Measuring the effectiveness of EXGAME and ADGAME, and analysing the users' behaviour and opinions towards ADGAME through observation and questionnaires.

The evaluation of EXGAME provides some insight into the ES's ability of working successfully in different organizational levels and the possibility of the organization-wide ESs deployment. As an advisor, ADGAME allows some insight to be gained into the effectiveness of an expert advisory system and users' opinions of using an expert system to support their decision making.

This thesis consists of nine chapters (including the introduction). The following is an outline of each chapter.

Chapter two, *Organizational Decision Making and Expertise,* introduces some basic concepts of organizations, organizational decision making and control. It analyses decision making activities in terms of Anthony's (1965) and Simon's (1977) frameworks and discusses the organizational intelligence, expertise and information requirements according to the framework adopted.

Chapter three, *Expert Systems For Organizational Decision Making,* presents a review of the literature on the development and application of expert systems, particularly those issues relating to the use of ESs in organizational decision making. Problems identified through the literature review are summarised at the end of the chapter.

Chapter four, *Research Method,* gives a detailed explanation of the research objectives. A description and explanation of the concepts and principles of computer simulation, experimental method and the business game which are the basic essence of the research approach adopted are presented. The assumptions and expectations of the experiments and surveys conducted are stated. The research plan according to the research method is outlined.

Chapter five, *EXGAME and ADGAME - Development,* describes decision making situations in the MAS1 game and the development of the expert systems EXGAME and ADGAME. It covers knowledge acquisition and representation techniques used, the system architecture, the way EXGAME plays the game, and the differences between EXGAME and ADGAME.

Chapter six, *EXGAME and ADGAME - Experiments,* outlines all the three experiments conducted with EXGAME and ADGAME. A description is given of the experimental design and the results obtained. Ways of evaluating both EXGAME and ADGAME systems are stated. An initial discussion based on the results is presented in the final section of the chapter.

Chapter seven, *Users' Behaviour and Opinion Analysis,* involves two parts. The first part describes surveys conducted to investigate the students' decision making behaviour when playing the game, while the second part presents surveys carried out to study the ADGAME users' attitudes towards the ADGAME system. Key findings which emerged from the ADGAME surveys are highlighted.

Chapter eight, *Discussion,* reviews the research objectives, the method adopted based on these objectives, and the experiments and surveys conducted within the research. The lessons and experience which emerged from the overall research and the important issues concerned with the research are discussed.

Chapter nine, *Conclusions,* once again reviews the overall research work, and summarises the research experience and findings that emanated from the overall research. The extension of research findings into the real world, the research limitations and recommendations for further work are also identified.

# Chapter Two

## ORGANIZATIONAL DECISION MAKING AND EXPERTISE

This chapter reviews some basic concepts of: organizations; knowledge, intelligence and expertise in organizations; and organizational decision making. Anthony's (1965) well used framework for viewing the organizational decision making, and Simon's (1977) concepts of three decision making phases and 'programmed' and 'nonprogrammed' decisions are presented. The framework adopted for this research is described and the different characteristics of decision making in the three organizational levels are discussed.

## 2.1 Organizations

An organization can be simply described as "a group of people working together towards objectives with a framework devised to ensure cooperation and coordination" (Bentley 1986, page 6). "An organization exists to carry out some purpose or set of purposes" (Klein et al, page 328). The success of an organization may be measured by how well it achieves its measurable objectives and to what extent it has balanced and at least satisfied, as opposed to optimized, the results it has obtained (Goble 1989).

The concept and nature of an "organization" has been studied from a number of perspectives including sociology, social psychology, political science, economics. Most of the research is based on empirical research and forecasts; it is very difficult to experiment on their assumptions and theories in the real world since the organizational environment is always changing and cannot be controlled. Nowadays with the increasing use of computers, computer simulation has been widely used to deal with problems in many areas, especially in the natural science and engineering fields. Computer simulation has enabled people to carry out experiments on the system of interest. Although in social science this technique is not applied as widely as in other areas due to the complexity and uncertainty of human behaviour, with the rapid development of artificial intelligence (AI) technology which aims to enable researchers to simulate human being's behaviour, it is more and more imperative to address our attention to computer aided research methods, such as computer simulation and experimentation.

## 2.2 Knowledge, Expertise and Intelligence in Organizations

### 2.2.1 Expertise

The definition of "expert" in the Oxford English Dictionary is one "who has gained skill from experience" and "whose special knowledge or skill cause him to be regarded as an authority". Harmon and King (1985 page 31) defined that an expert is "one who is widely recognized as being able to solve a particular type of problem that most other people cannot solve nearly as efficiently or effectively". MacCrimmon and Wagner(1987) analyze that there are three key aspects implied in the definition: (1) a body of knowledge, (2) proficiency in applying the knowledge, and (3) the ability to learn from experience.

Experts are characterized by Hart (1989) as having the following features:

Effectiveness - they use knowledge to solve problems, with an acceptable rate of success.

Efficiency - it is not sufficient to be able merely to solve problems; experts can solve them quickly and efficiently.

Awareness of limitation - experts know what they know. They are aware of what they are able to deal with, and what needs referring to someone else.

Versatility - experts can perform well in relatively unfamiliar situations.

Moreover Hart summarizes the way in which people use experts:

As a provider of information - the expert has a great deal of knowledge readily available.

As a problem-solver - using knowledge an expert can solve problems.

As an explainer - the expert should be able to explain how he came to his conclusion (pages 16-18).

According to Hart's last view, an expert should be able to explain his/her decision making or problem solving strategy, but in practice experts have difficulty to perform this role. The inability of experts to explain how they reach certain decisions is a major problem in ES development.

In summary, experts have a body of knowledge which is unfamiliar to the layman and furthermore, they are able to use that knowledge to solve difficult problems in a particular domain.

### 2.2.2 Knowledge and intelligence

Both knowledge and intelligence are highly abstract concepts and it is not easy to define them. People attempt to define knowledge and intelligence in terms of their understanding and background. For example, Beerel (1987) describes knowledge as

- familiarity gained by experience

- a person's range of information

She further states that knowledge is different from information since knowledge includes not only information but skills and training, perception, imagination, intuition, common sense and experience.

From the AI point of view, Hart (1989) concedes that it may be easier to recognize than to define intelligence. She says:

> "It is clear that intelligence is associated with a specialization of knowledge, and that it involves the ability to learn and to adapt to the environment. It requires the acquisition, use, retention and transfer of knowledge." (Hart 1989 page 14).

A number of propositions concerning organizational intelligence and expertise from organizational theory were developed by Wilensky (1967), derived from his extensive research in this area. He defined organizational intelligence as gathering, processing, interpreting and communicating the technical and political information needed in the decision making process. The nature and degree of intelligence utilized by an organization will vary according to the external and internal problems it encounters in its decision making procedures (The Open University 1974). Since Wilensky's definition about organizational intelligence is not derived from AI research, but from organizational study, the 'intelligence' here mainly refers to the decision making process and is a wider definition than the 'intelligence' in AI.

### 2.2.3 Discussions

Discussions on the knowledge, expertise and intelligence in organizations in the literature are from two different aspects:

From the aspect of organizational management

Wilensky (1967) found that the resources an organization devotes to intelligence, the kinds of experts it uses, and the function these experts serve are a production of several interrelated forces:

- the availability of intelligence;
- the relation of rationalization to its external and internal environment;
- the degree of rationalization of that environment;
- the organizational structural complexity.

On all counts one can expect that the typical formal organization in modern society, whatever its products or services, whatever the cultural context will make increasing use of experts. The different types of organization will devote considerable resources to the intelligence function by employing different kinds of experts.

The concept of "skill", according to Singleton (1981), is used as the basis for the understanding of resourceful individual behaviour. It introduces the complexities of the skilled individual interacting with other skilled individuals in relation to a common purpose, and explores the skills across the variety of management jobs in current society, such as the farm, the university, the social service, and the production, personnel, and marketing functions within a manufacturing organization, etc. It emerges that the skills have much in common in spite of the differences of size, structure, values and purposes between the organizations.

Stewart (1982) developed a framework for describing managerial jobs and highlights the flexibility that exists in jobs, that is, the choices they offer. She believes that the framework can be an aid to understanding both what a job is like and how a particular individual does it. She also discusses the choice of becoming experts for individuals and finds that the availability of this choice is determined by the kind of company as well as by the type of job. The company with a complex and rapidly changing technology, or one with a specialized market will offer more choices of expertise than one with a simpler technology or market. Large companies will usually offer more opportunities for choosing to develop expertise than smaller ones. In a smaller company managers will often have to have a broad knowledge about many aspects of their job. A large company has more use for specialized expertise.

From the aspect of KBSs/ESs

Simon (1981) argues that it is possible and, furthermore, revealing to study human intelligence through the creation and simulation of artificial intelligence on a computer. On the other hand, with the expanding use of KBSs/ESs, more attention is being paid to the study of the knowledge and intelligence of the expert, since it is believed that the power of an expert system is derived from the knowledge it possesses, not from the particular formalism and inference schemes it employs (Feigenbaum, cited by Lin 1986). The success of an expert system, then, is largely dependent on the quality of the knowledge obtained from the expert upon which it is based (Ernst 1986, Lin 1986, Waldron 1986). From this point of view, the key problem is to develop methods to acquire knowledge efficiently and effectively in order to build a KBS/ES which can be used successfully in practice. A number of papers and books address the topics of expert thinking and decision making from the standpoint of KBS/ES (Slatter 1987, Ciborra 1988, Davis and Bonnell 1991).

Shanteau (1987) makes a psychometric analysis of expertise and summarizes 14 psychological characteristics of expert decision makers. Steels (1990) discusses frameworks for studying expertise at the knowledge level and knowledge use level. Slatter (1987) contributes to the cognitive approach to knowledge engineering. This approach mainly attempts to embody in an expert system not just the human knowledge of a domain expert, but also the way an expert represents, utilizes and acquires that knowledge.

The need to capture and maintain expertise in organizations is a serious problem for business. For instance, Klein *et al* (1992) comment: "Currently, expertise is a scarce resource within many organizations, frequently acting as a severe constraint on the ways in which the organizations might be designed and the ways in which they might function. Often these constraints may not be particularly visible, but they have real influence on organizational capabilities, staff training and development, and general organizational culture". Klein *et al* propose a framework for organizational design in conditions where expertise may be replicated in the form of expert systems. They discuss the way to classify expertise and provide some suggestions about what kind of expertise is easily replicated in an expert system.

Managers have sometimes been characterized as knowledge workers (Holsapple *et al* 1987). In the course of arriving at decisions, managers may work with many kinds of knowledge in a variety of ways. The success of the organization will lie largely in its ability to harness the individual abilities and expertise in a positive and meaningful way (Beerel 1987).

A number of authors discuss the role of organizational knowledge and expertise (Pulkkinen 1985, Applegate *et al* 1987, Paradice 1989, Paton 1989). An organization can be seen as a 'knowledge-based business' (Davis and Bonnell 1991) and a knowledge processing system with different types of organization processing knowledge differently (Ciborra 1988). Davis and Bonnell (1991) state that companies are posturing themselves to compete as 'knowledge-based businesses', and are beginning to perceive their information, in-house expertise, and 'corporate memory' as organizational knowledge. They realize that companies are employing knowledge-based systems at various points in their overall organizational process, using knowledge to improve the performance of specific tasks in these processes. Therefore, organizational knowledge is seen as an enormously valuable corporate asset by Paradice and Courtney (1989) and an important asset that must be structured, managed, maintained and protected by Davis and Bonnell (1991), however, people still complain that "Data is everywhere, but knowledge is rare"

(Thomas Sowell, cited by Tang 1991).

Paton (1989) argues that the manager, irrespective of the function, acquires expertise throughout his career. This expertise is a company resource, as well as a highly transportable resource and a potential selling point. Overall people have realized the importance of knowledge and the problem is how to externalize and harness this knowledge, how to manage it, and how to make it accessible to appropriate people throughout the organization.

### 2.3 Structured and Unstructured Decisions

In "The New Science of Management Decision" (1977, third edition), Simon is concerned with the manner in which human beings solve problems regardless of their position within an organization. Simon's distinction between "programmed" and "nonprogrammed" decisions is well accepted. According to Simon:

> "Decisions are programmed to the extent that they are repetitive and routine, to the extent that a definite procedure has been worked out for handling them so that they don't have to be treated *de novo* each time they occur. ... Decisions are nonprogrammed to the extent that they are novel, unstructured, and consequential. There is no cut-and-dried method of handling the problem because it has not arisen before, or its precise nature and structure are elusive or complex, or because it is so important that it deserves a custom-tailored treatment. ... By nonprogrammed I mean a response where the system has no specific procedure to deal with situations like the one at hand, but must fall back on whatever general capacity it has for intelligent, adaptive, problem-oriented action." (Simon 1977 page 45-46).

Later Gorry and Scott Morton (1976) use "structured" and "unstructured" decisions for "programmed" and "nonprogrammed" decisions because they think these terms imply less dependence on the computer and more dependence on the basic character of the problem-solving activity in question. Gorry and Scott Morton's terms are more widely used now than Simon's original terms.

Mintzberg *et al* (1976) defines what is an unstructured decision later in a clearer way in light of his study. According to his definition, unstructured decisions refer to "decision processes that have not been encountered in quite the same form and for which no predetermined and explicit set of ordered responses exists in the organization." (Mintzberg *et al* 1976, page 246).

Concerning the decision making process, Simon (1977) claims that all decision making and problem solving can be broken down into three phases:

> "The first phase of the decision-making process -- searching the environment for conditions calling for decision -- I shall call *intelligence* activities (borrowing the military meaning of intelligence). The second phase -- inventing, developing, and analysing possible courses of action -- I shall call *design* activities. The third phase -- selecting a particular course of action from those available -- I shall call *choice* activities. ... Generally speaking, intelligence activity precedes design, and design activity precedes choice. The cycle of phases is, however, far more complex than this sequence suggests. Each phase in making a particular decision is itself a complex decision-making process." (Simon 1977 page 40-41, 43).

Gorry and Scott Morton (1976) call those decisions with one or two of the intelligence, design, and choice phases unstructured 'semi-structured' decisions. Turban (1988) gives the same definition and explains that semi-structured decisions are those "in which some aspects of the problems are structured and others are unstructured" (Turban 1988, page 839).

Decisions and design problems in organizations range widely from highly structured and well understood isolated decision problems at one extreme to unstructured, poorly understood complex interacting systems problems at the other (Holt 1991), but as Hadden (1986) points out most decisions obviously fall between the two extremes. Usually, the more unstructured the decision the greater the number of unknowns and the more constrained the information available.

### 2.4 A Framework for Decision Making Analysis

A framework for viewing the organizational decision making is essential as a means of looking at decisions made within an organization. Simon's classification of programmed and nonprogrammed decisions is based on the way in which the manager deals with the problems which confront him. Another commonly-held view originally proposed by Anthony (1965) is that there are three recognizable levels of decision making which are closely associated with levels of responsibility. The three levels can be named in one of two ways, namely as: 1. Strategic Planning; 2. Management Control; and 3. Operational Control; or, 1. Strategic level; 2. Tactical level; 3. Operational level. Anthony's categorization is based on the purpose of the management activities. According to Anthony (1965, pages 16-18):

> "Strategic planning is the process of deciding on objectives of the organization, on changes in these objectives, on the resources used to

> attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources."
>
> "Management control is the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization's objectives."
>
> "Operational control is the process of assuring that specific tasks are carried out effectively and efficiently."

According to Gorry and Scott Morton (1976) strategic planning implies two things: first it focuses on the choice of objectives for the organization and on the activities and means required to achieve these objectives; second, the strategic planning process typically involves a small number of high-level people who operate in a nonrepetitive and often very creative way. They point out that Anthony (1965) stresses three key aspects in the management control area:

1. the activity involves interpersonal interaction,
2. it takes place within the context of policies and objectives developed in the strategic planning process,
3. the paramount goal here is the assurance of effective and efficient performance.

The basic distinction between management control and operational control, they recognize, is that operational control is concerned with tasks whereas management control is most often concerned with people. The boundaries between these three categories are often not clear.

Gorry and Scott Morton combine the two views proposed by Anthony (1965) and

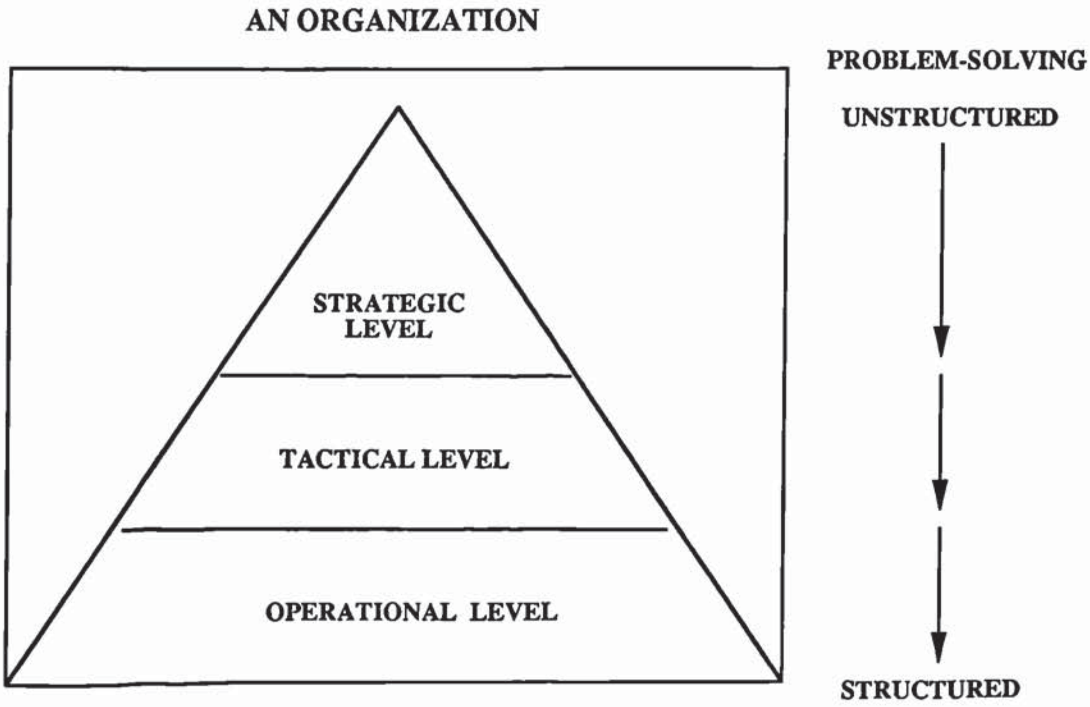



**Figure 2.1 The framework for decision making analysis**

Simon (1977) to create a framework to examine the purposes and problems of an information system's activities. It consists of a matrix with management's activities - strategic planning, management control and operational control - on one dimension and the structure of the problem under consideration - structured, semi-structured and unstructured - on the other. This framework has received a substantial amount of attention in the management information systems literature (O'Leary and Turban 1987).

It has been suggested that most decisions are unstructured in strategic planning and structured in the operational level (Beerel 1987, Barrett and Beerel 1988). So, the author simply uses a one-dimension framework which is described in figure 2.1 instead of the matrix framework to examine the control and decision making activities in an organization. This framework indicates that the nature of the problem-solving related to the three levels of management activity proposed by Anthony (1965) generally varies from unstructured to structured. It is believed that this simpler framework describes the general characteristics of control and the decision making process within an organization and is more suited for use in this research.

In figure 2.1, at the lowest level, the tasks are highly structured, but when moving to higher levels, the decision making demands greater experience, initiative and discretion. The problems that arise are less clearly definable, and the optimal solution may be less evident. At the highest level of an organization, management is faced with highly unstructured problems surrounded by a great deal of uncertainty. The decisions to be taken have a strategic impact, and therefore the implications of making good or bad choices can be very severe indeed (Barrett and Beerel 1988).

## 2.5 Organizational Decision Making

### 2.5.1 The manager as a decision maker

There is no doubt that the success of an organization depends on the ability of a manager to make good decisions, and to make them at the appropriate time. The better the quality of the decisions taken the greater the harmony between the different decision making activities, and the more chance an organization has of out-performing its rivals (Barrett and Beerel 1988).

Concerning the general functions of managers, Blanning (1984) draws two general conclusions about what managers do. The first is that managers perform certain identifiable tasks, primarily decision making, implementing and controlling, and organizing and communicating. The second is that managers seldom accomplish these tasks directly, but rather work through a network of people.

### 2.5.2 Decision making and information requirement at different levels

Looking in detail at the functions of experts in organizations, it is seen that there are differences between the three levels in figure 2.1.

Decisions at the operational level enable the whole organization to function in detail. Such decisions are characteristically short-term and determined with a low risk and high degree of certainty. The focus of managerial efforts at this level is on daily problem solving activities. The expert or manager in this position may be called a technical manager and is likely to be a specialist in a narrow domain as the knowledge required here is more specific than that at higher level units. The task-orientation of operational control requires information of well-defined and narrow scope. This information, it is argued by Gorry and Scott Morton (1976), is quite detailed, very frequently used and must therefore be accurate. It arises largely from sources within the organization, but also from the external environment. However, the information coming from the external environment is only taken into this level of decision making if it fits a clear and predetermined pattern (Goble 1989). Traditionally, operational managers have relied heavily on quantitative tools as decision aids, but recent advances in AI, such as expert systems, make qualitative decision support possible by providing expert advice and help (Gibson and Vedder 1989). For example, operational managers might consult an expert system for advice on processing insurance claims.

At the strategic level, the manager is responsible for the "external and future" and for making long term plans. Such decisions are frequently high risk with a considerable degree of uncertainty attached to the outcomes. The knowledge needed for this level is not as specific as that in the lower level and is more unstructured. Beerel (1987) points out that managers are continuously faced with complex and unstructured decisions, where there is a high level of uncertainty and a lot at stake. The strategic manager mediates the relations between the organization and the outside world and he/she is responsible for the general direction of the company, so the relationship of the organization to its environment is a central matter of concern and predictions about the future are particularly important. As a result, the information needed by strategic planners stands in sharp contrast to those of operational control. The information required is aggregate information, and is obtained mainly from sources external to the organization itself. Both the scope and variety of the information are quite large, but the requirements for accuracy are not particularly stringent. Strategic managers predominantly employ qualitative tools to support important decisions facing the organization (Gibson and Vedder 1989).

At the tactical level, the manager has a mediatory role between strategic and operational managers. The main concern at this point is to put the policy targets as laid down at the strategic level into the operational level, to allocate resources and to solve conflicts between units. The expert or manager here may be called an organizational specialist who transmits policies downwards or reports on basic unit feelings and opinions; or both.

Torrington and Weightman (1982, 1987) describe the management component of middle managers' jobs as a combination of common sense, a moderate amount of flair for dealing with people, and knowledge of a few administrative routines. Their activities can be classified as either technical, administrative or managerial. Every manager has to balance the various aspects of the job and the effective manager is the one who gets the balance right. Gibson and Vedder (1989) indicate that the tactical managers serve as a liaison between strategic and operational managers. For example, they must establish policies for implementing strategic decisions throughout the organization. The information requirements for management control fall between the extremes for operational control and strategic planning (Gorry and Scott Morton 1976). Because of the managers' functions, they need to have good communication and negotiation abilities and sound knowledge of dealing with people. Consequently, the tactical level can employ both qualitative and quantitative decision support tools.

In short, as Gorry and Scott Morton (1976) have found the decision process, the implementation process, and the level of analytical sophistication required of managers all differ sharply across the three levels. As a result, the managers' training, background, and style of decision making are also different. For example, the skills required of the managers involved in strategic planning are analytical and reflective, but in the case of operational control, solutions and models involved are much more the concern of technical experts. The operational managers have a more focused problem and often have a technical background.

### 2.5.3 Interaction of the three levels

The operation of an organization can be viewed based on the hierarchy of systems described by Anthony (1965), each of which consists of a variety of decision activities. Anybody making a decision needs information and that information must be conveyed via a communication channel within the organization (Goble 1989). The communication and information links between the three levels play a vital role in making good decisions. Goble (1989) suggests that the strategy level receives internal information from the tactical level and then develops a policy which is set as a target and passed back to the tactical level for implementation. The tactical level clarifies and details the operations that are to take place and issues these to the operational level. However, Goble argues that there is still an issue which needs to be addressed: how do the communication and information links between the levels relate to the nature of the decision making?

## 2.6 Summary

In summary, the success of an organization depends on the decisions made by its staff while the ability to make good decisions depends on the decision maker's own experience and knowledge. It has been well recognized that knowledge, expertise and organizational intelligence are enormously valuable organizational assets. A better understanding of the way in which experts reach decisions by employing their knowledge and intelligence can help ES developers to build expert systems more effectively.

Simon (1977) and Anthony (1965) develop two different ways of looking at managerial activities within organizations. Simon's "programmed" and "nonprogrammed" decisions which are later called "structured" and "unstructured" decisions is based on understanding the way in which the manager deals with the problems that confront him, whereas Anthony's categorization of "strategic planning", "management control" and "operational control" is based on an understanding of the purpose of the management activities. These two views are combined in this thesis in order to suggest that from strategic level to operational level, the nature of decision making activities in an organization varies from unstructured to structured.

What is generally understood is that the strategic planning function is designed to answer for the long-term integrity of the organization as a whole. In contrast, management control is oriented towards the short-term and is concerned with regulating the performance of some major segment of an organization with respect to whatever goals or standards might have been set at the strategic level. Finally, operational control is concerned with managing the day-to-day activities of an individual unit in the light of criteria established at the management control level.

The motivating belief of many researchers is that AI technology can provide opportunities which enables ESs to mimic expert decision making and make it possible to maintain, extend and share the organizational intelligence. The next chapter discusses how KBSs/ESs can tackle expert decision making and problem solving.

# Chapter Three

## EXPERT SYSTEMS FOR ORGANIZATIONAL DECISION MAKING

This chapter introduces some general concepts of an expert system and discusses some issues related to expert system development and applications. It reviews the current state of ES applications in organizations, especially their use in decision making and problem solving. The framework for analysing decision making in an organization described in the last chapter is used as the basis of discussion and analysis.

## 3.1 What is an Expert System?

### 3.1.1 A definition

There are many definitions of expert systems and knowledge based systems which reflect the purpose of a specific system or the differing users' perceptions of such systems (Candlin and Wright 1992). Here are some examples. An expert system has been described as:

> A computer program that uses expert knowledge to attain high levels of performance in a narrow problem area (Waterman 1986, page 390).
>
> An intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution (Feigenbaum, cited by Harmon 1987, page 5).
>
> A computerized advisory program that attempts to imitate or substitute the reasoning processes and knowledge of experts in solving specific types of problems (Turban 1988, page 409)
>
> A computer system that performs functions similar to those normally performed by a human expert (Goodall 1985, page 10)

A knowledge-based system has been described as:

> A computer system in which the knowledge used is made explicit, and is separated from the computer programs which interpret and apply it. Expert systems are a particular type of knowledge-based system (Barrett and Beerel 1988, page 240).
>
> A computer program that uses knowledge and problem-solving techniques on a skill level comparable to those of human experts (Pau 1986, page V).
>
> A computer-based system which supports, or performs automatically, cognitive tasks in a narrow problem domain which are usually only carried

out by human experts (Bader *et al* 1988, page 266).

The concepts of an expert system and a knowledge-based system are not often differentiated, although a knowledge-based system is sometimes taken to be a broader description where expert systems are included as a subset of knowledge-based systems (Ernst and Ojha 1986, Waterman 1987, Bader 1988). Edwards (1991a) suggests that all expert systems are knowledge-based systems, but that there are some knowledge-based systems which are not expert systems, although these are relatively few at present. The terms "expert systems" and "knowledge based systems" are used synonymously in this thesis.

### 3.1.2 Basic components of an expert system

An expert system is usually seen as consisting of three major components (Lee 1988, Krebs 1989, Kathawala 1990, Abdul-Gader 1991, Cheng and Bizruchak 1991):

(1) Knowledge base: a reservoir of domain facts and rules that symbolize expert knowledge.

(2) Inference engine: algorithms used to derive inferences and to control the reasoning process.

(3) User interface: provision for user interaction with the system.

The interaction models of expert systems have been classified into three types (Bader 1988, Edwards 1991a):

*stand-alone system* - interaction is with the user only;

*embedded system* - interaction is with company databases, management information systems or PC-based tools. The operation of the KBS involves the exchange of data between the KBS and other systems as well as dialogue with the user;

*integrated system* - complete absorption within an information system, so that the user does not interact directly with the KBS but indirectly through the user interface of the host system; the latter handles the interaction with any KB components. Thus, the operation of the KBS may be triggered without the direct intervention of the user at all;

## 3.2 Construction of an Expert System

### 3.2.1 Methods for building an expert system

Developing expert systems is still seen as a specialized craft rather than a mature technology (Gray 1992). Thus how to build an expert system efficiently and effectively is a topic which has received much attention (Holroyd *et al* 1985, Bader *et al* 1988, Ignizio 1990, Wilson 1990, Edwards 1991a, 1991b, Whitley 1991, Underwood 1992). Currently, there are some methodologies concerning the development life-cycle of expert systems and several papers have discussed the differences between ES development and conventional software development (Edmonds *et al* 1990, Edwards 1991a).

### 3.2.2 Tools for building an expert system

An expert-system-building tool is primarily the programming language used by the knowledge engineer or programmer to build the expert system (Waterman 1986). There are now many tools available to build expert systems and these may be categorised as follows:

. Conventional programming languages, such as C, Fortran, Pascal, etc.

. Expert system shells, such as Crystal, Xi-plus, etc.

. AI programming environment or knowledge engineering toolkits

. AI programming languages, such as Lisp and Prolog

Conventional programming languages or numeric manipulation languages that are used in information systems are procedural in nature and rely heavily on numeric processing in order to solve a problem. They can be used for ES development, but they were not designed for knowledge engineering applications and may be awkward to use.

ES shells are preprogrammed computer-based systems that have the basic inference engine and the representation scheme for general expert system applications. Thus, the cost and time required for development can be reduced substantially. However, because a particular shell is best suited for developing a certain type of ES, it might lack the flexibility to handle the wide range of applications most organizations encounter (Lu and Guimaraes 1989).

AI programming environment combine the packaged inference engines of shells with the lower-level facilities of AI languages, they similarly combine the advantages and disadvantages of both (Goodall 1985).

AI programming languages are designed to suit the development of expert systems, but they do not offer a good flexibility for interface design and can be expensive in development time.

In a survey conducted by Doukidis and Paul (1990) which was about the application of artificial intelligence techniques amongst OR Society members, they found that 23% of developers used conventional programming languages (Pascal, C, Basic, Fortran), 62% shells, 12% AI environments and 52% AI languages (percentage exceeds 100 percent due to the multiple responses).

Choosing a right tool for ES development is a complex task and a number of researchers have contributed to the topics of tool selection for ES development (Basden 1984, Goodall 1985, Harmon and King 1985, Pollitzer and Jenkins 1985, Waterman 1986, Badiru 1988, Barrett and Beerel 1988, Lu and Guimaraes 1989).

### 3.2.3 Knowledge acquisition for expert systems

Through years of experience, experts have built up a body of knowledge which they use to make informed and wise decisions. Some of this knowledge has come about through particular experiences, and cannot be found in a text book or set of procedural rules. Experts often make judgements based on intuition. It is more than likely that they have never had to state explicitly how they make these judgements and decisions (Hart 1988). Since human beings are not good at expressing their knowledge and find it difficult to explain how they reach certain decisions, Knowledge acquisition, i.e. how do we get the knowledge out of the head of an expert in order to put it into the computer, is seen as a crucial problem concerning the success of an expert system and is often cited as the bottleneck in the design of an expert system (Waldron 1986, Mumford 1987, Cleal and Heaton 1988, Hart 1989, Weckert 1991). Much has been written about this topic (e.g. Bosman 1985, Dickinson and Ferrell 1985, Kidd 1987, Slatter 1987, Diaper 1989, Davis and Bonnell 1991). Most of these indicate that experts are not conscious of the knowledge and strategies they employ to solve a problem. They are poor at representing their knowledge and it is difficult for them to explain how they reach some decisions. Humans do not understand their own knowledge and skills well enough to be able to build it into machines (Weckert 1991).

Many techniques have been devised for knowledge acquisition. Some commonly used approaches are structured interview, observation, rule induction by machines and repertory grid analysis. In practice, people may need more than one method to get knowledge from experts. Doukidis and Paul's survey (1990) showed that the knowledge acquisition methods used by their respondents are as follows:

100% -- interviewing the expert
28% -- taking the expert through case studies
18% -- use of induction techniques
16% -- recording the expert at work
4% -- use of automatic knowledge acquisition tools

### 3.2.4 Knowledge representation

Knowledge representation is the process by which knowledge is organized and structured. It is very versatile as there are many ways of representing identical knowledge, and so the choice of representation may be difficult. There are several ways to encode the facts and relationships that constitute knowledge. Knowledge representation techniques have been discussed by many researchers (Harmon and King 1985, Barrett and Beerel 1987, Lee 1988, Mochler 1989, Paradice 1989, Edwards 1991) and include:

--Production rules

--Frames

--Semantic networks

--Object-oriented programming languages

--Predicate calculus

--Access-oriented programming languages

--Logical expressions

The most common way of representing knowledge is in the form of Production Rules. Several surveys have shown that the rule-based paradigm still appears to be the most prominent form of knowledge representation (O'Neill and Morris 1989, Doukidis and Paul 1990). Tables 3.1 and 3.2 cite the results of the two surveys summarised by Doukidis and Paul (1990) and O'Neill and Morris (1989) respectively. Doukidis and Paul's survey was restricted to the OR area; while the other was concerned with general expert systems development. O'Neill and Morris also found that it was larger software houses that were more adventurous with other forms of representation.

**Use of knowledge representation techniques**

**Table 3.1**

| Technique | % |
|---|---|
| Rules | 62 |
| Trees | 18 |
| Semantic nets | 16 |
| Frames | 15 |
| Hybrid scheme | 15 |

(from Doukidis and Paul 1990)

**Table 3.2**

| Form of representation | % |
|---|---|
| Rules | 56 |
| Everything | 17 |
| Frames | 10 |
| Semantic nets | 7 |
| Decision trees | 5 |
| Object-oriented programming | 5 |

(from O'Neill and Morris 1989)

Note: the percentage exceeds 100 in table 3.1 due to multiple responses.

### 3.2.5 Evaluation of expert systems

Generally speaking, it is difficult to evaluate the performance of an expert system because there is no objective standard against which it can be measured (Wensley 1989). Therefore expert system evaluation is seen as another challenging task confronting the ES developers and many issues in testing expert systems are still unresolved (Gupta 1992). Finlay *et al* (1988) argue that as the tools available to create computer decision aids become more widely used within organizations, the need to validate systems becomes more pressing and this appears to be particularly so for expert systems. Grogono *et al* (1991) have outlined some of the issues involved in evaluating expert systems and cite almost 200 papers on the topic since 1980. However, in comparison with the extensive literature on the design and development issues concerning KBSs, Vinze (1991) argues that the literature on ES that addresses the subject of validation is still small. Although this situation is changing and more and more people have made efforts to develop more effective methods for ES validation (Liebowitz 1986, O'Keefe *et al* 1987, Finlay *et al* 1988, Berry and Hart 1990, Preece 1990, King and Phythian 1992), no satisfactory methods have been generally accepted.

Evaluation can cover system verification, validation and user acceptance (Preece 1990). The commonly used distinction between verification and validation is that *Verification* checks the internal correctness and consistency of the product, while *Validation* checks the correctness of the product with respect to the user's requirement (Grogono 1991). O'Keefe *et al* (1987) define validation of expert systems as the process of "testing systems to ascertain whether they achieve acceptable performance levels" (page 81).

Hollnagel (1989) states that expert system evaluation is comprised of three different aspects: reliability, validity and usability. Both the first and second aspects aim to prove that the expert system works correctly, while the third aspect aims to demonstrate that the expert system produces the benefits that were expected from it. An expert system has both internal and external reliability. The internal reliability is used to characterise the way which the expert system works, i.e., the reliability of its internal functioning and mechanisms. The external reliability represents the view of the expert system that a user may have, i.e., how reliable the expert system is considered to be as a part of a solution. Validity refers to whether the expert system in practical use provides the results it should. Usability refers to the ease with which the user can apply the system according to its purpose, irrespective of the level of experience and proficiency of the user. Specific evaluation criteria based on Hollnagel's studies are:

. correctness of the final decision,

. accuracy of the final decision,

. correctness of the reasoning techniques,

. sensitivity,

. robustness,

. quality of the human-computer interaction

. cost-effectiveness.

The performance of an expert system can be evaluated in the context of its overall objective(s) (Wensley 1989). If a system is designed to replace an expert then it must exhibit performance which is comparable to that of an expert. If, on the other hand, the system is designed to give expert advice to a user, it should help the user to achieve the level of an expert in most areas.

Preece (1990) discusses the methods for expert system evaluation and divides them into two types: empirical methods and logical methods. O'Keefe *et al* (1987) present both qualitative and quantitative methods for validating expert systems. The qualitative methods they have summarized are face validation, predictive validation, turing test, field tests, subsystem validation, sensitivity analysis, and visual interaction. In a study group meeting reported by Angelides (1992), O'Keefe explains three common approaches to validating a KBS: case testing, turing tests and field tests. With case testing, cases previously solved by an expert are run through the system, or new cases are presented to both. With turing testing, a third-party has access to the solutions from both expert and machine, suitably blinded and assesses both. With field testing, prototypical expert systems are placed in the field, and then performance errors are detected as they occur. In this case systems can fail, i.e. incorrect solutions can be spotted before any harm is done. The testing of an ES is crucial as Lederer and Nath (1991) comment, the failure to test sufficiently can cause considerable problems for the users who must rely on them to do their jobs.

Berry and Hart (1990) highlight the importance of evaluating the usability of systems and their effectiveness. They emphasize that evaluation by users can help to determine the utility of a system: that is, whether it produces useful results, the extent of its capabilities, its ease of interaction, the intelligibility and credibility of its results, its efficiency, speed and reliability. Edmonds *et al* (1990) point out that the first goal of user evaluation is to provide feedback on the design and operation of the system, and to convey the results into the next stage of the design and implementation work. The scope of what is to be evaluated will depend upon the context but will usually include general design features of the user interface, the accuracy and appropriateness of the expert system advice, and the reliability, performance, acceptability and ease of use of the whole system. The basic methods for evaluating usability are summarised by Berry and Hart (1990) as interviews, questionnaires, system walk-through, formal observation, system logging and simple experiments. The user's evaluation of an expert system is a very important part of the ES validation, and has generated several case studies on the topic (Rees 1991, Duangploy and Hashemi 1991, Vinze *et al* 1991)

Berry and Hart (1990) address the issue of evaluating systems within organizations. They comment that very few expert systems are used by individuals who work independently of other people. Most people work within organizations and it is therefore necessary to consider evaluation from an organizational perspective because the system has to match the social and political factors within the host organization (Berry and Hart 1990).

### 3.3 Applications of Expert Systems in Organizations

As Coursey and Shangraw (1989) indicate, expert systems have moved out of the academic laboratories and are diffusing currently into a wide variety of organizations. A number of papers and books are devoted to introducing and developing ESs for organizations' use (Burbrige and Friedman 1987, Martin *et al* 1991, Candlin and Wright 1992). As mentioned in chapter two, the organizational control and decision making activities can be seen as consisting of three control levels (strategic; tactical; and operational levels) which are described by Anthony (1965), with decisions varied from unstructured to structured which are explained by Simon (1977). The following sections discuss some issues associated with ES applications in organizations through the framework proposed by Anthony and Simon.

#### 3.3.1 Some surveys about ES applications

Before discussing the issues associated with ES applications, the author presents some survey results reported in the literature. This can provide some general ideas about the current use of ESs in organizations.

Surveys of the use of expert systems in organizations show interesting differences in their results (see table 3.3). For example, Ansari and Modarress (1990) sent survey questionnaires to 500 directors of information centres, data processing managers and system analysts whom they believed to represent 500 different companies of all types and sizes in the USA and received 175 usable responses. Of these, 70% indicated that their companies had an expert system in place, 24% had more than 60 rules in their knowledge base, 46% used less than 60 rules. The remaining 30% of respondents said they were considering the possibility of implementing an expert system programme. Jones (1991) reports a survey conducted in the middle-tier insurers in USA. The survey included 100 mid-tier firms - 50 property and casualty and 50 life companies that make up the 51 to 100 largest in each category. It showed that 58% of the firms are "active" in the ES area. Active is defined as having systems in use (21%), underdevelopment (12%), or research under way (25%).

These two surveys contrast with an earlier survey in the USA by Beheshtian-Ardekani and Salchenberger (1988). Their aim was to determine if companies in certain industries were more likely to be using expert systems or if organizations which had successfully implemented expert systems had any common characteristics. In this survey, 126 companies were selected at random and 47 of them responded, but only two of them (4%) were actually using expert systems. The main reason given for delaying the development, or purchase decision was the belief that an expert system would not be cost effective at that time; user resistance was also reported as an important reason. The

Table 3.3 Surveys about the use of ESs

| Names of the survey authors | Year | Country | Number of questionnaires sent | Types of responses surveyed | Number of valid responses received | ESs have been used | ESs are likely to be used in the near future |
|---|---|---|---|---|---|---|---|
| Beheshtian-Ardekani & Salchenberger | 1988 | USA | 126 | Data processing manager of each company selected by random | 47 | 4% | 4% |
| Ansari & Modarress | 1990 | USA | 500 | Directors of information centres, data processing managers and systems analysts, each represents one company | 175 | 70% | 30% |
| Higby & Farah | 1991 | USA | 2993 | Marketing executives selected at random | 212 | 6% | |
| Jones | 1991 | USA | 100 | Middle-tier insurers selected | 100 | 21% | 12% underdevelopment, 23% research underway |
| Walker | 1988 | UK | 262 | Production manager of each company | 58 | 7% | 21% |
| The Systems · International/es (Connect) | 1989 | UK | | A wide variety of organizations and types of users | 450 | 11% | 15% developing systems 14% prototyping |

suggested cause of user resistance was the fear that their jobs will be at stake when their companies complete their expert system projects. The threat of displacement is a very common reaction to new technology. It is possible that the situation changed drastically in the intervening two years, but unlikely. Another survey carried out by Higby and Farah (1991) in a group of U.S. firms also shows different results. The aim of this survey was to investigate the current status of Marketing Information Systems, Decision Support Systems, and Expert Systems. The survey was sent to a random sample of 2993 marketing executives and 212 usable questionnaires were received. About 6% of the respondents indicated that they used ESs, mainly used for order processing, inventory control, facility location and sales forecasting. Higby and Farah suggest that the profile of an ES technology user is a large firm with more than 1000 employees and annual revenues in excess of $300 million.

A survey conducted by Walker (1989) in 1988 showed a very low level of awareness of the potential of using expert systems to support management within manufacturing organizations in the north east of England at that time. Among 58 responses, only 7% said that ESs techniques were being used within the company, 21% said that ESs had been considered and may be introduced, and 45% had never considered the use of ESs but would like to learn more about their potential for use within manufacturing management. Investigations one year later show a similar pattern. A survey (The Systems International/es (Connect) 1989), of 450 responses from a wide variety of organizations in the UK, found that 52% have only a watching brief, and only 11% have operational systems. This is consistent with Harvey's (1989) finding, in which he states that compared with Australian, Japanese and American companies, where over

20% of companies have put at least one expert system into use, the comparable percentage in the UK is 10% (Harvey 1989).

Although the survey results show some differences since each survey was conducted for different purposes in different countries, at least two things are clear: 1. The usage of ESs is increasing, and 2. The percentage of companies using ESs is higher in the USA than in the UK.

### 3.3.2 The role and the functions of expert systems

The roles and the functions of a KBS/ES have been categorised in many different ways. Classifications according to role have been suggested as client, instructor and pupil by Mumford (1987); to replace an expert, an additional expert, an adviser, an assistant, a knowledge servant by Barrett and Beerel (1988); action, expertise, advice and check-list by Ernst and Ojha (1986); consultancy, checklist, training, refining expertise, communication medium and demonstration vehicle by Basden (1984) and assistant, critic, second opinion, expert consultant, tutor, automaton by Edwards (1991a). Another classification based on the functions of the organizational system within which they operate was suggested by Edwards (1992) and classified as interpretative, diagnostic, design, planning, monitoring, education and training, and control by Beerel (1987).

In addition to the above, Coursey and Shangraw (1989) propose an expert system typology which is based on the decision-making role of expert systems in the organization through the lens of Simon's (1977) intelligence, design, choice decision-making model which they think aptly describes phases in human decision making. They surveyed the literature as well as their own development experience with expert systems, and defined seven categories of expert systems: (1) consultative, (2) training, (3) expert replication, (4) exploratory systems, (5) conventional task, (6) interface, and (7) task execution. They indicate that training and interface focus on intelligence activities; consultative and expert replication stress the design phase; task execution systems are developed for the choice phase; exploratory systems are used predominately in intelligence and design, while conventional task systems are used in all three phases.

Underwood (1992) simply classifies the expert system applications into three types based on how the system is integrated and controlled by the user: a stand-alone system (which automates decision making and displaces human experts), an embedded system (which is a "black box" decision making component that is built into another program and is to make a person's expertise available to a program), and an expert assistance system (in which the human experts remain in control of the process and the purpose of the system is to help the user apply his experience and judgement to the problem at hand). Underwood's category is similar to the three types of ESs defined by Bader (1988) and Edwards (1991a) which is mentioned in section 3.1.2, but Underwood's expert assistance system can also be a Bader and Edwards "stand-alone system", if it is not integrated with other management information systems. However, although there are many ways to group expert systems, it is important, as Beerel (1987) mentioned, not to get bogged down by classification.

No matter in which organizational levels ESs are used and in which decision making phases they are involved, generally, expert systems can be developed for two purposes: one is in a support role, such as giving advice or hleping a person to analyze the problem, and the other is in a replacement role which means it can take over the human's job.

As a replacement

The functions such as: expert consultant, tutor, automaton (Edwards 1991a); action (Ernst and Ojha 1986), to replace an expert (Barrett and Beerel 1988); task execution (Coursey and Shangraw 1989) and stand-alone system (Underwood 1992) mentioned above are considered as being a replacement for a human being.

The concept of replacement here has to be clarified. An expert system may be used to replace an expert, or may replace not only the expert but also the end-user. Whoever it may replace, if the system (not the user) makes final decisions, it is considered to have a replacement role.

As a support tool

The majority of functions described above such as: expertise, advice and check-list (Ernst and Ojha 1986); an additional expert, an adviser, an assistant, a knowledge servant (Barrett and Beerel 1988) and assistant, critic, second opinion (Edwards 1991a) belong to the classification of support role.

In a support role, the system is designed to support non-experts (in most cases) or to support experts. It assists human beings but it does not replace them. An expert support system can be designed for different users: it can be developed for expert use only which is described by Coursey and Shangraw (1989) as "developed to help the manager or expert develop and analyze possible solutions". Alternatively, it can be used by non-experts to obtain expert advice or other forms of help in accomplishing some task (Basden 1984). When an expert support system is used to provide advice to a non-expert, it is used as an advisor. Therefore an expert advisory system is a particular kind of expert support system.

### 3.3.3 Debate on the role of expert systems

There are still different opinions about what the roles of ESs should be. Most people indicate that ESs are more frequently used for a support purpose rather than a replacement purpose. For example, "it should be stressed that ESs are most sensibly used as tools to assist rather than to replace." (Hart 1989); "it is important to stress that an expert system cannot be expected to replace an expert." (Barrett and Beerel 1988); and "ESs are not intended to replace the decision maker but to assist people in dealing with various problems." (Cheng and Bizruchak 1991). Ow and Smith (1987) argue that in certain cases (though they do not mention what the cases are), the systems may replace people in their jobs, but more frequently, they play the role of intelligent consultants in decision making. Moreover, Beerel (1987) emphasizes that as far as she is aware, and she has discussed this with other workers, no one has been replaced by an expert system in carrying out a job. In other words the system is a tool aimed at supporting the user in his task and not acting as a human substitute.

It is argued further that it is quite impossible to replace an expert completely; and even if it were feasible to achieve expert level performance, the human attributes of creativity, generality, and ability to adapt to new situations would all be lost (Barrett and Beerel 1988). However, Keller (1987) suggests that expert systems possess the potential to replace people, this is nothing new, but what is different about expert systems is that "we are talking about replacing professionals, not clerks". Keller does not discount the possibility that some professional-level tasks requiring specialized intelligence can actually be done as well, or better, by an expert system as by human experts, but for the time being, he suggests that it is better to think of an expert system more as an apprentice, an intelligent assistant, than as a replacement for human experts.

Some researchers (Council for Science and Society 1989) find that, at present, almost all existing KBSs are designed to assist problem solving, to improve the quality of human decisions, not to take over a task. They point out that in some situations, such as those where bad decisions could result in some very substantial losses, the goal of ES development should be to build a support system to aid, not replace. Some autonomous KBSs are being designed, mainly for tasks that require a fast response based on the analysis of large amounts of data, but these are in specialised areas such as financial dealing or weapons control. They suggest that KBSs should, whenever possible, be deliberately designed to complement human workers rather than replace them. Human creativity and judgement should be respected, and the control and scheduling of the task should rest with the human user.

A survey carried out by Doukidis (1988), however, showed that among 67 ES cases investigated, 87% of them were in a support role (supplying expert advice) while the rest 13% were in a replacement role (replacing human experts but not the end users). The result is shown in figure 3.1. He says "clearly, the role of ES in most cases is to support a user; this matches with the aim of ES to supply expert advice.". Another survey carried out by The *Systems Internationalles* (Connect) (1989) analyzed the intended users of ESs and divided the ESs by intention: advise a lay person; knowledgeable user; replace human and real-time feedback control. Figure 3.2 shows the survey result. According to the definition discussed in section 3.3.2, systems for advising a lay person are expert advisory systems, and systems for knowledgeable users are the systems for supporting experienced people. Both advising a lay person and knowledgeable users are systems used for support purpose, and systems used for replacing a human are obviously for replacement purpose, but it is not clear here what system the real time feedback is. These surveys contradict with Hart's, Barrett and Beerel's comments, but this may due to how they define and understand "replacement". Another reason is that Hart *et al*'s comments intend to advise people not to replace expert completely from their point of view, but in practice it is a different situation.

In summary, it is not expected to replace an expert completely, but at least some of an expert's functions can be replaced by an expert system. Most ESs may be designed for the support purpose, while some of them may be built for the replacement purpose. The possibility that an ES could replace humans can not be discounted, however.

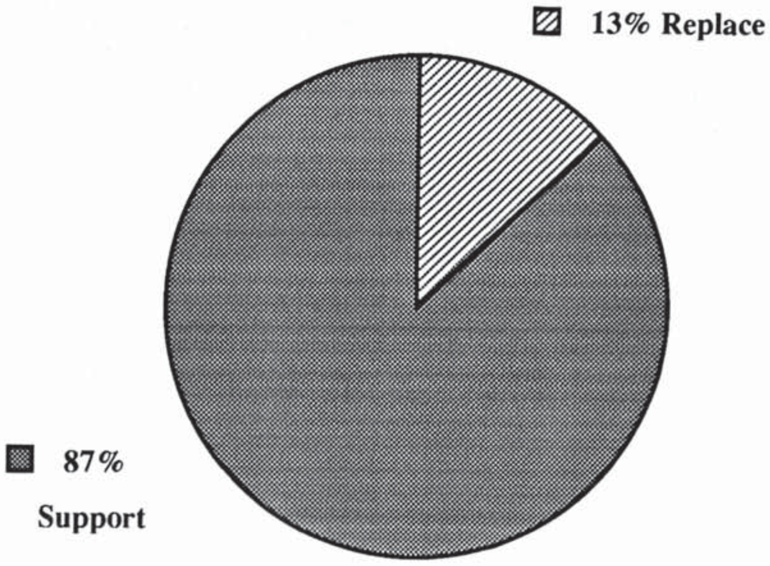



**Figure 3.1 Survey result by Doukidis**

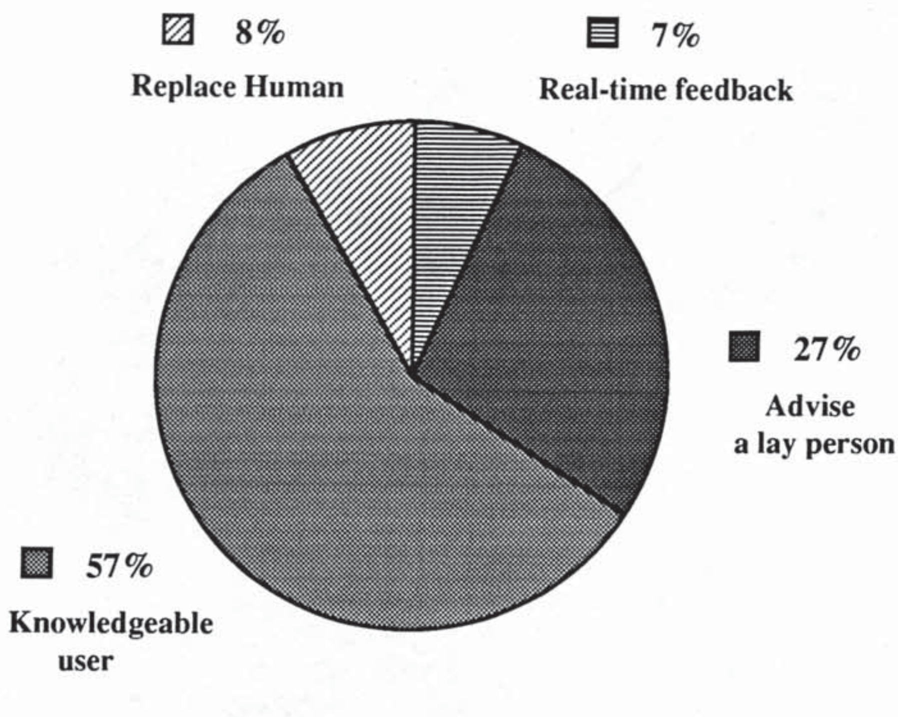



**Figure 3.2 Survey result by The System International /es (Connect)**

### 3.4 Expert Advisory Systems

Advising is the act of assisting another person in coming to a conclusion within a situation (Licker 1991).

As has been discussed in section 3.3.2, expert systems can be developed for two purposes: to replace or to support a human. An expert support system can be designed for different users: it can be developed to hlep experts or experienced people to analyze a problem and, it can also be used by non-experts to obtain expert advice or other forms of help. "Like a human expert, such a computer system can extract additional information from a user by asking questions related to the problem during a consultation. It can also answer questions asked by a user about why certain information is needed. It can make recommendations regarding the problem or decisions at the end of the consultation, and when asked by a user it can explain the reasoning steps gone through to reach its conclusions" (Mockler 1990 page 7).

The following are some examples of expert advisory systems reported in the literature:

VATIA (Ernst and Young 1990): A professional VAT advisor which is being used in Ernst and Young was developed using the Crystal shell. The main benefits reported are an improved quality of service to clients, and that VAT specialists are freed from routine for higher-level work.

TRANAID (British Nuclear Fuels plc (BNFL) 1990): An expert system to provide expert advice on transport safety. It was developed using the Leonardo 2 shell and is used at BNFL and by other users internationally. The major benefits are to provide reliable and consistent advice and to reduce the workload on scarce skilled personnel. Training and improvement in the expertise of users is also stated as a non-quantifiable benefit.

Armstrong (1992) describes several help-desk advisors, such as The LAN Advisor and WordPerfect Advisor, developed using 1stCLASS Knowledge-Based development tool. The benefits of using these are to improve the quantity and quality of services delivered to users and save the cost of telephone enquiries.

The Strategist (Schumann *et al* 1989): A business strategy advisor to help users to analyze both market and technology factors and to suggest possible business strategies. It was built using the Expert System Environment (ESE) expert system shell. The Strategist's results show that the recommendations appear useful for the planning of product strategy.

Jacob and Keim (1990) developed a knowledge-based decision aid for information retrieval. The system was developed using the EXSYS Expert System Development Package. They tested the system against the non-users and the results of the experiment provided some indication that the use of a knowledge-based information retrieval system will result in enhanced decision effectiveness.

The Strategist and Jacob & Keim's system are prototype systems. Other systems, such as: BMS (Budget Management System) -- an expert assistant system dedicated for the financial manager to the design of budgets under constraints (Bicard-Mandel and Vlondakis 1991); SPARTA -- an expert system for advising on the stocks of spare parts in inventory systems (Petrovic *et al* 1990); GAIN -- an expert investment consulting system (Donalisio *et al* 1991), are also prototype systems which are not discussed in detail here.

The major benefit of the advisory systems reported in the literature can be concluded as improving the decision making effectiveness of non-experts and freeing the experts for more creative and higher level work. A minority of studies also cite training of the non-experts as a benefit.

Because an advisory system is built for non-expert users, the user's acceptance is a very important factor for its success. It is important to note that even if the expert advisory system satisfactorily represents the expertise in the domain, there still remains the question: "Will the end-users use the system?".

## 3.5 The Use of ESs at the Different Levels of an Organization

Referring to the use of ESs in the three organizational levels of Figure 2.1, Gibson and Vedder (1989) explain that as expert systems are impervious to pressure and provide timely, consistent, and uniform help for making decisions, they can assist all three management levels, but Barrett and Beerel (1988) indicate that the most evident use for ESs is in the middle ground, i.e. addressing those problems which are neither highly structured nor totally unstructured. These are beyond the reach of conventional computer systems (though the authors do not mention Decision Support System (DSS), but it is the area of DSS also), and will include many technical, professional, and managerial tasks. Highly unstructured tasks call for too much knowledge, and are accessed in ways which are too subtle, for it all to be encapsulated in a computer system. This means that expert systems are likely to support only particular aspects of the work. Burbrige and Friedman (1987) point out also that expert systems are not especially appropriate in totally structured situations but that an ES will shine when incomplete data and uncertainty are common.

The following sections discuss issues concerning the use of ESs in terms of different organizational levels.

At the operational level

The current use of expert systems appears to be confined largely to operational decisions. Doukidis's (1988) survey shows that among 67 ES cases investigated, 78% of ESs were used at the operational level and 3% of them were for strategic work and 24% were concentrated on managerial work (response rates here add up to more than 100% possibly due to multiple responses). Connell and Powell's (1990) survey shows similar results, indicating that end-users of ESs are more typically at a low organizational level. In the book "Practical Experience in Building Expert Systems" edited by Bramer (1990), 8 of the 11 systems described are at the operational level, with the other 3 systems at the tactical level.

At the tactical level

Blanning (1984a, 1984b, 1984c) has suggested that ESs can be developed to provide decision support to managers in public and private organizations who make manufacturing, marketing, financial, personnel, and other decisions. He recognized four areas for an expert system for managers (ESMs): 1. resource allocation, 2. problem diagnosis, 3. scheduling and assignment, and 4. information management, which are mainly the domain of tactical managers.

There are a number of examples about the use of ESs for middle level management (Bramer 1990, Yang and Jiang 1990, Balaila *et al* 1991, Rasmus 1991, Touche Ross 1992). Touche Ross's (1990) survey indicated that 36% of KBSs/ESs surveyed are used for middle management, with 48% for technical staff, 13% for clerical/administration and 3% for director/senior management. One successful example reported by Jasany (1991) and Rasmus (1991) is of a Forge Shop Scheduling System (FsESS). It balances the objectives of all departments to better allocate the flow of work through the forge. It also reduces lead times and the work-in-process inventory, allowing the forge to meet its on-time delivery and efficiency objectives. It is comprised of three modules: the knowledge base, the automatic and interactive schedulers, and the interface to the company's database. Since FsESS has been in use, the company has experienced a 5 to 10% improvement in material yield, reduced energy consumption, and seen a reduction in order turnaround time.

At the strategic level

Goul (1987) indicates that ES techniques have not generally been used at the strategic level. Connell and Powell (1990) provide evidence for this phenomenon from the survey they carried out in the domain of accountancy. They found that for the ES survey, end-users of such systems were more typically at a low organizational level, although the backing of senior management was considered important. Doukidis's (1988) and, more recently, Touche Ross's (1992) surveys mentioned earlier show the same result with only 3% of ESs investigated having been used for strategic tasks. However, it is believed that the support of a decision-making process in strategic planning can be enhanced with the use of expert systems (Kampfner and Mashhour 1991). Therefore, there has been a call to expand the focus of expert systems to include support for complex, unstructured decisions within organizations (Applegate *et al* 1987).

Some authors (Beerel 1987, Mockler 1989, Schumann *et al* 1989, Borch and Hartvigen 1991, Kampfner and Mashhour 1991) have addressed issues relating to the implementation of expert systems to tackle strategic problems. Examples of these include:

> STRAEX (Borch and Hartvigen 1991), a knowledge-based system for strategic market planning by supporting the choice of marketing segments;
>
> The Strategist (Schumann *et al* 1989), a business strategy advisor to help users analyze both market and technology factors related to existing products or potential products and to suggest possible business strategies for these products based on the market and technology assessments;

PLEXSYS (Applegate *et al* 1987), a knowledge-based planning system to support the planning process from initial formulation of the planning problem or task, to implementation of the plan, which has been implemented in the Management Information Systems (MIS) Planning and Decision Laboratory at the university of Arizona from 1985 and since then over one hundred planners from a variety of organizations have used the system.

$I^2SC$ (Scheel and Flores 1991), an intelligent system to support the strategic decision making process to enhance competitiveness by considering all the relevant variables that determine the competitive advantage of a firm, as well as integrating the perceptions, reasoning and expertise of top-management, with the knowledge and observation of the operating level managers, and it offers a variety of benefits to the firm's top-management, mainly in the strategic planning on competitiveness and on how to support competitive strategies based on information, knowledge, and current facts.

However, most of the systems are still in prototype stage and not in commercial use.

In the area of strategic decision-making, one of the fundamental problems is a lack of understanding of the cognitive process of management (Borch and Hartvigsen 1991). It is suggested that an ES be used as a tool rather than as a replacement for strategic planning (Goul 1987).

### 3.6 Organizational Benefits from ESs

There is no doubt that organizations can get substantial benefits from the use of expert systems and these benefits have been well documented (Edosomwan 1987, Nadkarni and Kenny 1987, Turban and Watkins 1987, Barrett and Beerel 1988, Kastrud 1991, Keller 1988, Valliere and Lee 1988, Hollnagel 1989, Paradice and Courtney 1989, Paton 1989, Anderson and Stach 1990, Willems 1990, Ashman *et al* 1991, Churcher 1991, Candlin and Wright 1992, Loofbourrow 1992). The following paragraphs present some viewpoints from these.

According to Valliere and Lee (1988), ESs provide many people in an organization immediate access to the consultative service of the expert, thus improving the expert's productivity. ESs reduce the possibly of excessive demands on the human expert, thus improving his productivity. They also reduce the organization's reliance on the human expert, which means that expert knowledge is still available should the human expert become incapacitated or leave the organization.

The benefits of expert systems given by Willems (1991) are as follows:

-- reducing the need for highly paid experts

-- making these experts even more productive

-- allowing novices to perform expert tasks

-- improving the consistency of decision making

-- documenting the rationale for decisions

A company manager who made use of a knowledge based system for products design said: "We are taking expert information from the top 10 percent of our staff and putting it in the hands of the other 90 percent" (Jancsurak 1991). The knowledge based system makes it possible for less experienced engineers to capitalize on the expertise of specialists (Jancsurak 1991).

Expert systems may not entirely replace experts, but they will definitely reduce the amount of time their expertise will be needed (Ryan 1988).

Some of the surveys which are described in section 3.2.1 provide analysis about the ES benefits. For example, the survey reported by Jones (1991) shows more than three-quarters of the mid-tier insurers active in the use of ESs reported that the top three benefits derived from the technology are 1. improvements in productivity, 2. enhanced quality and consistency, and 3. distribution of scarce expertise. Ansari and Modarress's (1990) survey found that 54% of the companies with an ES in place reported improvement in decisions made by non-experts as the most important benefit. It indicated that an expert system makes it possible for less experienced people to perform at levels closer to those of the experts. Nearly 45% named consistency in decision making as the second most important benefit. They found that expert systems can provide more consistent advice to the decision makers than can human experts. Response time in some decision areas is also faster, according to 28% of the companies, while 14% of respondents cited improved training as an important benefit (but they did not mention whether these ESs were designed as training tools or not). They said that expert systems can help novices to become more experienced workers, while 21% of the responding companies said that use of expert systems had saved substantial operational costs, especially in cases where humans must rely on extensive equipment for monitoring and control. This last point about cost saving is contrasted with the survey of The *Systems Internationalles* (Connect) (1989) which shows that the most important benefits are those concerned with the accuracy of decisions, increasing capability of problem solving, quality of work, etc. (details are shown in the article), while the least significant benefits are those concerned with cost factors, such as reduction in staff numbers or using cheaper staff with lower skill.

Another benefit, that an expert system could improve the human expert's ability at problem-solving, has been mentioned by other workers (Goodall 1985, Edosomwan 1987, Slatter 1987, Edwards and Bader 1988, Wensley 1989, Burbridge and Friedman 1991), but this issue is still an area which needs further exploration. Turban and Watkins (1987) indicate that some ESs have proved to do a better job than humans because they make fewer mistakes and are more consistent in their recommendations.

Furthermore, Goodall (1985) analyses the reasons why expert systems can perform better than a human. He points out that expert systems: 1. make fewer errors, 2. do not become tired or bored, 3. will not overlook a solution, 4. can handle large volumes of data, 5. can respond more rapidly, 6. can function in hostile environment.

Slatter (1987) argues: human experts are known to be inconsistent, unreliable and to disagree with their colleagues on important matters; such observations suggest that a reasonable goal for expert system design is not merely the achievement of expert level performance but, ultimately, an improvement in human expertise. Results presented by Michalsi and Chilausky (1980), where machine-induced rules proved better at diagnosing soy bean diseases than rules derived from an expert, indicate that this is already the case for some types of task.

Finally, the benefits of the expert system approach to organizational decision making can be summarised as follows:

(1) Preservation of knowledge. An expert's expertise can be embedded in the knowledge base. It is readily available and will not be lost if the manager is away, busy, or indeed leaves the organization.

(2) Distribution of knowledge. Once the knowledge has been captured in a ES it is easy to make copies of the system, thereby distributing the knowledge contained in the system to a number of different sites within an organization. The surveys mentioned above all indicated this was an important benefit to organizations.

(3) Managerial development. By freeing the manager's time for more creative activities, this will help them use their time more effectively. The reduction in time needed to evaluate alternatives and to coordinate interdivisional efforts is considered a major benefit to organizations.

(4) Effective training. Expert systems may be designed to act as a training tool. An ES can reduce the amount of time spent in training by enabling trainees to acquire

parts of the required expertise directly from the system rather than from instructors.

Like a DSS, which is believed to improve the effectiveness of decision making rather than its efficiency (Turban 1988), an ES in a support role is also intended to improve the effectiveness of decision making. However, this may not apply to an ES which is in a replacement role, for example, an expert system for automation should be able to work effectively as well as efficiently. Cost saving benefits are claimed by most of people, but not all the ES surveys provide supporting evidence.

### 3.7 Organizational Impact of ESs

Due to the increasing use of KBSs/ESs, the need for studying the impact of expert systems on organizations is indicated by many researchers (Berkin 1986, Benchimol *et al* 1987, Mumford 1987, O'Leary and Turban 1987, Turban and Winskin 1987, Lu and Guimaraes 1989, Weitz 1990, Willems 1990, Loofbourrow 1992). Straub and Wetherbe (cited by Willems 1991, page 174) suggest that "as we move from the 'era of data dominance' to the 'era of knowledge dominance', ...there will be a thinning and flattening of management ranks...[and] momentous changes will result from a fundamental rethinking of the nature of the work people do and the nature of the work departments do". Loofbourrow (1992) points out that it should be recognized that "building expert systems, applying expert systems technology and managing human computer teams requires some rethinking about how we view our organizations." (page 62). Ryan (1988, page 32) stresses that "I believe it is time to start thinking about those issues (the possible consequences of expert systems) in great detail and begin to prepare ourselves for a new society that will be the result of expert systems."

Some organizational problems can arise through the use of ESs technology. O'Leary and Turban (1987) have examined the potential organizational impact of expert systems along eight organizational dimensions: decision making, organizational structure, degree of centralization/ decentralization, organizational effectiveness and efficiency, organizational roles, leadership and power, communications flow, and personnel requirements. They argue that ESs could cause changes not only in job content and the number of employees in specific jobs, but also the organizational structure.

Applegate *et al* (1988) cited Leavitt and Whisler's prediction about future organizations in their paper which appeared in 1958 that ... "the role and scope of middle managers would change. Many of the existing middle management jobs would become more structured and would move downward in status and compensation. The number of middle managers would decrease, creating a flatter organization". Huber (1988) set forth some hypotheses concerning the effect of computer-assisted decision and communication support technologies on organizational decision processes and structures. One of them is that "use of computer-assisted decision or communication support technologies reduces the number of hierarchical levels involved in authorizing organizational actions" (page 326), but only weak support for this hypothesis is found by him in the observations of managers that information technology is associated with a decrease in the number of middle-level managers.

Lu and Guimaraes (1989) conducted a survey about selecting an appropriate expert system application. Considering the impact of expert systems on the organizational structure, the survey showed that the implementation of expert systems in an organization could affect a large number of positions; it might change the skill requirements or political influence for expert system-related positions.

At present, as Barrett and Beerel (1988) state, information normally flows only up and down an organization, and expertise rarely flows anywhere at all! They believe that expert systems can create horizontal exchanges where none existed before. O'Leary and Turban (1987) indicate further that the use of ESs will lead to a wider dispersion of the expertise throughout an organization. In addition they cite Mowshowitz's (1985) suggestion that the implementation of organizational knowledge in an expert system can lead to an increase in effective centralization by building different top management's policies and procedures into the expert system. Thus, any decision made by the expert system will be reflected in top management's policies. The use of expert systems may give top management more direct control of its organization's activities and reduce its reliance on expert staff and middle management (Ryan 1988). In the future a company will still need middle managers to analyze and improve the expert system, Simon (1977) argues that although the demand for line management is substantially smaller, middle managers are needed for the new staff operations of designing and maintaining the automated decision-making and planning systems.

When discussing the impact of ESs, Applegate *et al* (1988) said:

> "The information systems themselves - not the people - can become the stable structure of the organization. People will be free to come and go,

> but the value of their experience will be incorporated in the systems that will help them and their successors run the business" (page 135).

The issues addressed by others over the impact of ESs are still matters for conjecture. Insufficient evidence has yet been found to support the hypotheses mentioned above, so how to obtain real feedback about the impact of ES implementation is still an area which needs further consideration.

## 3.8 Issues Concerning the Success of ESs

"Today, although AI expert systems still occasionally make news, the subject doesn't have the same high profile (as in the mid-'80s). Research continues, but more quietly. What happened?" (Mckague 1992 page 9). For example, it is noted that in the development of training, the use of ESs appears to have peaked in 1988 and is currently in a downward trend (Wankel and Abraham 1991). Although a large number of ESs have been developed every year, reports about the successful examples are relatively few. Some have noticed this phenomenon and try to find solutions (CE Roundtable 1990). For example, Meyer and Curley (1991) identified that of many companies that had invested in ES technology, only a few had achieved substantive results. Klein *et al* (1992) point out that the practical use of ESs has been disappointing, with relatively few systems convincingly implemented. Some factors associated with the success of ESs are discussed in following sections.

Development and implementation issues

Some researchers have realized the problems related to the success of an ES implementation and made efforts to build expert systems which will be applicable during designing stages and successful in their use (Wilson 1990, King and McAulay 1991, Kloppenborg and Plath 1991, Meyer and Curley 1991, Gupta 1992). Deschamps (1991) presents some reasons why an expert system fails instead of the technology reason. One reason is lack of the right support from organizations and other factors include managing education, getting acceptance, funding, managing organizational change, updating knowledge base, etc.

Meyer (1991) indicates many prototype expert systems are never truly implemented and diffused within organizations, and suggests that some of these prototypes fail to be implemented because management has not fully realized the need for DP professionals in the areas of systems integration and distributed data management. What is the importance of more traditional computing skills, such as database programming or systems integration, in comparison to knowledge-base encoding and other aspects of "AI programming" (Meyer 1991).

Gupta (1991) indicates that a wide margin still exists between the potential that expert systems hold and their current capabilities, and it is important, he argues, to underscore the differences between potential capabilities and current status of expert systems because a lack of understanding of these issues often leads to unrealistic expectations and unsuccessful systems.

Currently most of the work on expert systems has centred on the technology involved in their actual construction. For success at the organizational level, it is essential that the system is used and liked by the organization's personnel. While direct end-users might be forced to use a system, it is unlikely that under such conditions the system will ever be a great success and it certainly will not perform to its maximum possible potential. It is suggested that ES development should address the really difficult issues that involve real people and the organizations they work for (Diaper 1990). How to tackle expert systems implementation successfully within an organization has been discussed from different points of view by various researchers (Mumford and MacDonald 1989, Deschamps 1991, King and McAulay 1991, Meyer 1991). They suggest that like any other computer information system, the availability of knowledge-based systems does not necessarily mean realization of their full potential. If people ignore the organizational aspects of ES development, these systems may or may not be used, and even if they are used, productivity enhancement may or may not be attained (Abdul-Gader 1991). Berry and Hart (1990) indicate that not only must the system match user needs and support users in their tasks; but it must also match the system and the social and political factors within the host organization. Furthermore, managers must understand the limitation of technology and realize that the expert systems implementation is never finished (Kastrud 1991)

Therefore, there is a need for more understanding of expert decision making and an organizational framework which is more suitable for implementing ESs in organizations. Some workers (Burbridge and Friedman 1987, Meyer and Curley 1991, Sharma *et al* 1991) have realized this and have turned their attention to approaching expert systems from social and technical perspectives, as have Sharma *et al* (1991) who have proposed a socio-technical model for deploying expert systems within an organization.

Jander (1991) discusses some other problems with a specific ES application. He found that expert systems from HP and Network General could solve some Local Area Network (LAN) problems quickly, but they could not be fine-turned. The ES do a good job when handling familiar problems but cannot be trained to try different approaches or handle new problems. The inability to customize the knowledge base limits the utility of the system.

Meyer and Curley (1991) synthesize the results of a study of a number of firms that successfully developed ESs and try to help managers determine suitable ESs development strategies for their own jobs and companies. They have argued that management should focus on choosing the most appropriate projects and matching them with the technological tools, funding level, staffing, and development processes that are consistent with the firm's internal resources, its organization, and its market opportunities.

<u>Selection of domain</u>

ESs are not applicable to all types of problem. There are no clear-cut instances in which an ES should or should not be used. However, some have tried to identify the most applicable area or cases where ESs can be at least considered as an alternative (Cheng and Bizruchak 1991), and others have discussed what sort of problems are suitable for ESs (Townsend and Feucht 1986, Waterman 1986, Burbridge and Friedman 1987, Valliere and Lee 1988). For example, Lu and Guimaraes (1989) attempt to present a more global organizational view of expert systems to help managers select the most appropriate ES applications for their organization. They argue that with widespread use and excitement about the potential benefits of ESs, many organizations might be too eager to seize this opportunity and therefore select unsuitable applications. They might also fail to consider the alternative to expert systems development (Lu and Guimaraes 1989). Ignizio (1990) argues that an expert system is not a tool for use on virtually any problem.

User factor

An expert system is for users. Despite their apparent success in the laboratory, many early systems were not successful in practice. It seems that an insufficient awareness of user needs and requirement has contributed to this failure (Hart and Berry 1990). The human factor issues in expert systems design and acceptance are discussed by several researchers (Madni 1988, Rees 1992, Suh and Suh 1993). Many have addressed the issues about the importance of user involvement, and argue that the success of the expert system is gauged by its usefulness to users (Beerel 1987, Edmonds *et al* 1990, Després and Rosenthal-Sabroux 1992). Some research has shown that the low user involvement has resulted in poor operational use (Duchessi and O'keefe 1992). One very common fear on the part of corporate end-users is whether their jobs will be at stake when their companies complete their expert system projects. Blanchard (1991) says that "Indeed, with most companies it becomes something of a public relations strategy to emphasize that humans are continuing to make those vital decisions that affect peoples lives and livelihoods, and expert systems are used to bolster the decision making process", despite the fact that expert systems do replace people in some cases as shown in surveys mentioned previously (section 3.3.3).

O'Neil and Morris (1989) conducted a survey of ES producers in the UK. The survey aimed to establish the nature and scope of ES projects, the skills and methodologies used in their development and the background and experience of the personnel employed to develop them. They concluded that "From the evidence offered by the survey, the real enemies of successful ESs appear to be over-ambition, ill-chosen applications, bad project co-ordination, lack of communication, mistargeted systems, and an ignorance of real user needs and how to address them" (page 99). The solutions to these problems, they suggest, lie in a more realistic assessment of potential applications, treating the user as equal partner in the development process, and the establishment of effective communication channels between experts, developers and users.

### 3.9 Decision Support System and Expert System - Differences?

DSS and ES are two growing areas in computer applications. Since both of them share the same aim of supporting users in decision making and problem solving, some have made comparisons between them (Ford 1985, Turban and Watkins 1986, Beerel 1987, Connell and Powell 1990, Edwards 1992). Some of these comparisons are presented in this section.

Turban (1988) defines a Decision Support System (DSS) as:

> "An interactive, flexible, and adaptable CBIS (computer based information system) that utilizes decision rules, models, and model base coupled with a comprehensive database and the decision maker's own insights, leading to specific, implementable decisions in solving problem that would not be amenable to management science optimization models *per se*. Thus, a DSS supports complex decision making and increases its effectiveness" (Turban page 109).

Edwards (1992) regards a DSS as simply "A system which enables the user to access data and/or models so that he or she may make better decisions" (page 115).

The general belief about DSS is that it attempts to improve the effectiveness of decision making rather than its efficiency (Turban 1988).

Ford (1985) compares DSSs and ESs in four primary areas: 1) objectives and intents, 2) operational differences, 3) users, and 4) development methodology. He finds the fundamental goal of a DSS and an ES is basically the same; they seek to improve the quality of the decision. The objective of a DSS is to support the user in the decision making process by providing access to data and models. The objective of an ES is to provide the user with a conclusion or decision significantly better, or more often correct, than the user could reach. A DSS allows the user to confront a problem in a flexible, personal way in manipulating the data and models. With an ES, the user has little or no flexibility. Users of a DSS are mostly upper and middle managers who helped design the system. ES users, on the other hand, are typically scientists or researchers who did not develop the system. Ford gives a few examples to support his analysis (page 25).

Turban and Watkins (1986) did some comparison between DSSs and ESs in terms of objectives, the problem attacked, system structure and the problem boundaries applied.

They argue that the objectives of the system are different: the DSS supports the human who makes decisions, while the ES operates as an advisor; the problem area attacked by a DSS is broad and complex, while an ES is restricted to a much more structured and narrow domain; the database of a DSS contains facts while its counterpart in an ES, the knowledge base, contains, in addition to facts, also procedures for how to solve problems; additionally, an ES typically involves a closed-system assumption, that is, the problem domain is circumscribed and the system's functions are confined to boundaries, while in a DSS context, the world is open.

When addressing the differences of DSS and ES, Edwards (1992) analyzes examples of four expert system developments in management and administration, and asks the question - "Are they really different from decision support systems?". He argues that "at least in management and administration, ESs are the same as DSSs in the operations they perform and the organizational functions they assist, but different in terms of the tools used to build them and the source of the model(s) they contain" (page 121).

Some researchers' comparisons are based on surveys. For example, Doukidis (1988) carried out a survey on 67 ESs to investigate whether they employ DSS concepts (this survey has been described in section 3.3.1). The survey shows that three fundamental DSS issues, semi-structured task, support and effectiveness, are explicitly applied in an ES. Doukidis argues further that although both DSS and ES have similar aims, they achieve them in completely different ways. The main differences are at the boundary of the problem-space and the way they tackle the problem. A DSS encourages the user to explore a wide problem-space, while the ES approach bounds the problem-area within well defined-domains. This point about domain boundaries agrees quite well with Turban and Watkins's finding mentioned above. Instead of a fixed problem-solving process, the DSS system provides a flexible problem-solving environment of tools and data for the user to play with in his own way. On the other hand, in the ES approach, past experiences on repetitive tasks are formulated as problem-solving processes for future use, and the system's operation is usually goal-orientated and system-driven.

Connell and Powell (1990) also conducted two independent surveys of DSS and ES applications in a sample domain - accountancy - to assess the view of their functionality held by users of the systems, particularly their functional differences. The surveys demonstrated that DSSs and ESs are used over a wide range of applications and provide no evidence in favour of any particular application areas being more natural candidates for one type of system in preference to other. The results from the DSS survey indicate that the predominant groups of DSS users were at very senior levels, which Connell and Powell say bears out the Moore and Chang (1980) stance that DSS is an enhancement of management information systems with a focus on decision support at the higher organizational levels of the organization. Users of DSS perceived that the use of DSS has enabled firms to offer new services to clients, rather than to automate or enhance existing activities. Whereas in the ES survey (described in section 3.3.4), end-users were more typically at a low organizational level and the perceived benefit was typically that of spreading expertise among a wider group, particularly at lower levels within the organization.

Cadden and Banai (1991) carried out some experiments to analyze how individual differences of the users affect their perception of the usefulness of two computer aids - expert systems and decision support systems - and their decision to use these systems. The experiments gave some interesting findings about the user's different responses to the selection of either a DSS or an ES as a decision making aid. They found that the user's cognitive style plays a critical role in determining their responses to these two computer decision making aids and they indicate that experts will find expert systems to be less useful than decision support systems. The author of this thesis believes that this is due to the different features of DSSs and ESs in the way they support the users mentioned above. Since DSS provides a flexible problem-solving environment for the user to play with his/her own way and can amplify the capability of the expert, it is no surprise that experts will like DSS more than ES (which is usually system-driven and has a fixed decision-making process).

Some experiments on the effect of DSS have given interesting results. For example, the experiment conducted by Coll *et al* (1991) which examines the efficacy of decision support systems indicates that in the circumstances of the experiment (a decision problem requiring non-overload multidimensional analysis and integration), a computer decision support system neither reduces the time required to come to a decision nor improves the quality of the decision. Analysis suggests that "computer reluctance" on the part of members of the DSS group was an important factor in the results obtained. Kottemann and Remus (1991) carried out experiments to investigate the effect of DSS formal models and "what if" analysis on performance, both when learning is occurring, and when learning is completed. The experimental task used was production scheduling and the subjects were 30 volunteers from an MBA course in Operational Research and

Information Systems. In order to measure the performance, the experimental task was wholly quantitative and the experimental DSS embodied an accurate model of the underlying problem. They found no evidence that DSS predictably improves the decision making performance. They argue that while DSS may shorten the number of periods needed to learn a decision task, this does not imply that DSS improves the quality of what is learned. They presented some potential explanations for these unexpected results.

Experimental results from Coll *et al* which show that a DSS does not save time is consistent with the general belief that a DSS is about effectiveness not efficiency, but the results of the two experiments mentioned above which indicate that a DSS does not improve quality are unexpected and contradict the belief that a DSS is about effectiveness. If experimental subjects of Coll *et al*'s experiment lacked motivation to use a DSS and they used it as they were required, then the result would not reflect the real problem. On the other hand, the results indicate that computer reluctance must be treated seriously since it will greatly affect the implementation of DSSs. As a DSS is not intended for learning, the result of Kottemann and Remus's experiment is in doubt, and it may not be extended to general cases. However, there still remain some questions about the effects of DSS's and ES's and further research may be needed to provide more evidence.

### 3.10 Problems Raised by the Literature Review

Although expert systems have been introduced into organizations, the literature review suggests that some problems still arise which either remain unsolved or have not received enough attention.

Benefits and effects of ESs

"Although expert systems are used in many organizations, they are often still considered untested technology" (Krebs 1989, page 12). From the applications viewpoint, it has been argued (Coursey and Shagraw 1989) that like many new technologies, expert systems suffer from the "black box syndrome"; very little is known about their effect on organizations, much less is understood about their actual effectiveness, and many organizations are still uncertain about the benefits of expert systems. These problems have also been identified by other researchers (Basden 1984, Lin 1986, Mumford 1987, Nadkarni and Kenny 1987, Klein. *et al* 1992). Although this problem is being improved recently, it still needs more investigation.

It is believed (Goodall 1985, Turban and Watkins 1987, Ansari and Modarress 1990) that the use of ESs as a replacement of a human decision maker can make decisions not only as good as a human but also faster. However, as far as expert advisory systems are concerned, the literature survey (Schumann *et al* 1989, Oz *et al* 1993) suggests that an expert advisory system is able to improve the user's decision making effectiveness (such as VATIA and TRANAID described above), but whether it can improve the efficiency or not is still in question. Some confusion exists about the function of an expert advisory system, as to whether it should improve the efficiency of decision making or not. Some research suggests that to speed up the decision making process is a benefit of an expert advisory system(Hadden 1986), but others do not agree; Townsend and Feucht (1986) argue that the question-and-answer dialogue used by KBSs/ESs to reach their conclusions is often slow.

Moreover, although the literature suggests that an expert advisory system has the ability to improve the user's decision making effectiveness and some research (Coll *et al* 1991) has demonstrated the DSS's ability in improving users' decision making effectiveness, as far as expert advisory system are concerned, the literature contains virtually no direct comparison between ES-users and non-users to provide evidence for this benefit. Most comparisons are between ES users and experts, or between ES users and some "gold standard" for correct decisions.

Research into the organizational impact of ESs is another area which is mentioned as needing more attention. Turban (1987) has called attention to the magnitude of this impact which he believes may be extremely large in many organizations. Expert systems may have wide-spread effects within organizations, they may affect patterns of communication, the amount of integration and differentiation, the degree of centralisation and the level of bureaucracy. Although there are many conjectures about these impacts, not enough evidence has been found in the literature.

User factor for ES development and implementation

Despite considerable success of ESs, there have been failures (O'Keefe and Rebne 1993). ESs may fail in many ways. From design stage to operational stage, an expert system may fail because it is not a real expert system, in that it does not possess sufficient expert knowledge or the knowledge is presented badly. It may fail because of organizational problems, such as being implemented without the necessary support elements, rather than for technical problems. Approaching expert systems purely from a technological perspective is a mistake that too many companies have realized too late (Birch and Jaspersohn 1988, Rodger and Edwards 1989). The purely technical issues can no longer be claimed to be major obstacles for the successful ESs because increasingly successful systems are being developed and many researchers have made considerable progress in this area. There are a number of important non-technical aspects which must be addressed if an expert system is to be successful (Suh and Suh 1993).

The ignorance of user factor can be seen as one of the no-technical issues contributing to the ES failure. People need to address user's aspect into their ES design and application procedure. ES is for users. An insufficient understanding of user opinions and behaviour towards using ESs may cause the system failure or limit the system's capability.

Organization-wide ES Deployment

Most of the research about ES applications so far has been restricted to a specific aspect of an organization. With the increasing use of ESs in decision making, organization-wide deployment of expert systems is a possible area for more research. It is inevitable and necessary to investigate the issues of the implications of deploying several expert systems together as a co-ordinated system in an organization. A difficulty is seen in the need of understanding how several expert systems can be connected to translate and communicate co-ordinating information like human experts do.

Evaluation of ESs

Few people would disagree that expert system evaluation is one of the most crucial issues in their development. The testing of knowledge-based systems is extremely important, because of their complexity and the nature of their role in decision making and decision support tasks (Preece 1990). Although a number of evaluation methods have been proposed, there is still a need for a more systematic methodology for ES evaluation. Also, there are no specific evaluation criteria for assessing ESs in their different roles, for example, what is the difference between the evaluation of an ES as a replacement of a human and as advisor to help a human?

### 3.11 Summary

This chapter has reviewed the current state of ES development and applications. It emphasised the issues concerning the use of expert systems in decision making in organizations and discussed them from different points of view through the framework described in previous chapter.

The review of reported work shows that although numerous expert systems have been developed each year, reports of successful examples are relatively few. Though many have no doubt about the practical value of ESs, comparatively little effort has been directed into considering wider issues which the practical use of expert systems raises. In particular, little assessment has been made of the impact of expert systems' implementation on organizations. Some questions have been raised during the literature review. The next chapter deals with the methodology used in this research.

# Chapter Four

## RESEARCH METHOD

This chapter outlines the research objectives, the method adopted and the research phases. The research objectives identified after the literature review are presented. The research method which was adopted for this project is explained. The concepts and general principles of the experimental method, computer simulation and business game are then described and, finally, the expectations of the experiments and surveys are discussed.

### 4.1 The Research Themes Identified

#### 4.1.1 Questions identified through the literature review

Chapter three reviewed the current issues concerned with ES applications through the literature survey, and the problems identified were summarised at the end. These problems are associated with the following aspects:

-- Benefits and effects of ESs

-- User factor for ES development and implementation

-- Organization-wide deployment of expert systems

-- Evaluation of ESs

#### 4.1.2 General research objectives

Considering the problems recognised through the literature review, this research was set up to investigate the following issues related to the use of expert systems for decision making in organizations:

1. The effectiveness of ESs when used in different roles, to replace a human decision maker or to advise a human decision maker.
2. The users' behaviour and opinions towards an expert advisory system.
3. The possibility of organization-wide deployment of expert systems and the role of an ES in different organizational levels.

## 4.2 Research Method Adopted

There are three alternative approaches to investigate the above issues: 1. case study, 2. survey, 3. experimentation. The basis on which it was decided to use experimentation is outlined below.

There are some difficulties for an extended case study in terms of the research objectives:

- Firstly, to get access to a suitable company which enables the author to explore the coordination of experts in different divisions and talk to them is difficult and extremely time consuming.
- Secondly, to develop a set of ESs would be very time consuming and impossible within the limited time available for the study.
- Thirdly, from the management concern, to test an expert system in a real organization would be very difficult, because, in practice, the test of an expert system for a replacement purpose would be quite risky without knowing its possible effects, especially on upper level management; the use of the advisory system should be made either compulsory (every one uses it) or optional (some use it); the first method can not reveal the differences between aided and unaided users, and the second one is managerially dubious.
- Fourthly, case study needs more financial support for travelling, interviewing and technical equipment.

Thus, the method of case study was seen as time consuming, expensive and lacking in the organizational support.

Survey techniques usually include personal interviews and mailed questionnaires. The survey method of mailed questionnaires has been used widely in the ES area to investigate different aspects of ES development and applications, but it is effective only under the proper conditions, such as when the information needed can be obtained easily and quickly; when the information is possessed by persons willing to respond by mail; and when complete mailing lists are available. This method is seen as not adequate for this research purpose due to following reasons:

1. There is difficulty in finding the proper samples. Although ESs have been used in organizations, successful examples in the decision making area are few and examples of the organization-wide deployment of ESs are even scarcer or may not exist at the moment. Consequently, the investigation about the coordination of ESs in different divisions and the effect of organization-wide deployment of ESs would be difficult or even impossible to carry out.
2. Although a survey questionnaire can approach more organizations and the information gained may cover a wide range of issues, the purpose of this research is to concentrate on the use of several ESs as a linked system in one organization and thus needs to obtain a deeper understanding and insight than mailed questionnaires can offer.

In these circumstances, it was wise to start by using an expert system in an artificial environment and doing experiments on it which enable the experimenter to have better control of the tests, repeat some tests easily, and do them more quickly. So, the experimental method was considered as the better way to investigate the issues concerned in the research rather than a survey or an extended case study.

Since the aim of the research is concerned with the use of ESs for decision making activities, the experimental vehicle on which the research experiment could be conducted should be a decision making simulation. Because a business game has been recognized as "realistic, dynamic simulation of the actual business operation of a company. ..." (Broom 1990 page Xii), it was thought to be an adequate decision making simulation system. Thus, rather than a complex real environment, the more limited and controllable condition of a business game was selected as a simulated organizational environment and the game company was used as the simulated organization. The next sections introduce some basic concepts of business games in general, and then explain why the MAS1 business game was selected as the specific research vehicle.

### 4.3 Business Games

Business (or management) games are a well-established and highly respected educational medium in a variety of training areas (Brand and Walker 1981). It is an area which has been already studied by many researchers. Many books address the topics of the development, implementation and assessment of a business game (Armstrong and Taylor 1970, McFarlan *et al* 1970, Tansey 1971, Gibbs and Howe 1975, Taylor and Walford 1978, Hollinshead and Yorke 1981, Gray and Waitt 1982, Elgood 1990). Some believe that whether in training or management problem solving, games have the overriding advantage of being able to combine the power of sophisticated computer models with the creativity possible from human thought processes and individuals' interactions (Brand and Walker 1981).

A business game is a major use of the simulation technique in education and a great number of simulations and academic games have been devised (Unwin 1971). According to Taylor and Walford (1978), business games range from fairly simple decision-making exercises lasting little more than an hour, through to extremely elaborate simulations involving perhaps several days to complete a single round of decision making.

**4.3.1 Definition**

Business games that were developed in business schools and other institutions after 1945 were a direct growth from war games and owe much to the initiatives instituted in 1956 by the American Management Association (Taylor and Walford 1978). They have had a powerful influence on what is expected under the title (Elgood 1990). A business game is defined as:

> "a realistic, dynamic simulation of the actual business operation of a company, with students assuming the various management roles, planning and making decisions for the ensuing quarter's operations - and living with the results of those decisions for the foreseeable future." (Broom 1969, page xii).

A business game enables students to learn some management skill by participating in managing a simulated company. The students play roles which are like those of managers in real life. It is an easy and quick way for students to gain knowledge from their own participation. Business games are well accepted by business schools and are a part of most management courses.

Elgood (1990) divides games into the following types:

- Model-based games
- Direct-access computer games
- Progressive games
- Activity simulations

The latter include structured experiences, organization models, practical tasks, outdoor activities.

The traditional form of the management game is a decision making exercise in which a company and its situation are described in writing, often backed up with a great deal of data. The oldest and best known type of management game is the model-based game.

The problem from the game designer's point of view is the accurate simulation of the organization or situation. It is essential to capture the essence of the organization as well as the essence of the situation being simulated (Brand and Walker 1981).

Computers had a powerful influence upon the earlier management games because they permitted the application of complex rules with great rapidity. A computer-based business game is a special type of computer simulation (see section 4.5.2) which is neither for the purpose of understanding the system behaviour, nor for evaluating strategies for the system operation, but for providing a business environment for training students.

### 4.3.2 Aims of a business game

A business game is a very useful supplementary instruction tool. It requires a realistic simulation of actual business operations and usually is highly dynamic. Among the important objectives are the provision of experience in dealing with managerial problems and the evaluation of a manager's performance ( the student's performance in acting as a manager). More specifically, according to Broom (1969), a business game should:

(1) Help the student to recognize and assess new problem situations;

(2) Promote his/her understanding of the several functional areas of management and their interrelationships;

(3) Evoke a sense of responsibility for the results of decisions;

(4) Afford practice in working as a member of a management team making decisions in dynamic situations.

### 4.3.3 Evaluation of the performance

Performance assessment of game participants varies greatly depending on the purpose of the game. Because a game creates a dynamic situation with opportunities for showing mental and behavioural skill, judgement can normally be based on both the results achieved in the game, and the manner in which a person is seen to tackle its problems. The latter judgement is more difficult than the first.

The game which would be used in this research must be an activity simulation game based on an organization model in terms of Elgood's (1990) classification. Success in playing this type of game is measured mainly by profit, but profit is not the only valid objective of a business, nor can it properly become the sole goal in a business game. Business survival is also very important, so each firm should strive to be competitive so as to remain able to continue in business. Hence, for a game simulating a manufacturing company, factors important (in varying degrees) for the evaluation of its results include the following (Broom 1969):

1. Profit
2. Cash position
3. Inventory position
4. Market share
5. Capacity to produce
6. Amount of unfilled orders
7. Market position of products

## 4.4 Choice of Experimental System

As it was decided to use an experimental method with the business game environment as the vehicle for carrying out this research, the selection of a suitable game was important. There were many kinds of business game, the reason why the MAS1 business game was chosen is explained in this section. All experiments were conducted within the MAS1 business game environment, either with an expert system managing a whole company or with an expert advisory system advising human players.

### 4.4.1 Necessary features

When looking for a suitable game as the research vehicle, four functions were seen as the most important features for judging its suitability: 1. A range of different management roles; 2. Direct competition; 3. Clear measures of performance; and 4. repeatability. The choices available at the time were as follows:

1. Using one of the business games running at Aston Business School.
2. Purchasing a suitable business game from game suppliers.
3. Developing a specific business game for this research.

The third choice of developing a business game before the experiment was not realistic because of the time and effort needed, particularly to develop a game robust enough for inexperienced users of computers. So, at the beginning, this possibility was excluded.

There were four computer-based business games in use at Aston Business School: the MAS1 Business Game, Markstrat, an economics game and Proteus. Markstrat is only for the marketing area and does not include other management roles. The economics game similarly has no role allocation and does not have a competitive environment. Proteus has role allocation, but it is not a directly competitive game and individual runnings are not directly comparable, so, it is not repeatable. The MAS1 game (see section 4.4.2 for detailed description), was the only internal game which was adequate for this research.

Looking for games from outside suppliers, Elgood (1988) describes more than 200 management games, compiled from questionnaires completed by their producers in the UK. Each game is described in terms of its target group, subject areas, nature and purpose, and the means by which the outcome is established and made known. He also gives the administrative details such as the number of players, the number of teams and the time required.

Among the 200 games described by Elgood, most of them are limited to one specific function area, such as: cooperative skills/group effectiveness, creativity, leadership, problem solving, negotiating, planning, etc. About thirty games can be considered as organizational simulations, but some of them are manual games. This would mean that any data to be used by the expert system, or in analysis of the experimental results, would need to be input to the computer specially. This was thought to be an unnecessary overhead, and so non-computer games were rejected. Taking out those which are non-computer games, only 19 games are left. Referring to the four requirements for a suitable business game, it was found that:

1. Eleven games lack a range of different management roles: The Component Game, Executive Team; Lawn Trimmer, Management Process, The MRP Games, Financit, The Workhorse, Production Line Inc., Reputable Merchants Limited, The Electronic Local Authority and Klever Kard Kompany;

2. Four games lack direct competition: Mandate, Melnikoff, Comanex and The metal Box Business Game;

3. One game's results are determined by players' presentations: The Qwerty Drive.

4. Two games lack repeatability: Carpart and Iverhunt.

Only one game, called Woodstock, satisfies the four requirements. However, compared with the MAS1 game, both of them have general manager, production, marketing, sales, personnel and finance roles, but Woodstock does not have R & D role. So, MAS1 and Woodstock are similar games, but MAS1 has more complete roles and had already been used at Aston Business School which meant that there would be no installation problem for its use and it was possible to use students as the research subjects. Therefore, the MAS1 business game was finally chosen. However Woodstock would also have been a suitable vehicle in principle.

Overall, the MAS1 business game selected here includes most functional departments of a manufacturing company; it provides a well simulated management environment and suits the research purpose very well.

Firstly, and most importantly, the MAS1 business game is split into functions and this characteristic made it possible to build up a set of ESs and connect them together, which made it possible to investigate the linking issues of ESs development.

Secondly, it has a competitive simulated market and is run in a competitive environment. This characteristic gives an ES a chance to compete against human rivals. Moreover, the game system provides an equal opportunity for six competing teams or individuals, and by setting the ES to play the game with human teams or individuals in this environment, the result can be compared with humans, and the differences between them can be judged fairly and clearly. This is an advantage which is not likely to be obtained in a real world implementation of ESs due to the difficulty of repeating the decision making events.

Finally, by making an expert advisory system available to students for playing the game, it is possible to explore the user's opinions and behaviour towards the ES application and also to compare the performance of aided and unaided human players.

### 4.4.2 MAS1 Business Game

The MAS1 game is a computer simulated business environment to enable students to manage six companies while competing with each other. Figure 4.1 presents the general structure of this business game. Each game company is a simulation of a small manufacturing company which makes vehicle exhaust systems from sheet metal purchased as raw material. The finished product is sold to motor manufacturers as original

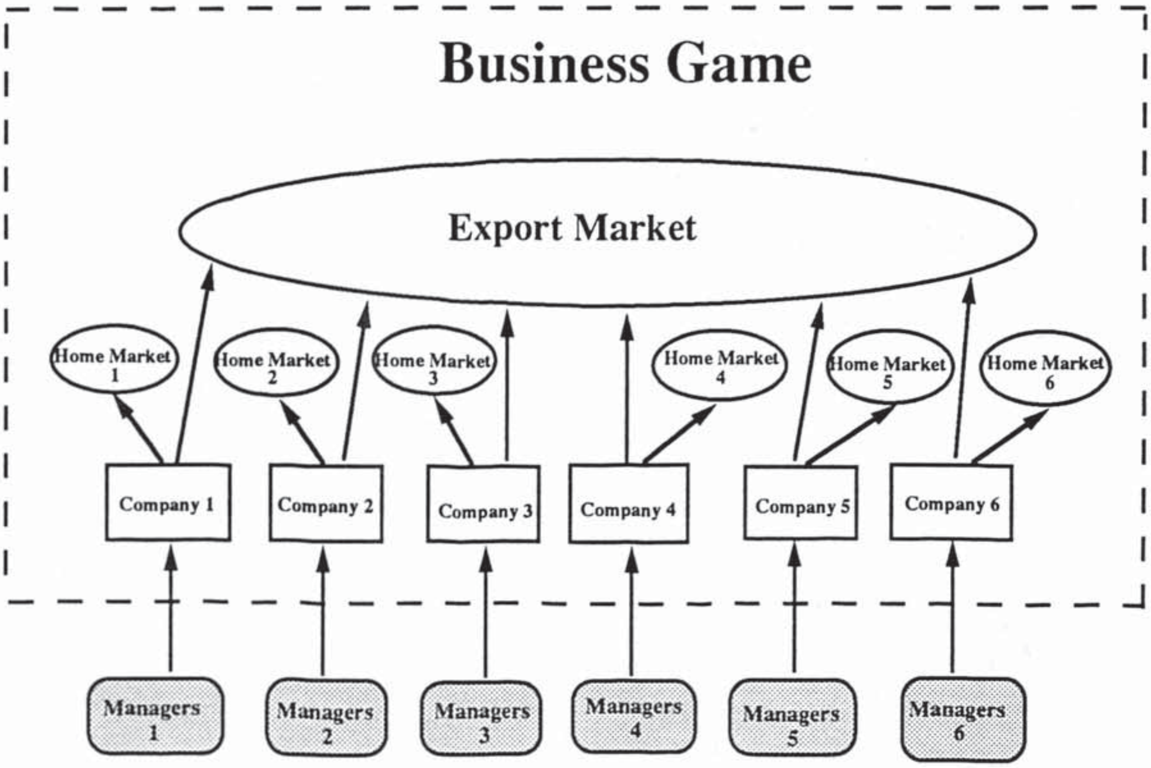



**Figure 4.1 The Structure of the MAS1 Business Game**

equipment, and to dealers and the public as replacement parts. Several companies are making the product, but each is based in a different country and has a near-monopoly in its home market. The motor manufacturers (the company's customers) who could decide to make the product themselves rather than buy it in are the competition in the home market. If the company loses these customers it will be hard to win them back as they will have made a substantial investment in their own production lines. They will also be able to compete in the parts market. There is an export market created by a developing assembly and distribution industry in the countries concerned. There is no brand loyalty in any market. More details of the decisions in the MAS1 game are described in section 5.1.

The MAS1 game is briefly described in table 4.1 in terms of the headings used by Elgood (1988) in his "Directory of British Management Games".

Table 4.1 A general description of the MAS1 business game

| | |
|---|---|
| *Background:* | Manufacturing industry |
| *Classification:* | Activity simulating (organization model) |
| *Nature/Purpose:* | To improve decision making and communicative skills within a organizational environment |
| *Suitable for:* | Students, novices, junior managers |
| *Number of people game can accommodate:* | 6-60 |
| *Number and size of teams:* | 6 teams of 1-10 members each |
| *Time requirement:* | 1-5 days |
| *What players do:* | Team members assume specific roles in different divisions within a company and make operating decisions about how it should be run in certain periods. Decisions are input into the computer each period |
| *How results are determined:* | Profit making, process quality and company's general condition at the end of the game |
| *Subjects/Functions explored:* | General management, organization theory, production, sales, marketing, personnel, research and development, finance and accounting |
| *Skills enhanced:* | Setting objectives, analysing information, communicating, organizing, planning, recognizing and using relevant data, determining priorities. |
| *Interactive or non-interactive:* | Interactive |

**4.5 Experimental Method and Computer Simulation**

Since the research adopted the experimental method with a computer simulation system, the characteristics, advantages and limitations of the method chosen are now discussed in detail in this section.

### 4.5.1 Experimental method

Experimentation is a widely accepted research method in the natural sciences and is used increasingly in the social sciences with the wide application of computers. Generally, experimentation is described as a special type of investigation used to determine whether, and in what manner, variables are related (Emory 1976). It permits studying a universe by using a relatively small sample; it permits the testing of hypotheses; it permits inferences as to results (Clover and Balsley 1979).

Bailey (1987) concludes that in an ideal experiment the experimenter is able to exercise four forms of control:

(1) He/she has control over the environment in which the experiment is conducted and is able to hold constant or otherwise control any environmental or extraneous factors that might affect it;
(2) He/she can also control the composition of the experimental and control groups, generally by assigning subjects to these groups by matching or randomization;
(3) The third type of control is control over the independent or causal variables;
(4) The experimenter has the ability to measure the values of the dependent variables both before administering the independent variable and after administering it. The difference between these scores gives a rough indication of the effect of the causal variables.

According to Bailey, the advantages of experiments are:

1. *Establishing causality.* He argues that experiment is definitely the best method in social science for establishing causal links.
2. *Control.* A true experiment offers the ultimate in control. The ability to control has important ramifications for data analysis and hypothesis testing. The investigator can probably get by with a smaller sample size than he/she could in a more uncontrolled study, as the experiment offers less chance for error caused by extraneous factors.
3. *Longitudinal analysis.* The experiment provides opportunity for studying change over time. The experiment may be of short duration, but even short experiments provide more opportunity to study change than do cross-sectional studies such as surveys.

In short, the main advantages of experimental method are as follows:

1. The experimental control is easier than in a natural environment.
2. It is often less time consuming,
3. The experiment can be repeated many times until the experimenter is satisfied with the results,
4. More different conditions can be created and tested,
5. It may be less costly than other techniques in certain instances.

However, there are some disadvantages to the experimental method as a research design, for example: in some projects, the control may be difficult or impossible to establish; all experiments are "artificial" to some degree; and people still argue that experimenter's expectations may affect experimental results (Emory 1976, Clover and Balsley 1979).

### 4.5.2 Computer Simulation

Simulation, according to Emory (1976), has been variously described and defined. In its most general form it may be described as *the process of conducting experiments on a model of a system* (Emory 1976 page 322); or in more detail, *the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behaviour of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system* (Shannon 1975 page 2). Garvey (1971) describes simulation from an education aspect as "simulation is the all-inclusive term which contains those activities which produce artificial environments or which provide artificial experiments for the participants in the activity." (page 206).

Simulation is a practical and widely used problem-solving technique (Poole and Szymankiewicz 1977). It involves the construction of a replica or model of the problem for the experimenter to test alternative courses of action. This gives the experimenter a greater insight into the problem and a better position from which to seek a solution (Poole and Szymankiewicz 1977). There are certain advantages in employing a simulation approach in management science and, as Pidd (1988) argues, it may be the only way of tackling some problems.

Computer simulation methods have developed since the early 1960s and may well be the most commonly used of all the analytical tools of management science. Simulation does not necessarily involve computers, but the availability of these devices has been the impetus to extend the application of simulation to many new areas (Payne 1982).

In a computer simulation people use the power of a computer to carry out experiments on a computer-based model of the system of interest. The analyst builds a model of the system of interest, writes computer programs which embody the model and uses a computer to imitate the system's behaviour when subjected to a variety of operating policies. Now that microcomputers offer significant computer power for a minimal cost, a computer simulation approach seems to make even more sense in management science (Pidd 1988) and also other areas.

The simulation approach can be used to study any problem. However, Payne (1982) argues, it is a reasonable approach only under certain conditions. It requires a model to represent the system behaviour and therefore this model must adequately illustrate the primary effects which relate to the problem being studied. He points out that until such a model is available, simulation cannot be used.

Simulation is a very powerful method for solving problems because of its wide applicability and because it provides a laboratory to study systems without the costs of building or modifying the real systems. The advantage offered by simulation is that it can be completely controlled and completely observed. Other benefits are associated with low cost, time saving, replication and safety. However, it is very difficult to draw accurate conclusions from simulation studies because simulation is imprecise. Also, simulation results are usually numerical, thus, as Shannon (1975) comments, there arises the danger of "deification of the numbers".

An additional advantage of simulation is its powerful educational and training application. The development and use of a simulation model allows the experimenter to see and play with the system (Shannon 1975). Several discussions of the educational aspects of simulation are in the book edited by Tansey (1971).

### 4.5.3 Some relevant research using computer simulation and controlled experiments

A number of studies have been carried out within DSS and ES/KBS areas by using computer simulation and controlled experiments. Some examples are presented in the following sections.

Cadden and Banai (1991) conducted research to analyze individual differences in determining how a user will respond to either an expert system or a decision support system (this work is described in section 3.9). In order to test their hypotheses, a DSS and a set of ESs geared to operate in the environment of the DECID-P/OM simulation game were developed and used in experiments with three groups of participants - an undergraduate class in Production/Operations Management (P & OM) (20 subjects); a graduate class in P & OM (36 subjects); and certified members of the American Production and Inventory Society (10 subjects). The results showed that "experts" would find expert systems to be less useful than decision support systems.

Lerch and Prietula (1989) carried out an experiment to investigate how people trust expert systems by providing users with advice either from expert systems or from humans with different qualifications (human experts and novices). The stimuli for the experiment consisted of a set of ten traditional financial management decision problems. The participants were 85 students. The experimental environment was handled on a PC using ECI/PC software. They found that subjects had the same level of confidence in the expert systems as in the human novices, but higher confidence in the human experts.

Experiments by Kottermann and Remus (1991) (discussed in section 3.9) were to investigate the effects of DSS formal models and "what if" analysis on performance. The results showed that neither of them helped improve decision making. Tasks relating to production scheduling were simulated on a computer and the subjects were 30 volunteers from an MBA course. One interesting thing they found in their prior research with this task was that there was no difference in performance between managers and graduate subjects without work experience.

Jacobs and Keim (1990) developed a knowledge-based information retrieval system using the EXSYS expert system development package and tested it in simulated tasks with a group of students on an information systems course. Each participant was asked to assume the role of the manager of a large systems development project and was told that there had been some problems on this project. The participant's specific task was to determine to what extent the senior programmer was responsible for causing the described problem. The results of the experiment showed that the use of a knowledge-based information retrieval system will result in enhanced decision effectiveness. The users of the knowledge based system considered more factors than the users of the menu-based system and made more effective decisions.

Duffy produced an expert system at Witswatersrand University in South Africa (Computer Mail, 1989). which beat 10 teams of businessmen in a management game called SIME (Service Industry Management Exercise). The participants were delegates on Managing and Micros courses and they all had several years' experience as managers. The results suggest that expert systems could be projected into the real world of general management. The question is, "How far?"

All the experiments mentioned above have used a computer simulated environment, and most of them used a group of students as experimental subjects, although some used managers and experienced people as well.

### 4.6 Advantages and Limitations of the Method

The general advantages of experimentation and computer simulation has been discussed in above sections. These advantages are also applied here. To emphasize them again: it is believed that experimenting with a computer simulated business game is: 1. easier to control and observe; 2. less time consuming; 3. repeatable; 4. less expensive; and 5. safer.

Obviously, there are certain disadvantages of the method. First is its limitation to an artificial environment and the further efforts that will be required to extend the system to the real world. Additionally, the competitors and users of the system are students who are not real managers although they may become managers in the future; some students may have no motivation in game playing since they are required to do so. Finally, because the game is run as part of the students' management course, and students only play the game once a year, the course time table determined the research time table.

## 4.7 Expectations of the Experiments and Surveys

### 4.7.1 Research Assumptions and expectations

To summarise the research method, the research was going to use the MAS1 business game as its research vehicle with the students as the experimental subjects to test the two developed expert systems, EXGAME and ADGAME. As discussed in section 3.10, it is believed that an ES for replacing a human decision maker would make decisions as good as a human decision maker and also faster; an expert advisory system would help its users make decisions better than non-users, but whether it would save a user's time is still not clear. It is also realised that there is a lack of understanding of user's opinion and behaviour towards using an expert advisory system, such as the user's reaction when an ES is available to them, the user's perception of ES benefit, the users' preference for the different forms of advice, and user's decision making confidence. The literature review shows that so far nobody mentions the difference in the knowledge base between an ES to replace and to advise a human decision maker. So, it is assumed that there is no difference between the knowledge bases of the two expert systems in the same domain performing different roles. In the light of these assumptions, the following expectations were put forward. These expectations are grouped according to the research issues described in chapter 1 and section 4.1.2 in chapter 4. So, in this research it was expected that:

Issue One: The effectiveness of ESs when used in different roles, to replace a human decision maker or to advise a human decision maker.

1. EXGAME would replace the game players completely in making decisions for running the game.
2. EXGAME would perform as well as the good student teams or individual players and make decisions faster than them.
3. The knowledge bases of EXGAME and ADGAME would contain the same knowledge, i.e. ADGAME could use EXGAME's KB directly in advising its users (this expectation is also related to research issue three).
4. ADGAME users would perform better than non-users.
5. ADGAME users would make their decisions quicker than non-users.

Issue Two: The users' behaviour and opinions towards an expert advisory system.

6. Most of the student teams would be willing to use ADGAME, and the worst teams would be more likely to seek help from ADGAME.
7. ADGAME users would perceive that ADGAME could improve their management skill.
8. ADGAME users would prefer the general advice to the specific recommendation provided by ADGAME.
9. ADGAME users would feel more confident in decision making than non-users.

Issue Three: The possibility of organization-wide deployment of expert systems and the role of an ES in different organizational levels.

10. It would be possible to link several ESs in different divisions to work together.

### 4.7.2 Experiments conducted

Table 4.2 The test of the expectations

| Expectations | 1991-experiment | 1992A-experiment | 1992B-experiment |
|---|---|---|---|
| 1 | * | * | * |
| 2 | * | * | * |
| 3 | | * | * |
| 4 | | * | * |
| 5 | | | * |
| 6 | | * | |
| 7 | | * | * |
| 8 | | * | * |
| 9 | | | * |
| 10 | * | * | * |

* --- tested in the experiment

To test the above expectations, three experiments were conducted, named as 1991-experiment, 1992A-experiment and 1992B-experiment. The 1991 and 1992A-experiments were carried out along with student's course work and the 1992B-experiment was conducted purely for research purpose. The participants of 1992B-experiment included experienced students and a game tutor. Table 6.1 in section 6.2 provides a summary of the three experiments.

The table 4.2 summarises in which experiment(s) the expectations were tested.

### 4.7.3 User surveys

The user factor is recognised as an important aspect for making a successful ES application. Since one of the research objectives is to investigate users' opinions and behaviour towards using the expert advisory system, user surveys after the experiments with ADGAME were seen as necessary. The survey results were analyzed to examine those research expectations associated with the users' opinions. There could be several ways to survey the users' opinions, such as by questionnaire or personal interviews. User interviews were thought to be time consuming and difficult to carry out. Thus, the surveys were conducted by issuing questionnaires to the ADGAME users.

## 4.8 Criteria for Evaluation of Expert Systems Developed

When addressing the assessment issues, instead of only subjective criteria as used in Cadden and Banai's (1991) experiment or objective criteria as used in Duffy's experiment in Witswatersrand (Computer Mail 1990), the research here has employed both objective and subjective criteria in evaluating expert systems developed. EXGAME was evaluated by measuring its own performance, and ADGAME was evaluated by its users' performance and their opinions towards using it.

Measuring systems' performances

EXGAME's and ADGAME's performances were measured by objective methods.

The game outputs all the information about each company's operation status in numerical values at the end of the game. The performance was assessed from three dimensions:

1. The profit made at the end of the game
2. Process quality, which aims to examine the system's performance throughout the game playing
3. The general condition of the company at the end of the game, which aims to see whether a company avoids an "end of the world" strategy. This is important in terms of the relevance of the simulation results to the real world.

However, profit-making is the main criterion; more discussion about performance assessment is in section 6.1.

Analysis of users' opinions

Criteria used for users' opinions towards the ADGAME advisory system are subjective and are based on the questionnaires issued to users. As described in section 4.7.2, two user surveys were carried out after the 1992A- and 1992B- experiments, and the users' opinions obtained from the survey results were used as evaluation criteria for judging the usability of the ADGAME advisory system.

**4.9 Research Phases**

The research outlined above was carried out in three main phases with different objectives in each phase:

1. On the basis of the decision making framework, to simulate the expert decision making by developing a set of sub-ESs and integrating them into an organization-wide expert system, either to manage a simulated company with minimum human intervention (EXGAME), or to help the game player to make better decisions (ADGAME).

It includes the selection of an ES building tool, decision making analysis of the domain, knowledge acquisition for the expert system, representation of the knowledge in the form of rules, construction of the system and the initial testing of the system before the move to field testing.

2. To apply expert systems competitively in the simulated environment and measure the systems' performance. In more detail, to test EXGAME with student teams, or individuals, and to test ADGAME with different users.

At this stage the systems were tested in different experimental designs. For example, EXGAME was used not only against the human "managers" but also competing against each other; ADGAME was used by novices and experienced people. The effectiveness of EXGAME was assessed by its performance. The expert advisory system ADGAME was assessed by its users' performance and their opinions towards the system.

3. To analyze the users' opinions and behaviour towards the advisory system.

The users' opinions and behaviour were obtained by conducting user surveys and observing their behaviour through all the stages of the system implementation.

### 4.10 Summary

Following the problems raised by the literature review, the research objectives were established and the research method was determined. The advantages of experimentation with a computer simulation system include: easy control and repetition, low cost, time saving and safety. The MAS1 business game environment meets the research aims because it has a range of management roles, a competitive market, clear measures of performance and it is repeatable. Moreover it had already been used at the Aston Business School and students could be used as the experimental subjects. The following parts of this thesis discuss the development, implementation and evaluation of EXGAME for playing the game, and the ADGAME advisory system for helping students in playing the game.

# Chapter Five

## EXGAME AND ADGAME - DEVELOPMENT

This chapter describes the decisions required in the MAS1 business game and the way students play it with. It also explains how the decision making knowledge within this domain was obtained and represented. The design and construction of EXGAME and ADGAME is discussed. EXGAME is an expert system for playing the MAS1 business game. It was built using the PDC Prolog programming language. Its function is to analyze the current situation of a game company and create a decision file to take the place of that created by a human player in the required period. ADGAME is an expert advisory system that was built based on EXGAME. Its function is to help users to manage the game company, not to make decisions for them. The way EXGAME plays the business game and how ADGAME helps the users is illustrated, and the differences between EXGAME and ADGAME are outlined.

### 5.1 The MAS1 Business Game

As has been described briefly in chapter four, the MAS1 Business Game is played each year by undergraduate students at Aston Business School as part of their management course. Students are divided into teams and each team manages one simulated company while making decisions and competing with each other.

### 5.1.1 Decisions required in the MAS1 game

In order to run the game company, students have to make decisions and compete over twelve periods, with each period representing one month. The decisions to be made in each period are the same and cover the following functional areas:

1. PRODUCTION
2. SALES
3. MARKETING
4. PERSONNEL
5. RESEARCH AND DEVELOPMENT

Seventeen decisions (see table 5.1) need to be made in each period, including forty-three parameters.

Each team, or company, starts from a similar position, taking over the given firm's management at the end of a certain period (period fourteen in the MAS1 game).

**Table 5.1 Decisions required in the MAS1 business game**

| Production | Sales | Marketing | Personnel | R & D |
|---|---|---|---|---|
| 1. Specify one, two or three shift working<br>2. Allocate overtime<br>3. Production unit maintenance level<br>4. Increase or decrease the number of production units<br>5. Order raw material | 1. Set the price in each market<br>2. Allocate sales representatives to the market<br>3. Define dispatch priorities for each market | 1. Set home advertising expenditure in:<br>a. Generally available papers journals and magazines<br>b. Trade journals<br>c. TV<br>d. Public posters<br>e. Direct mail to the trade<br>2. Set export market advertising expenditure in above methods | 1. Set the wage rate for machine operators<br>2. Set the salary of the sales representatives<br>3. Specify training for machine operators and sales representatives<br>4. Increase or decrease the number of machine operators<br>5. Increase or decrease the number of sales representatives | Allocate a sum for research and development of<br>1. The production process<br>2. The product and its market appeal |

### 5.1.2 The Company's management information system

Each company has a management information system which records the results achieved by users' decisions. It also collects information about marketing, including information describing the activities of its competitors. This information is available to all student teams. The information system is set up to reflect the five divisions mentioned before.

Students do not need to have great computer skill to use the game system. As long as they can login and follow the simple instructions to make selections from various option menus, they can access everything they need.

### 5.1.3 Setting targets

In order to achieve a better performance, apart from the seventeen decisions, at the beginning each team is told to determine the company's overall business policy and strategy. Bearing in mind the requirement, that they should seek to achieve all the business objectives, such as earning profits in an amount consistent with business survival, each team should finish the game with undiminished ability to compete for the foreseeable future as a company within the given industry. This means that each company should avoid any "end of the world" strategies. At the end of the game some teams may succumb to the temptation of emphasizing profits to the exclusion of other valid objectives. This is a resort to expediency and should be avoided because it will cause the company to lose its long term survival capacity.

The business game is not a zero-sum game, all teams can do well or badly because each team has its own home market, but they do interact in the export market. A team's results are not only affected by the effectiveness of its own decisions but also by its competitors' actions.

### 5.1.4 Role allocation

Each team participating in the game requires a general manager, production manager, sales manager, marketing manager, personnel manager, R&D manager and financial manager. If there are still participants who need to be allocated a role, a team may specify other officers, such as assistant managers. To do well, team members who assume the management roles must fulfil the responsibilities for planning inherent in their positions. Each must co-operate with the other team members, exercising both initiative and good judgement.

### 5.1.5 The way students play the game

The description here of the way students play the game is based on observation. As mentioned in the last section, each student team consists of a general manager and several divisional managers. At the beginning of the game, they normally work out their overall objectives and strategic policies. During each game period, divisional managers make their decisions and discuss them at team meetings. All the information exchange and conflict solving are carried out at this time. A divisional manager can obtain information about the other divisions from the game company's information system as well as his/her own. Once decisions to be implemented in each division have been approved by a majority of the team members, the decisions will be input to the computer to activate these decisions in the game company.

Normally the game "period end" is run twice a week by a tutor in the business school who is responsible for the operation of the game system; students have no access to the main part of the game system. Each team must input their decisions into the game system for each period before the deadline. If they fail to do so, the decisions they made for the last period will be implemented again for the following period.

## 5.2 Building the Knowledge Base

This section focuses on how the knowledge embedded in EXGAME was obtained, and explains briefly why PDC Prolog was chosen and how the rule representation function within Prolog was used to represent the domain knowledge based on the understanding of the game decisions.

### 5.2.1 Knowledge acquisition for EXGAME

As discussed in section 3.2.3, knowledge acqusition is recognized as a crucial part of ES development. Many knowledge acquisition techniques have been developed. Four broad-classes are identified by Cleal and Heaton (1988):

.Text analysis

.Interview analysis

.Behaviour analysis

.Machine induction

Text analysis is used during the early stages of knowledge elicitation, as a route towards 'educating' the knowledge engineer. When the knowledge engineer has acquired the current jargon and knowledge of the domain, he/she will be in a better position to question the expert. It can be especially hard if the knowledge engineer has little knowledge about the domain expertise.

Interviewing experts is the most commonly used method in KA according to Doukidis and Paul's survey (1990). Interviewing experts includes tutorial interview, focused interview, structured interview, teachback interview, etc. (Neale 1988). In a tutorial interview the expert is asked to prepare an introduction talk, outlining the main themes and ideas of the domain. In a focused interview, the interviewer prepares the topics in advance, although not the precise questions; it is most like normal conversation and therefore expert cooperation is most easily obtained. The structured interview involves the detailed, depth-first sequencing of topics in an attempt to elicit all knowledge related to a particular concept or model. Teachback interviews involve the knowledge engineer trying to explain the topic back to the expert, to demonstrate his/her understanding of it. Actually there is no sharp distinction between the different interviewing techniques.

The repertory grid method is a special interview approach which is used to elicit the expert's conceptual structure. It allows the knowledge engineer to produce information about what the priorities and important factors are and how the expert thinks. The technique allows for probing of peoples' internal 'constructuralised' view of the world without the need to explicitly state what that view is.

Noting the difficulty experts may have in verbalizing their knowledge, watching the expert in action as he/she solves real problems is an obvious alternative to asking him/her what he/she does. Behaviour analysis also includes inquisitive observation. Inquisitive observation is used where the knowledge engineer interrupts the expert while they are at work and asks for explanations. Most behaviour analysis involves the use of video or audio recorders.

The aim of machine induction is to induce a general rule which covers all cases from a sample of example cases. A 'sufficient' set of examples must be input to the induction process. This is a crucial requirement. Particular problems are caused by continuous variables. The need to select a good example set is thus the biggest problem. Induction discovers knowledge away from the expert, providing the knowledge engineer with results, questions, and hypotheses to form the basis of a consultation with the expert. So, induction can be useful if there are documented examples, or if they can be obtained easily.

The knowledge in the domain of MAS1 game playing has its own features: there are some experts in business decision making and industrial management, and in how the game is constructed, but no expert at playing the game itself. There was no documentation on the best way to make decisions in the MAS1 game. Although students play it every year, the student performances in previous years had not been very satisfactory, and most students only play the game once. It was thus impossible to find a student "expert". So, it was important to adopt the KA techniques most appropriate to the somewhat unusual features of this particular domain of this research.

As pointed out by many people, more than one technique is often required during the KA process. The knowledge incorporated in the expert system developed was acquired by "playing" the game many times, interviewing the lecturer, Dr. Paul Robins, at the Aston Business School about the best way to make decisions and the reading of text books about organizational management and decision making (text analysis). If a person knows the game algorithm but has no knowledge of management decision making, he also can play the game well by using mathematical methods, but this is not the aim of EXGAME and ADGAME. EXGAME and ADGAME aim to make good decisions in managing the game company by acquiring the knowledge and expertise from the decision making and management aspect. Therefore, there was no access to the game algorithm or programme code itself. The most original approach in the KA here is the role play in the domain by the author. This is due to the specific character of the game. In summary, the techniques of knowledge acquisition used in this research can be described as text analysis, interview (mainly focused interview), and role play by the knowledge engineer.

KA methods such as repertory grid, behaviour analysis and machine induction were seen as obviously not appropriate because of the features of the domain. In more detail, because there is no direct expert in game playing itself, the repertory grid method and behaviour analysis were not applicable. Moreover because machine induction is not good at handling continuous variables and needs a range of correctly classified example cases which were not available for game playing, this method was also considered as inadequate. In summary, the feature of no expert available ruled out the use of repertory grid and behaviour analysis methods; no reliable classification of cases ruled out the use of the induction method.

Figure 5.1 shows the procedure of the knowledge engineering for EXGAME. There are no established expert players in the normal ES "expert" sense. The lecturers involved with running the game are not experts in playing the game. At the beginning of the research the author herself was considered as a novice in organizational decision making. After the selection of the research topic and identification of activities, the main steps of knowledge acquisition were as follows (see also figure 5.1):

1. Initially, playing the game to get some general impression about the decision making within the game company. The game play was carried out through all the knowledge acquisition process later on.
2. Talking to the lecturer who is the expert in the decision making area (but not in the game), reading books on management skills and decision making, especially about strategic planning.
3. Analysing the factors related to each decision, outlining them and drawing a relationship diagram (see figures 5.5 to 5.9 in section 5.2.3).
4. Consulting the expert again with the diagram and setting the initial

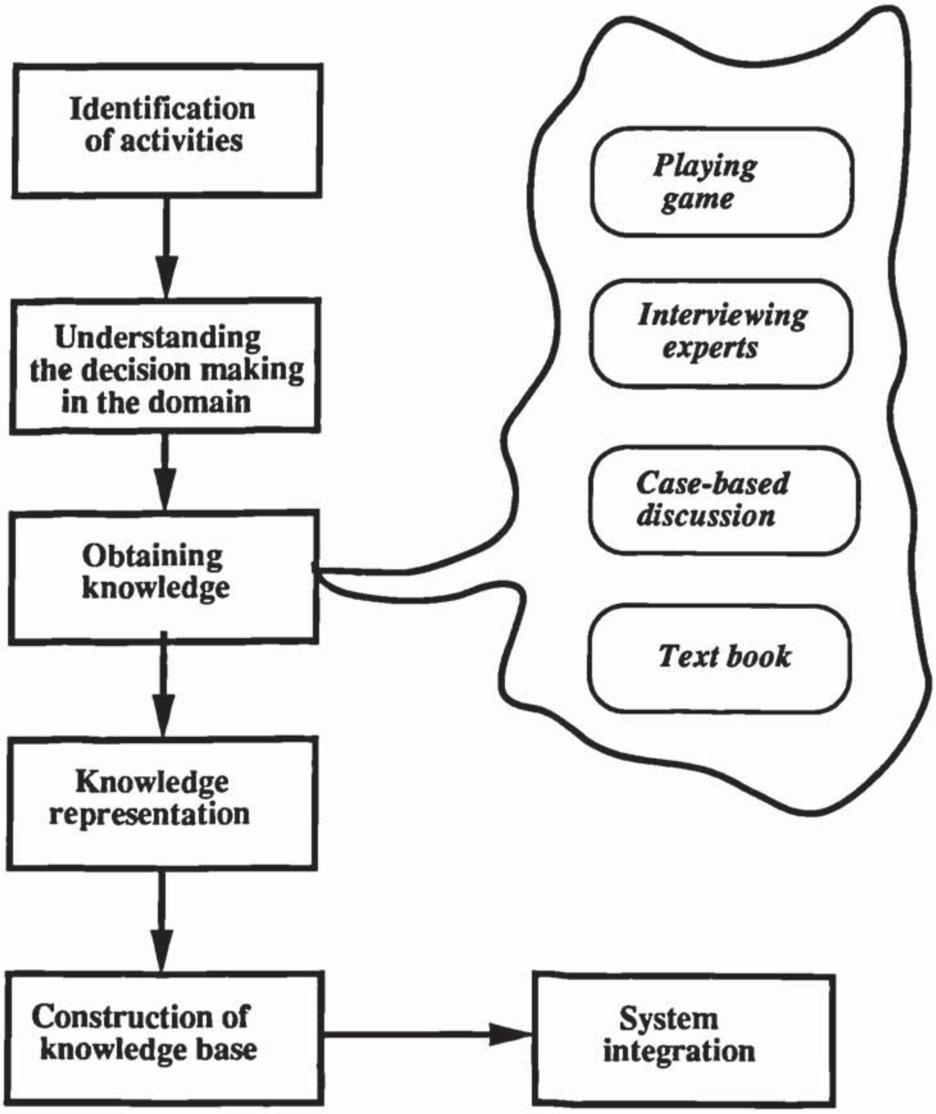



**Figure 5.1 Knowledge Engineering for EXGAME**

decision making rules.

5. Structuring the initial knowledge base, developing the prototype system and testing it in the game environment.

6. Conducting success and failure analysis with the initial knowledge base. Outlining some special cases and discussing the best solution with experts again.

7. Taking the suggestions from the expert and adjusting the KB of EXGAME, then going back to step 6 until a satisfactory result was obtained.

### 5.2.2 Understanding the decision making situation

Understanding the decision making situation involves studying and analysing the decision making process in the domain concerned. The knowledge base of an expert system is built on the basis of this understanding. Figures 5.2 and 5.3 show a general overview of the decision making in the game at the strategic and tactical levels.

Organizational Structure

Compared with large companies, small companies can be characterized by a simpler organizational structure and a stronger centralized leadership. Each of the MAS1 game companies is a small manufacturing firm which consists of five divisions. The game can be played by a group of students without assigning any functional responsibility, but in practice, it is suggested by tutors that each team needs a general manager to act as a strategic planner and tactical manager, and divisional managers responsible for different divisions, otherwise, there will be confusion among different divisions. Figure 5.4 shows the organizational structure for the game company suggested by the game tutor. The EXGAME expert system also adopts this structure for managing the game company. It has a top level expert system to represent the functions of the general manager and five divisional expert systems to represent different divisional

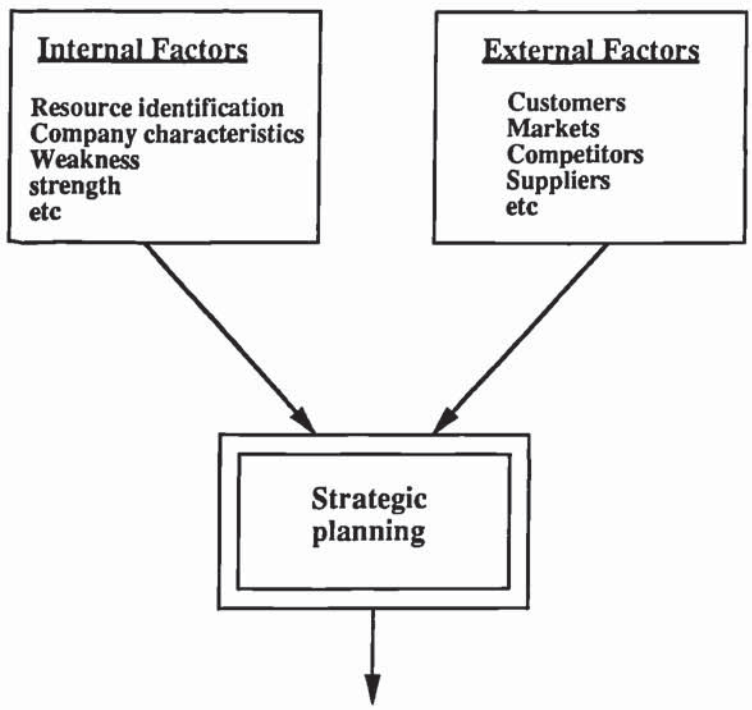



**Figure 5.2 A general overview of strategic planning**


**Figure 5.3 A general overview of managerial decision-making**

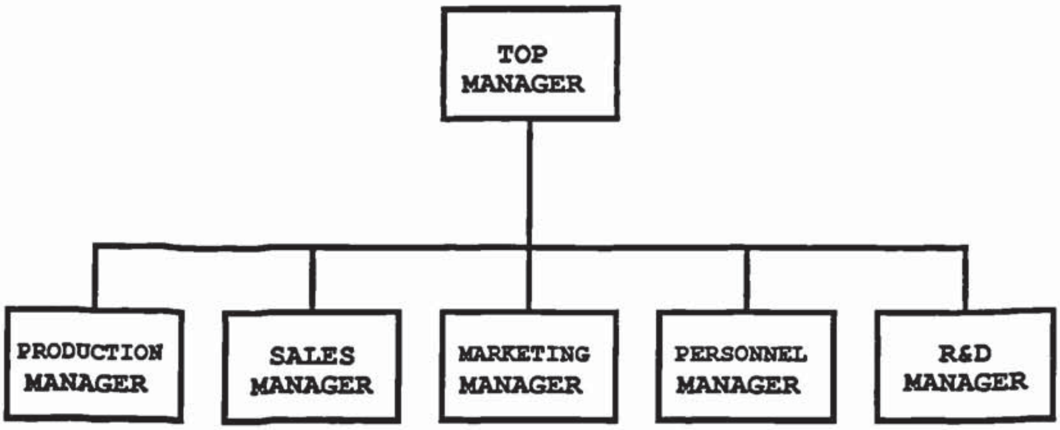



**Figure 5.4 Organisational structure suggested for managing the game company**

managers (see section 5.3.1 also).

Organizational Strategy

As has been discussed in section 5.1.3, in a normal situation the aims of the company are to make a good profit, to avoid any management mistakes through the game process and to avoid an "end of the world" strategy at the end of the game. There are different approaches to achieve this goal. Some of the alternatives can be summarized as:

1. Aiming for a reasonable market share with an average product quality and prices;
2. Aiming for high volume products with a low mark up;
3. Aiming for high quality products at a premium price.

There may be other alternatives, but these three were chosen because they were thought to be the most feasible. Besides, EXGAME was not intend to cover all the possible strategies, but to provide some good examples.

For example, if the company's strategic policy is to maintain a reasonable market share with an average product quality and prices, to make profit and keep the company in a good competitive state, this strategy needs to be translated into policies for each division:

For the production division, the policy is to maintain the current production capability and to reduce the production costs as much as possible.

For the sales division, a reasonable price for each market should be set to balance cost and benefit. The overseas markets should also be explored by setting a proper price.

For the marketing division, in order to stimulate market sales, especially the export market, the company needs to make efficient use of the advertising expenditure.

For the personnel division, the manager needs to set reasonable wages for operators and representatives, to reduce the number of operators and representatives leaving as few as possible and maintain a good balance between the training and production rates.

For the R&D division, the aim of the management is to achieve the best benefit from the money invested, and to set the product quality for an average position in the market.

On the basis of this analysis, all the above three alternatives are encoded into the knowledge base of EXGAME and the top level expert system provides the user with these alternatives.

### 5.2.3 Knowledge representation methods

As mentioned in section 3.2.4, knowledge representation is the process of organizing and structuring knowledge. A decision about which form of representation to use is generally based on what is possible in a particular circumstance. It may be associated with the nature of the problem that lends itself in an obvious way to a particular representation, or to the availability of a development tool which requires a specific form of representation. Although there are several ways to encode the facts and relationships that constitute knowledge, the most common way of representing knowledge is in the form of Production Rules.

Production rules

Production rules are easy for humans to understand and, since each rule represents a small independent granule of knowledge, can be easily added or subtracted from a knowledge base (Graham and Jones 1988 pp.38). But the knowledge base grows linearly in size with the addition of new knowledge.

Frames and Semantic networks

Except production rules, other popular ways of knowledge representation include frames and semantic networks. The frame-based representation is an alternative knowledge base representation that permits the hierarchical information about object relationships to be stored in the knowledge base. A frame is a knowledge structure that is used to describe one or more values of attributes arranged in a slot or filler format. Another way to represent knowledge is a semantic network. A semantic network is a collection of objects and relationships between objects together with some interpretation. Semantic networks are very good at expressing knowledge about class inheritance properties, demons, defaults and perspectives (Graham and Jones 1988). The disadvantage of the frame system or semantic network is the relative complexity that must be a part of the inference engine design, as well as the difficulty of changing the knowledge base hierarchy once the knowledge base is designed. In addition, it is very difficult to handle exceptions and awkward to represent uncertain or partial linkage.

Considering the following factors: the size of the knowledge bases in EXGAME and ADGAME is not large; it does not have many hierarchical levels; most decision variables are continuous; and the rules contain many mathematical calculations, the representation form of production rules was therefore thought appropriate.

### 5.2.4 ES development tools

As discussed in section 3.2.2, there are several ways to built an expert system. The tools available for expert system development break down into three major areas:

shells, AI languages and toolkits. The two important requirements for selecting an ES tool in this research were: 1. Interface with game system and databases; 2. Rule representation function. As the research started, the choices faced were: Prolog language, Xi-plus shell and Smalltalk.

PDC Prolog is the new version of Turbo Prolog. It has good facilities to deal with external databases and transfer them inward and outward. In this research it was able to handle a large amount of external data imported from the business game information system in the mainframe computer. Also, PDC Prolog was found to be very easy for a beginner to learn from its introductory book and tutorial programmes.

It was found that the Xi-plus shell is easy to build small expert systems and has a built-in explanation facility and multi-choice menus. Although the knowledge representation of if-then rules in Xi-plus suits the second requirement of the tool selection, it is too limited in dealing with external databases and transferring them inward and outward. Xi-plus is only able to access data on external files with some specified data format such as spreadsheet format. If the system needs to read a value from external data base, a call function has to be written in the rule base to invoke an external programme to return a single value or a list of values to the knowledge base, but in Prolog, once an external database has been retrieved, the knowledge base can refer to the data in the database anytime without repeatedly using a function call. So, there is a disadvantage of Xi-plus in interfacing with external databases. Also, the author felt that programming the system in Xi-plus is not as flexible as when using the PDC Prolog language.

Smalltalk is an object-oriented programming environment, but not an AI toolkit. It has its own Prolog function called Prolog/V. Due to the fact that a more Smalltalk-like syntax has been chosen in order to provide better communication between the two languages, the Prolog/V is quite different from the standard Prolog. Moreover, some of the Prolog functions are not implemented in Prolog/V, such as clause, debugging, display, get, listing, name, etc., and this definitely limits its usability. Since Smalltalk offers more facilities which were not needed for this research purpose, rather than only Prolog programming environment, the author would have had to learn more about the Smalltalk environment rather than the use of Prolog itself. This means that to use Prolog within the Smalltalk environment was much more time consuming. It was also found that programming the systems in Prolog/V was difficult because of its Smalltalk-like syntax.

Therefore after an initial trial of the above three possibilities, the decision to use PDC Prolog with its rule representation function was finally made.

### 5.2.5 Knowledge representation by rules

Knowledge can be represented with rules in the general form of:

if CONDITION then DECISION

The interpretation of such a rule is that if a *situation* satisfies CONDITION then infer DECISION. According to Michalski and Chilausky (1988), the CONDITION is a conjunction of binary statements and the DECISION is some action, decision or assignment of values to a variable. In general, the CONDITION can be any description expressed in some formal language. A *situation* is a description of some object or processes under consideration.

All the knowledge in the knowledge base of EXGAME was represented in the form of rules, because PDC Prolog requires this form of knowledge representation. The inference engine in PDC Prolog uses backward chaining.

Figures 5.5 to 5.9 show the factors considered by EXGAME in decision making for each of the functional divisions. The following paragraphs present some examples of the facts and rules in EXGAME.

Representation of facts and rules in EXGAME

A PDC program is a collection of facts and rules. In EXGAME, the facts are represented in the following ways:

Predicate (arguments)

E.g., some examples for representing the top policies:

top("strategic policy", S)
top("financial policy", F)

S represents the different strategic policies. S=1,2,3,4.
F represents the different financial policies. F=,1,2,3.

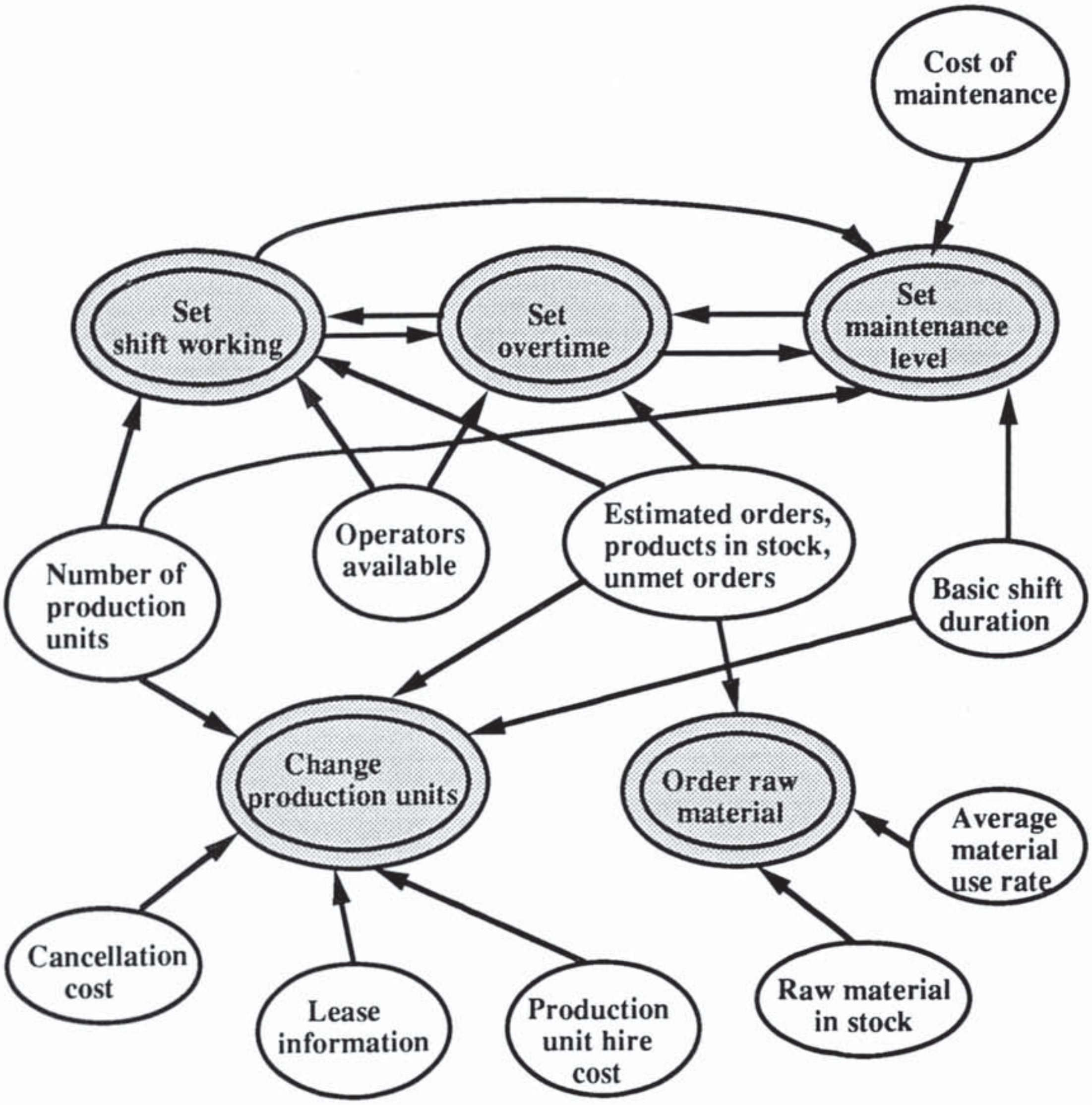



**Figure 5.5 A general overview of production decision making**

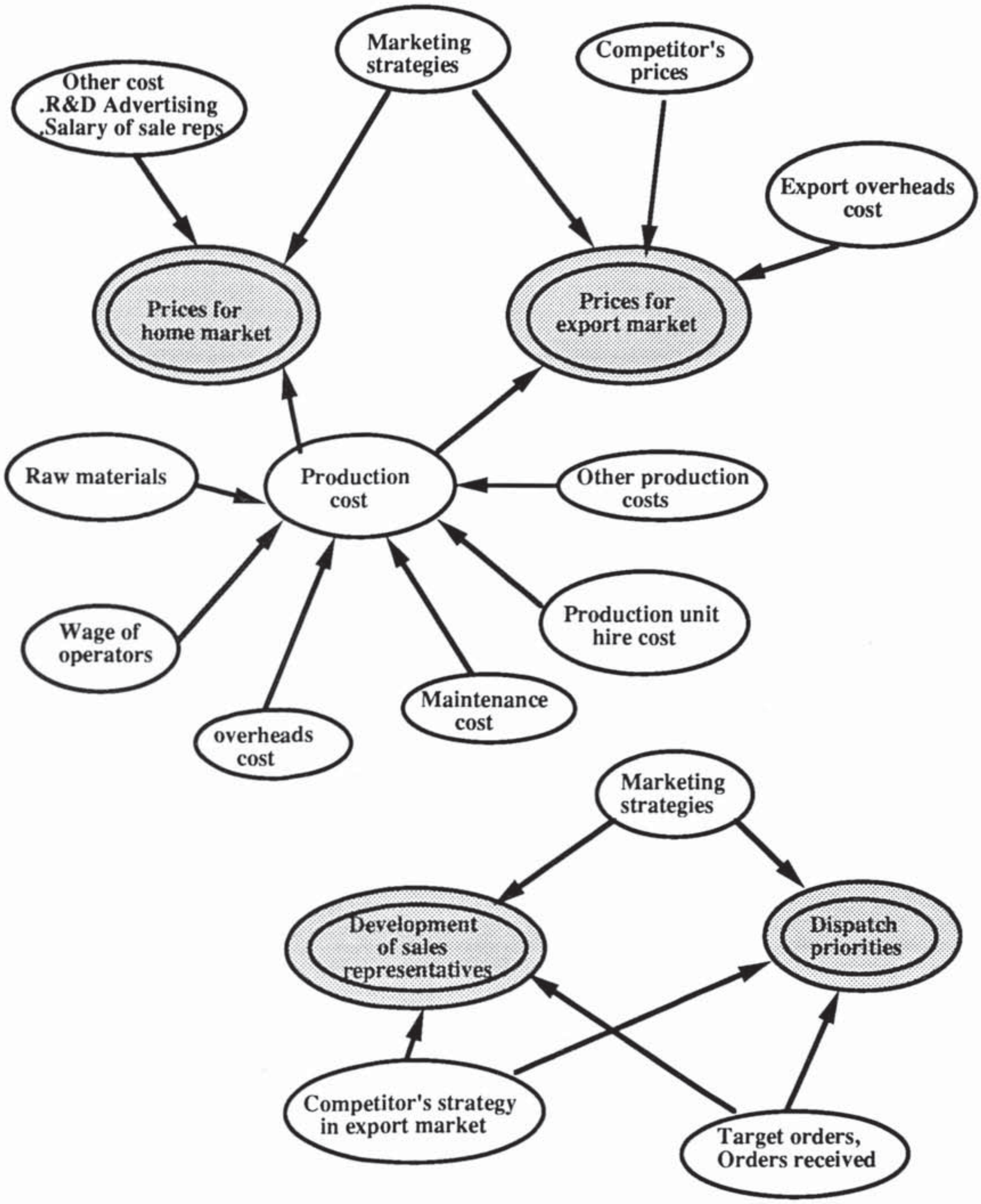



**Figure 5.6 A general overview of sales decision making**

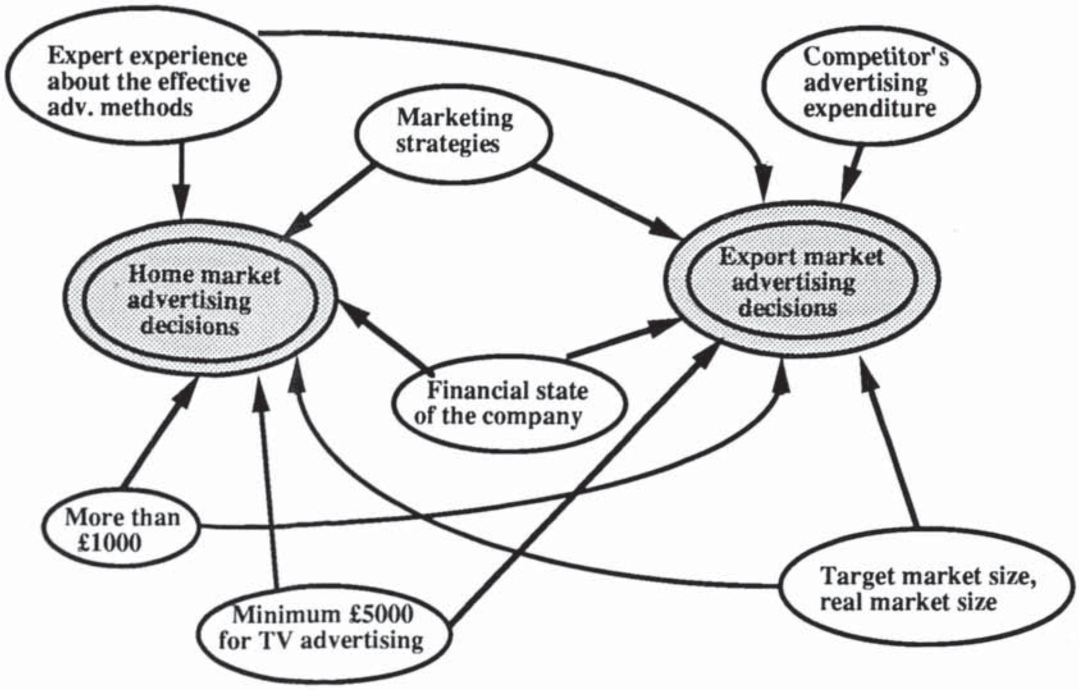



**Figure 5.7 A general overview of marketing decisions**

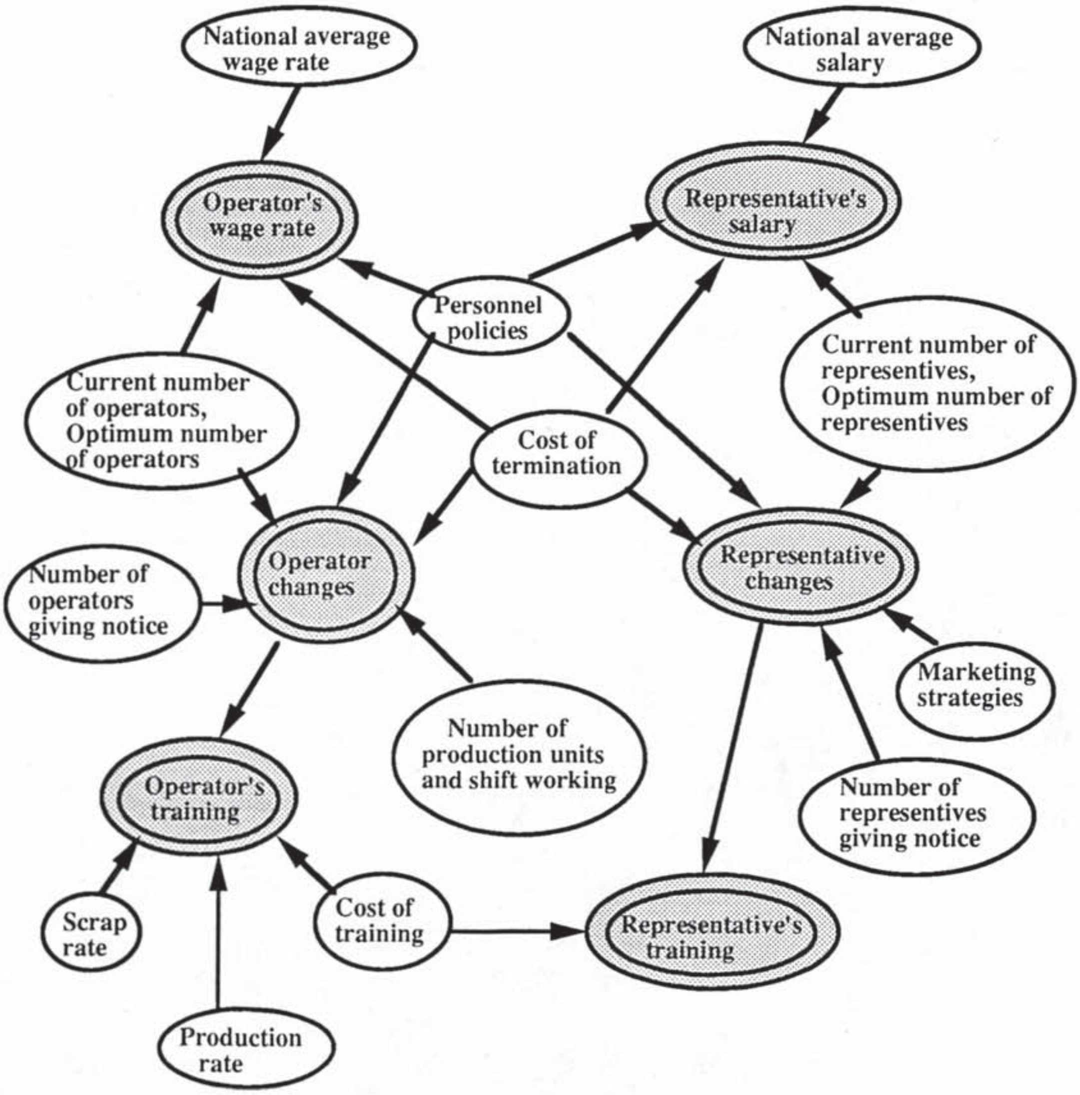



**Figure 5.8 A general overview of personnel decision making**

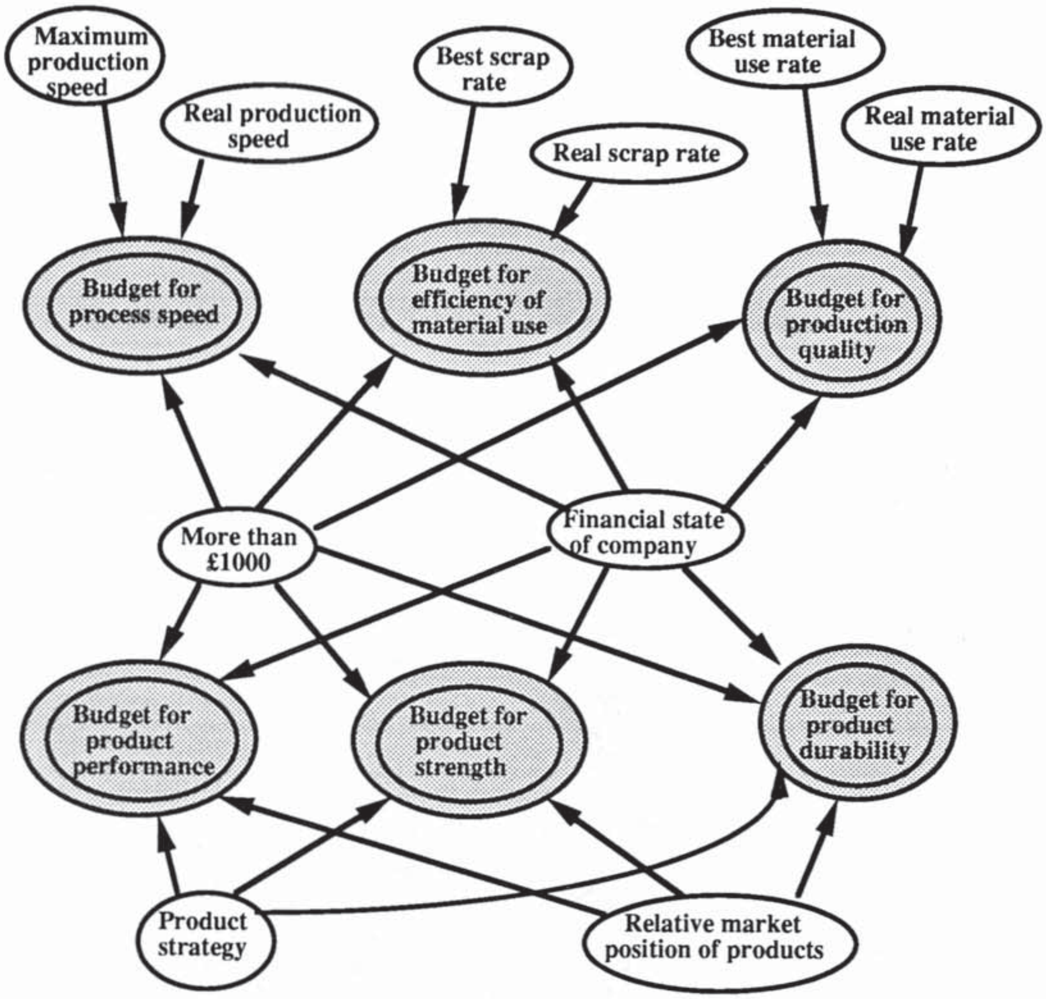



**Figure 5.9 A general overview of R&D decision making**

Some examples of the facts for representing the average prices of competitors:

avecom(Period_number, "competitors", "price for export market 1", P1)
avecom(Period_number, "competitors", "price for export market 2", P2)

Some examples of the facts for representing the general conditions of the company:

vbl(Period_number, Company_name, "production", P)
vbl(Period_number, Company_name, "scrap", S)
vbl(Period_number, Company_name, "raw material in stock", MS)

Since all the company information in the MAS1 game is represented by numerical data, most of the rules in EXGAME are also expressed by numerical data, i.e. conditions and decisions are described by numerical values or mathematical expressions. Some of them consist of English words, such as "Yes" and "No".

Some examples of rules implemented in EXGAME are described here. An example of a rule implemented in the sales division is:

If the strategic policy is "Aim for high volume products with a low mark up", and the period number is 2
Then the prices in the home markets should be reduced by 10% and the prices in the export market should be 10% lower than the average prices of competitors

In EXGAME, this rule is expressed in the following way:

```
goprice(S,T):- S=3, T=2, rate1(0.9).
rate1(R):- getprice_home(P1, P2), getprice_ave_export(P3,P4),
P11=P1*R, P12=P2*R, P21=P3*R, P22=P4*R.
getprice_home (P1,P2):- vbl(T,Company_name,"price1",P1),
vbl(T,Company_name,"price2",P2).
getprice_export(P3,P4):- avecom(T,"competitors","price3", P3),
avecom(T,"competitors","price4", P4).
```

Another example is

If the strategic policy is not "Aim for high volume products with a low mark up" or "Aim for high quality products at a premium price", and the orders received for last period are less than 3000 in home market and more than 3000 in export market

Then the prices in the home markets should be reduced by 5% and the prices in export market should remain at the same level as the last period

In EXGAME, this rule is coded as:

```
goprice(S,T):- S<>3, S<>4, T<>2,
get_order(Order_home1,Order_home2,Order_export1,Order_export2),
Order_home1+Order_home2<3000,
Order_export1+Order_export2>3000, rate2(0.95,1).
rate2(R1,R2):- getprice_home(P1, P2),getprice_export(LP3,LP4),
P11=P1*R1, P12=P2*R1, P21=LP3*R2, P22=LP4*R2.
getprice_export(P3,P4):- vbl(T,Company_name,"price3",LP3),
vbl(T,Company_name,"price4",LP4).
```

## 5.3 EXGAME - Its Operation and User Interface

### 5.3.1 Development process of EXGAME

EXGAME consists of six small expert systems refered to as sub-expert systems (sub-ESs). The development of EXGAME was completed in several stages. Firstly, five small expert systems were designed and built to make decisions for each of the five functional divisions. When these individual ESs were working, they were linked together through a top level expert system. After these sub-ESs were successfully connected as a whole system, the different strategic and financial policies were added into the top level ES and the implementation policies made for each divisional expert system were encoded into the knowledge bases of these systems.

At the beginning, it was intended to develop an expert system to replace the users completely, but it was soon realised that it was difficult or impossible to replace users at the strategic level owing to the many factors that would be covered when building the rules for strategic decisions in the knowledge base, including the behaviour of competitors.

The sub-ESs are linked to work together with different functions and databases. Each sub-ES is a complete expert system and they can be written, edited and compiled separately. If the user inputs the top level policies and some information about other divisions' decisions into it, the sub-ES can be used separately, but in this case the communication and control among divisions is broken down and the user has to pass information to each division. As EXGAME links them all together the communication task is reduced and therefore less time is taken than when using sub-ESs separately.

**5.3.2 Architecture of EXGAME**

The architecture of EXGAME is shown in figure 5.10. The top level expert system analyzes the company information and provides advice for choosing a proper strategic policy. Its function is like that of a top level manager. Once a strategic policy has been selected, it will be implemented through the five divisional ESs. After executing the top level ES, a Prolog data file containing the control parameters representing the company's policy, is created. The divisional expert systems make their own decisions by referring to the control database which contains the company's policies and information communication database.

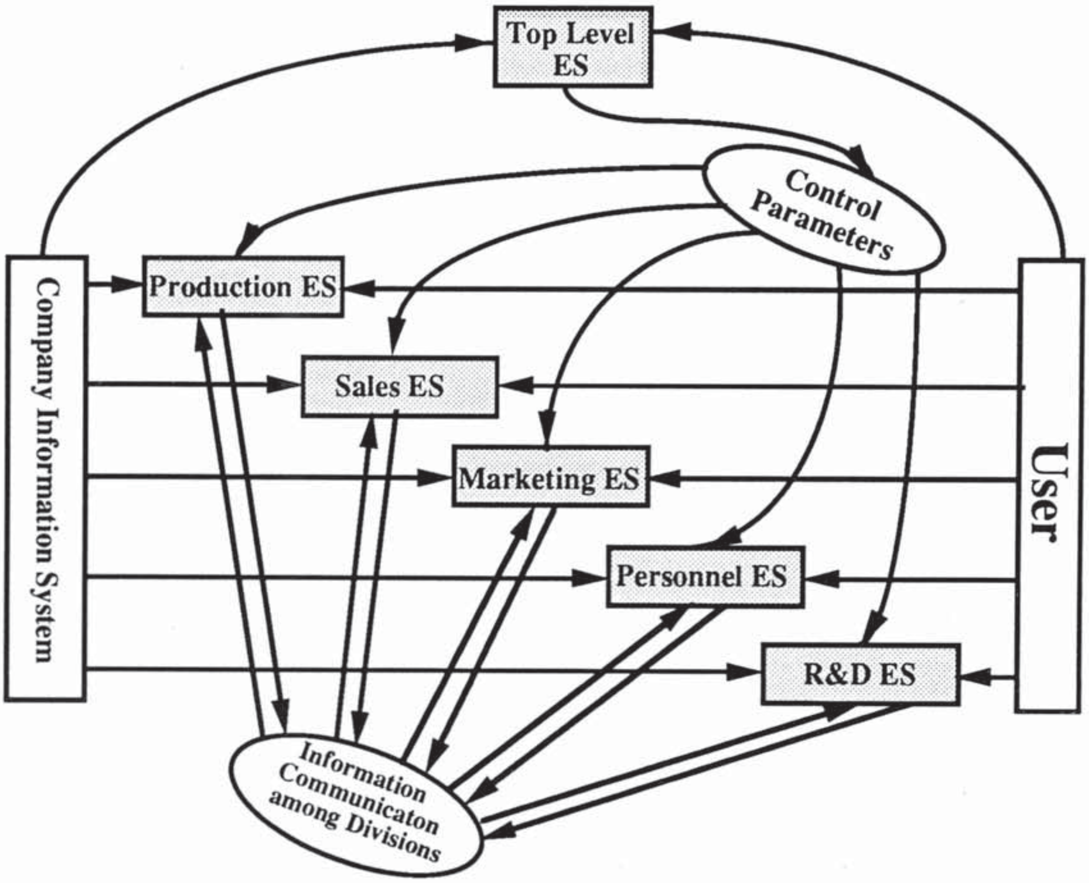



**Figure 5.10 The architecture of EXGAME/ADGAME**

### 5.3.3 The way EXGAME plays the MAS1 game

The working environment of EXGAME is shown in figure 5.11. When managing the simulated company, EXGAME obtains the company's information, through the Kermit communications software, from the company's information system on the mainframe computer. The company information system contains four types of information: History Report; Current State Report; Markets Report and Decision Report. A BASIC programme is used to translate the databases of the company's information system into a format which PDC-Prolog can recognize and read in. Figure 5.12 shows

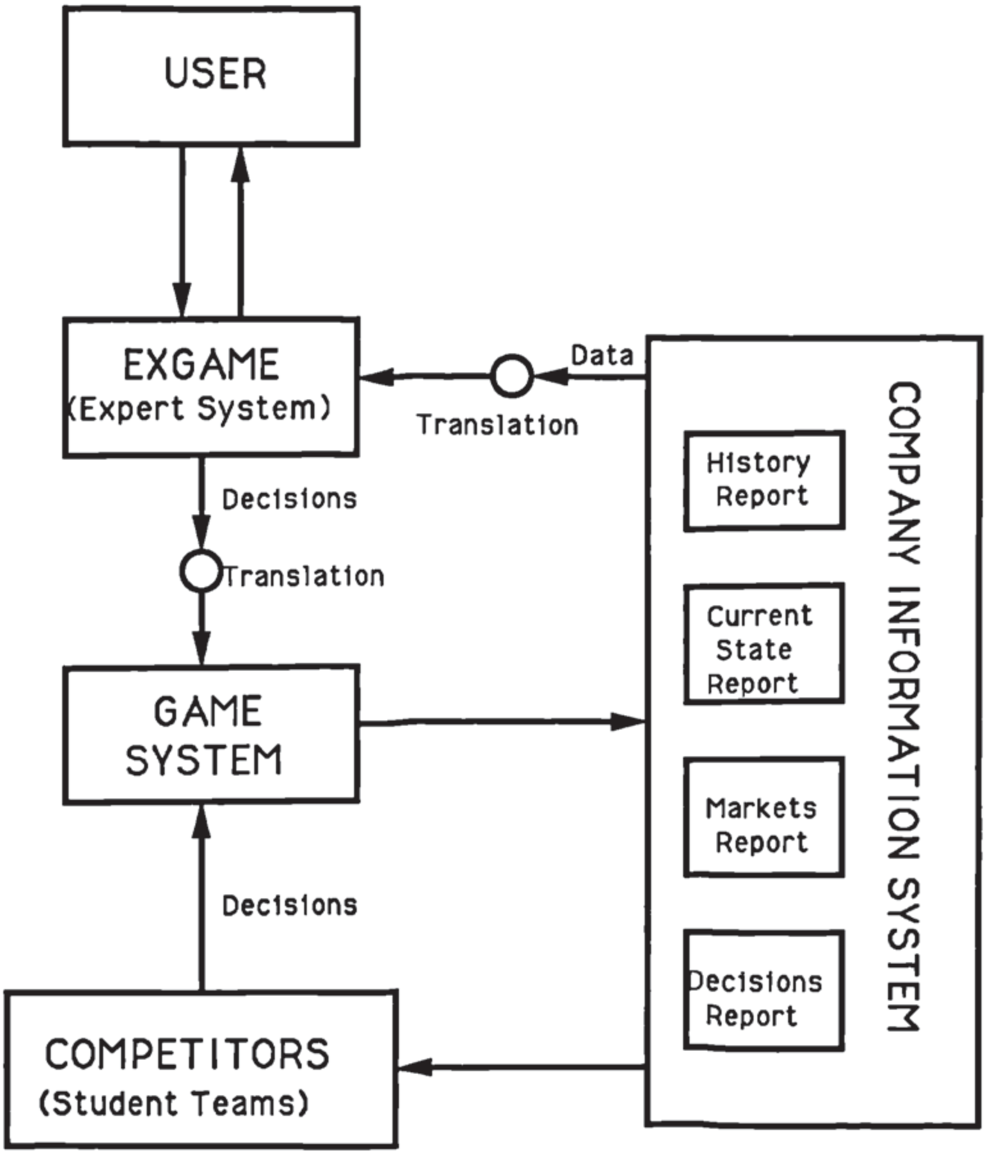



**Figure 5.11 The working environment of EXGAME**

the data translation procedure from the game system on the mainframe to the EXGAME database on the PC. The database of EXGAME contains all the information about the company managed by EXGAME as well as market and competitors' information. EXGAME extracts the information it needs for making decisions. The decisions are made by EXGAME according to its own knowledge base after the user has determined

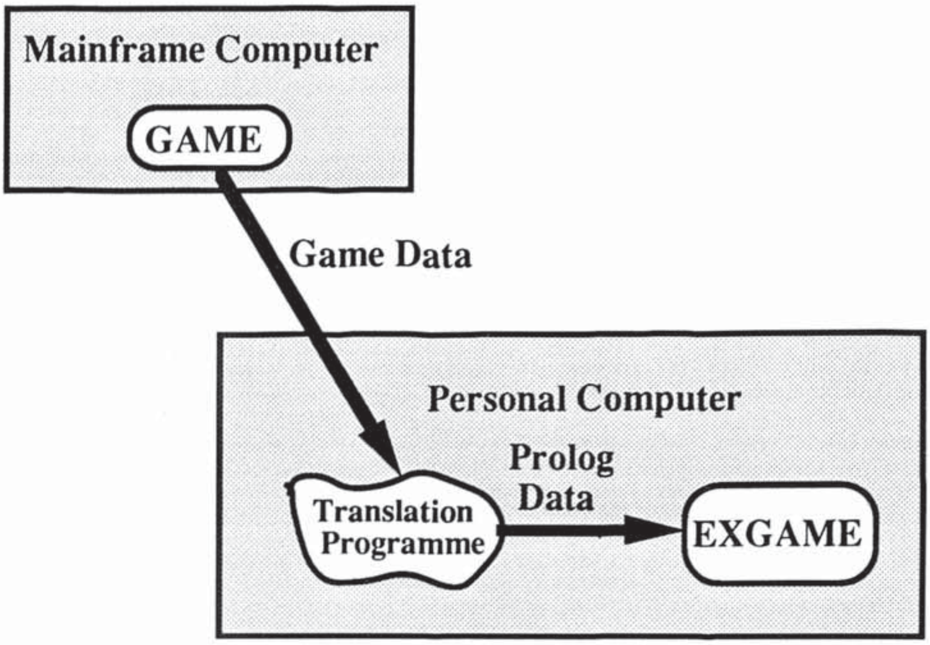



**Figure 5.12 Data translation from game system to EXGAME**

the strategic and financial policies required by the top level expert system.

In the Marketing and R&D divisional ESs, the system provides some tactical selections for users and users can make their own selection or let the system make it automatically. This aims to give the users some options at the tactical level, so they can make their own judgement if they like. For instance, the R&D sub-ES will present the following information and ask a user to make a selection:

*What is the company's strategy about the market position of its products?*
*1. Above average*
*2. Average*
*3. Below Average*
*********************************
*4. Make decisions by the system*

*Input your selection* __

the Market sub-ES will present the following options:

*What is the market advertising policy for export market?*
*--- The decision of the advertising expenditure*
*1. Depends on the last period's expenditure*
*2. Depends on the expenditure of competitors*
*3. Will be made independently*
******************************************
*4. Make decisions by the system*
--------------------------------------------
*5. Help information*

*Input your selection* __

In all the experiments described in chapter 6, the selections mentioned above were made by the EXGAME systems instead of by the user.

### 5.3.4 The intended users of EXGAME

Although EXGAME is designed to replace human players in the game, it is intended for research purposes. It is an expert system for experimental use by ES researchers and may be called an experimental expert system. In fact, it is a vehicle for testing the functions of an ES for decision making. Originally EXGAME is used by the experimenter, but the user could be anyone who is at least familiar with the business game and has some basic management skills because EXGAME can not replace the user completely as the user must determine strategic and financial policies.

As EXGAME was initially developed for replacing human players, the user interface is relatively simple. When activated, the main screen consists of two windows,

```
-------EXPERT SYSTEM FOR BUSINESS GAME-------      -------OUTPUT OF DECISIONS-------
                                                   PRICE HOME  -   O/E      22.000
                                                   PRICE HOM   - PARTS      23.000
  The cost of a product in last period:20.11      PRICE XPRT  -   O/E      23.000
                                                   PRICE XPRT  - PARTS      23.920
  The following data are the average              REPS HOME   -   O/E       0.500
prices of competitors                              REPS HOME   - PARTS       0.500
                                                   REPS XPRT   -   O/E       2.000
 Price Home -    O/E  22                           REPS XPRT   - PARTS       1.000
 Price Home - Parts  23                            PRIORTY HME -  O/E        1.000
 Price Xprt -    O/E  23                           PRIORTY HME - PRTS        4.000
 Price Xprt - Parts  23.92                         PRIORTY XPT -  O/E        2.000
                                                   PRIORTY XPT - PRTS        3.000

PRESS ANY KEY TO CONTINUE_
```

Figure 5.13 An example screen when using EXGAME

a dialogue window displaying the messages between the system and the user, and an output window displaying decisions made by EXGAME. Figure 5.13 shows an example of the screen when using EXGAME. Each window appears when necessary. After users have selected their company's strategic and financial policies through the menus provided by the system (see Figures 5.14, 5.15 and 5.16), they can use EXGAME to make operational decisions through the menu shown in Figure 5.17. EXGAME is keyboard driven with menu selection and keyboard input. There is no facility to explain why certain information is required and how certain decisions are made in EXGAME because it was not built for giving advice to novices. It does have a help function which helps a user to use EXGAME rather than provide domain knowledge about the business game.

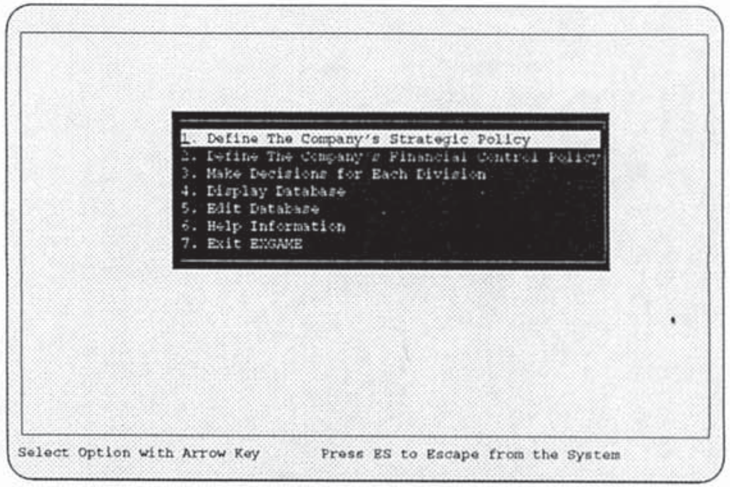



Figure 5.14 The main menu of EXGAME.

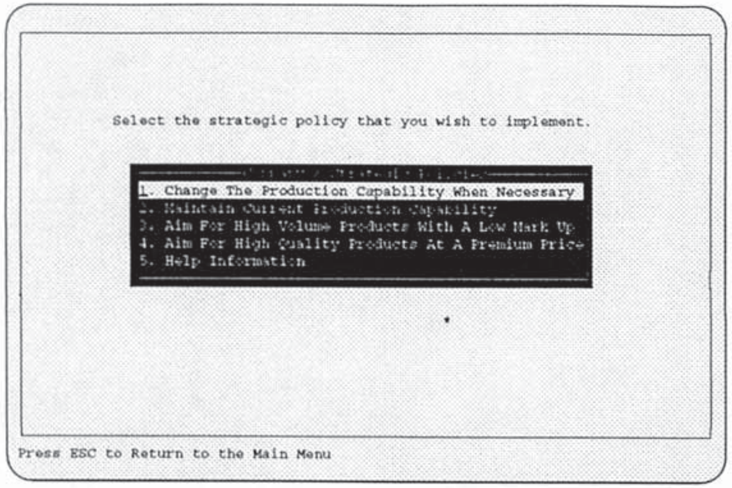



Figure 5.15 The menu for defining the strategic policy

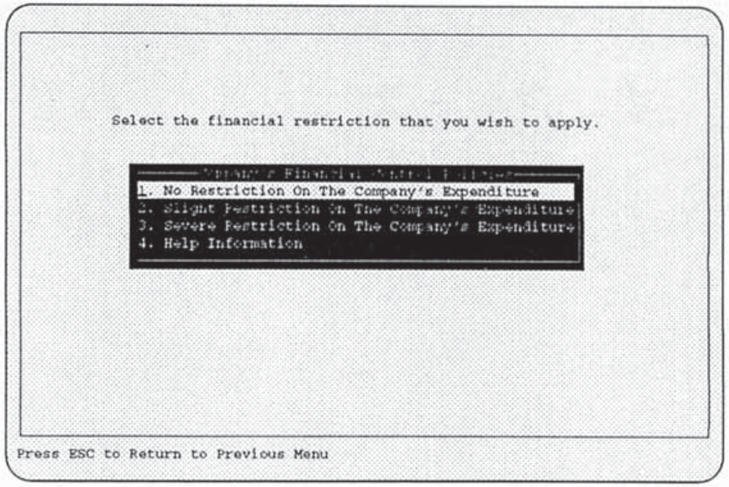



Figure 5.16 The menu for defining the financial policy

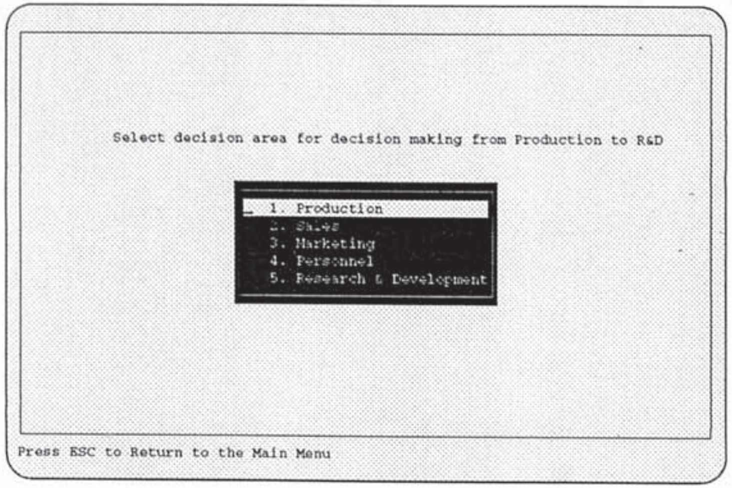



Figure 5.17 The menu for selecting decision making area

## 5.4 Development of ADGAME

### 5.4.1 ADGAME - initial feasibility

After the first experiment with EXGAME, the ADGAME advisory system, which would not replace the human players but act as a decision making aid, was developed. It could be developed based on EXGAME and the users could be either a group of the game company's managers/students or individual managers during game playing.

The purpose of ADGAME has been mentioned briefly in previous chapters, and in more detail ADGAME was built for

- Examining the effectiveness of an expert advisory system and comparing it with the performance of EXGAME which was intended to make decisions for managers/students with little user intervention, and had out-performed the students in the previous trials.
- Analysing the ability of an expert advisory system to help users improve their performance in the domain concerned by consulting the system.
- Obtaining some insight into the users' opinions and behaviour toward the use of an expert advisory system in their decision making procedure and other features associated with the use of an expert advisory system.

### 5.4.2 Design of ADGAME

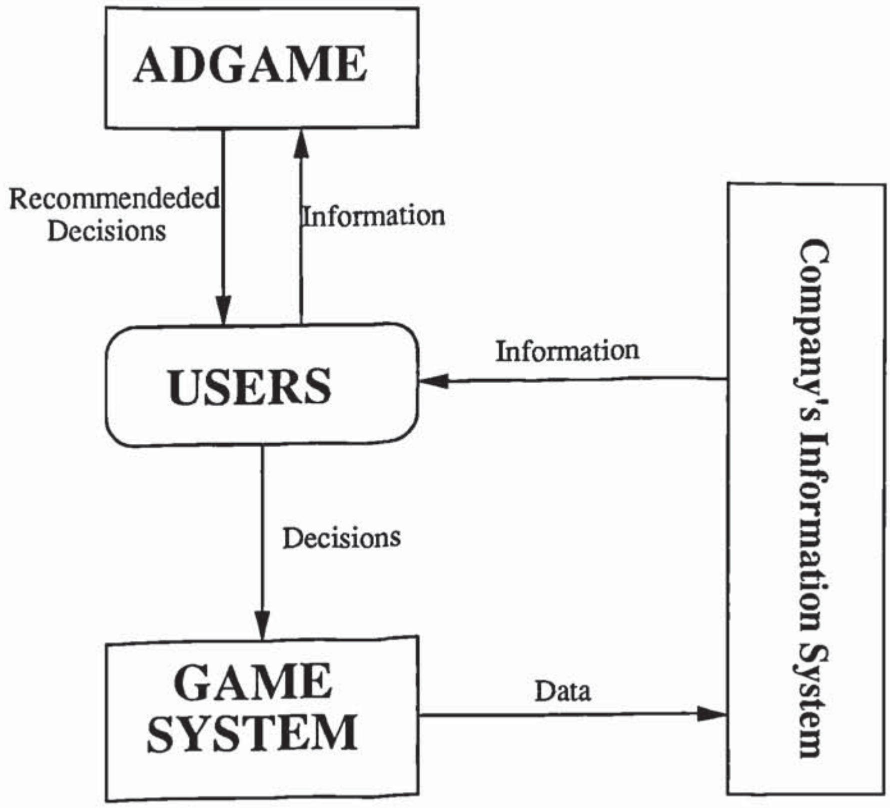
Initially, there were several possible alternative ways of developing ADGAME:

1. Modify EXGAME into an advisory system by adding more explanation functions, more user intervention, changing the method of information input and output and modifying the user interface;
2. Design a new advisory system using an ES shell;
3. Design an advisory system with a basic EXGAME knowledge base and structure but with a different design of the user interface using an ES shell.

The second and third alternatives may give a more flexible and friendly user interface, but would need more time to develop. Considering the time limit, EXGAME was changed into an advisory system with the same system structure by using PDC Prolog.

ADGAME was designed to be run independently from the business game system, so unlike EXGAME, it does not need to be connected to the mainframe computer. It is a stand alone system which makes it easier for students to use. The working environment of ADGAME is described in figure 5.18.

Referring to the information input of ADGAME at first the author was going to connect ADGAME to the game system and obtain data directly instead of asking the user to input data, but this was finally decided against. The procedure of answering questions during decision making is a way of helping the user to learn what kind of information is




Fiogure 5.18 The working environment of ADGAME

relevant to the decisions being considered. So, ADGAME asks a user for all the information it needs to provide advice (see sections 6.5.2 and 9.2.1 for more discussion).

### 5.4.3 ADGAME - its architecture

Because ADGAME was constructed based on EXGAME, its program architecture is the same as EXGAME (which is shown in figure 5.10). More explanations have been added to the system and some rules in the knowledge base are slightly different because the system considers more user requirements and gives the user more opportunities to control the decisions.

### 5.4.4 Users of ADGAME

ADGAME is designed to be used by people who want to obtain advice for playing the MAS1 business game. Although its users can be different types of people, they are mainly students. Therefore, understanding the user's requirements is an important aspect for designing a useful user interface. The author attended many team meetings in the first experiment with EXGAME (also the second one later). The experience gained from observing students' behaviour and decision making procedure revealed the weak points during students' decision making and the common mistakes students may make. This experience was very helpful in the design of ADGAME, especially, its explanation design.

### 5.4.5 User interface

During consultation the main ADGAME screen consists of three windows:

1. Data input window;
2. Dialogue window for messages between system and users;
3. Output window for recommended decisions.

Each window appears when necessary. The main menu of ADGAME is shown in figure 5.19. When consulting ADGAME, the section menus are the same as EXGAME (shown in figures 5.15 to 5.17). After users define their company's strategic and financial policies through the menus provided by the system (see figures 5.15 and 5.16), they can

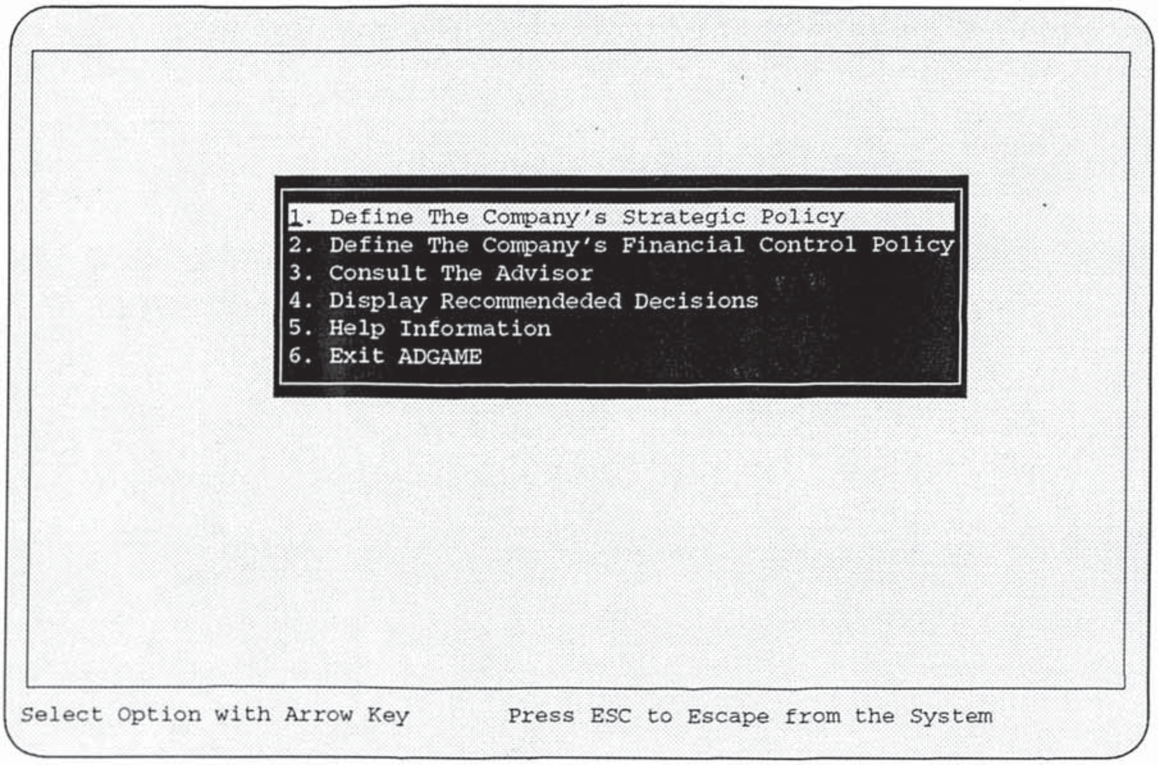



Figure 5.19 The main menu of ADGAME

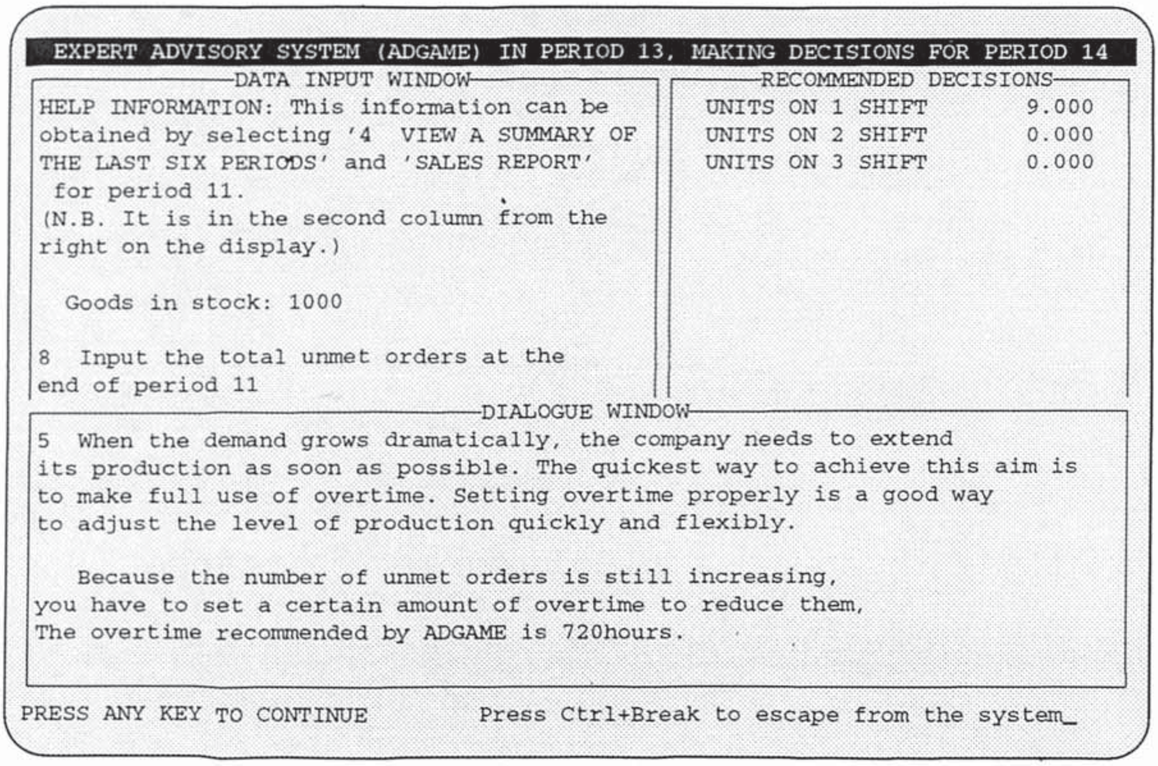



Figure 5.20 An example screen when using ADGAME

begin their consultation through the menu shown in figure 5.17. Figure 5.20 is an example of what it looks like in mid-consultation.

The advice provided by the system is presented in different ways:

1.General suggestions. E.g.

> *"According to your company's strategic policy, you only need renew the machine when any lease comes to an end. You don't need to consider hiring a new machine or cancelling current leases".*

2. Recommended decision ranges. E.g.

> *"Analysing the relative position of your products and your company's strategic policy, ADGAME suggests that the investment for a product's durability should be between 1000 and 2000 pounds more than the average investment of your competitors".*

3. Precise recommended decisions. E.g.

*Wage Rate: 4.25*
*Reps Salary: 1280.00*
*Hours of Ops Training: 6.00*
*Hours of Reps Training: 4:00*
*Ops Change (+/-): 2*
*Reps Change (+/-): 0*

ADGAME is keyboard driven with menu selection and keyboard input. Once a user has determined a company's strategic and financial policies and entered the screen of selecting decision area in figure 5.17, the system asks a series of questions related to the company's current situation and all the decisions are made in terms of the user's answers.

ADGAME has no function to show its reasoning procedure. This is for two reasons: firstly PDC Prolog does not have the built-in "why" function, and secondly (which is more importantly), the rules in ADGAME are not English-like, but are comprised of data and variables. Even if the system provided its reasoning procedure to the user, it would not look meaningful or understandable.

Each team has a team ID and password for using ADGAME, in order to trace the students' usage of ADGAME. The ADGAME system records how many times and for how long each team has used it.

### 5.5 Summary

This chapter has introduced the decisions required in the MAS1 business game which is currently being used by undergraduate students in Aston Business School. In order to get some insight into the use of expert systems in decision making, the business game was chosen as an experimental environment for testing expert systems' functions and effectiveness. EXGAME was developed and was intended to replace the human player for most of the decision making. EXGAME was built using PDC Prolog and the knowledge is represented in the form of production rules. EXGAME consists of six sub-ESs, with one representing the general manager and others responsible for making decisions for different divisions. The chapter has also described an expert advisory system ADGAME. ADGAME has a similar structure to the EXGAME expert system, but aims to help students make better decisions in the game. The following chapter presents the experiments conducted with EXGAME and ADGAME and summarises the yexperimental results.

# Chapter Six

## EXGAME and ADGAME - EXPERIMENTS

This chapter concerns the use of EXGAME and ADGAME as developed in this research. Three experiments were conducted, in which EXGAME was tested three times and ADGAME was tested twice. Additionally, EXGAMEs were used several times competing with each other. This chapter explains how these experiments were conducted and what experimental results were obtained. The method of performance assessment is discussed, and finally, some analysis based on the systems' performance is presented. The users' opinion is given in a separate chapter (chapter seven).

## 6.1 Evaluation of EXGAME and ADGAME

The development of EXGAME and ADGAME has been described in chapter 5. EXGAME and ADGAME were tested several times with the MAS1 game players. This section will discuss how these two expert systems were evaluated.

The evaluation of an expert system is a crucial part of ES development. As discussed in chapter three, the evaluation normally includes three aspects: verification, validation and usability. The verification refers to building the system "right", whereas validation refers to building the right system. Usability is associated with user acceptance. In the literature, the evaluation of an expert system has been discussed from different points of view and the importance of user evaluation has been stressed by many people.

The main objective of developing EXGAME is to replace a student team in playing the MAS1 business game. It has to fulfil the management tasks of making reasonable profit and maintaining its competitive position in the market, which are given to student managers also. The evaluation of EXGAME focused on determining whether it could satisfactorily perform the "real-world" tasks for which it was designed. For the evaluation of ADGAME, since it was developed to help the users to make better decisions whilst playing the game, its effectiveness as a decision making aid was evaluated from the measurement of the users' achievements and their acceptance of the system as a helpful tool.

In order to perform the evaluation of an expert system, a set of evaluation criteria is needed. These criteria may vary from domain to domain depending on different applications. In the MAS1 game, "The students are assessed on their ability to report and evaluate their performance and to identify significant aspects of management - formal and informal" (cited from the game tutor), but this method obviously cannot be applied to assess EXGAME directly since EXGAME cannot give any verbal reports. Therefore, to make the comparison between human teams and EXGAME clearer, a more detailed measurement criterion was required for this purpose. The main criterion used to evaluate a team's performance became the total profit made throughout the game, although other factors were taken into account. In general, the performance of EXGAME is analyzed along three dimensions:

1. The ability to make profit - Profitability is one of the most important goals for managing the game company and is, therefore, a major criterion for assessing the overall performance of the management in the game company. This criterion is represented by the total profit made at the end of the game.

2. The process quality - This is to examine the performance throughout the process of game playing. Mainly, it is to check EXGAME's ability to avoid mistakes typically made by students, especially, to maintain the company in a stable and competitive status throughout. A typical problem encountered by students is that a keenness to make profit results in other important factors being ignored. There are some traps for students if they do not consider the facts carefully before making their decisions. A list of typical mistakes that can occur is used to check against EXGAME's performance (see Table 6.6 in section 6.3).

3. The ability to avoid an "end of the world strategy" at the end of the game - This is to see the general status of a game company at the end, to check that a company does not implement the "end of the world strategy", such as stopping its investments in marketing and R & D divisions, increasing the prices of products excessively and ignoring the machine maintenance towards the end of the game in order to inflate the total profit figure "artificially".

The criteria for measuring the users' achievements of ADGAME are the same as those used for evaluating students' and EXGAME's performance and have been discussed in the previous paragraphs. However, the evaluation of ADGAME is determined not only by measuring the users' final achievements but also by their attitudes towards the system as an effective decision making aid. This user opinion can be obtained by different methods, such as interviews and questionnaires. The interview method was seen to be more time consuming than questionnaires for this purpose, so the survey of users' opinions was carried out by issuing a questionnaire to the ADGAME users.

The use of questionnaires can be a very effective means of getting opinions from a large number of people and summarising their viewpoints. Its major limitation is that the data obtained are usually restricted. There are two basic types of question, namely, closed and open (Berry and Hart 1990). In the former case two or more possible answers are provided. In the case of open questions no response alternatives are suggested. People are simply asked a question and they write their answer in the allocated space. The major disadvantage of open questions is that it is usually very difficult to carry out any meaningful statistical analysis, or to combine the answers to give an overall picture.

It is generally advantageous to design questionnaires made up of both types of question as these will cover the domain more effectively and be more interesting to complete. Therefore, the questionnaire for ADGAME includes both closed and open questions, but is dominated by closed questions (see the appendix 5).

## 6.2 Description of Experiments

This section will explain the three experiments carried out during the research. All three experiments were conducted to evaluate EXGAME in competition with human MAS1 game players. ADGAME was evaluated in two of these experiments. Table 6.1 presents a summary of the experiments carried out. Furthermore, EXGAMEs were also used three times to compete with each other. The detail of the EXGAMEs competing with each other is described in section 6.4.

### 6.2.1 The 1991-experiment

EXGAME was first tested against student teams in the period January-March 1991. About 180 undergraduate students participated in the business game playing as part of their management course work. They were divided into four groups named as A,B,C and D. Each group consisted of five student teams instead of six teams as the expert system represented one team in a group. There were about nine students in each team. EXGAME played as a team in the groups A, B, C, and the author managed one game company in group D. ADGAME was not developed at that time, so the 1991-experiment only concerns the performance of EXGAME.

**Table 6.1 Summary of the experiments conducted**

| Experiment | Time | General Description |
| --- | --- | --- |
| 1991-experiment | Jan.-Mar. 1991 | About 180 students were divided into four groups. Three EXGAMEs were used in three groups and the author played in another group |
| 1992A-experiment | Jan.-Mar. 1992 | About 170 students were divided into five groups. Five EXGAMEs were used. ADGAME was used by six teams from five groups from the middle period of the game playing |
| 1992B-experiment | May 1992 | 10 individual players divided into two groups participated. Two EXGAMEs were used and four people consulted with ADGAME |

### 6.2.2 The 1992A-experiment with EXGAME and ADGAME

After the 1991-test, EXGAME was further amended and its knowledge base was updated with the expectation that its performance would improve, especially with regard to making a higher profit and managing the company to maintain a more stable status throughout.

In this 1992A-experiment, EXGAME again competed against undergraduate students during their business game playing. This time there were about 170 students and they were divided into five groups named as A,B,C,D and E. Each group consisted of five student teams and one EXGAME expert system. There were 25 student teams in total and each team had between six and eight students.

As mentioned in the last chapter, after the 1991-test of EXGAME, an expert advisory system called ADGAME was developed on the basis of EXGAME, which acted as an advisor rather than a decision maker. For the 1992A-experiment, apart from the intention to test EXGAME again and confirm the result gained in the 1991-experiment, the other aim was to analyze the effect of the ADGAME expert advisory system.

During the 1992A-experiment, the advisory system was made available for all 25 student teams from the seventh period (there were 12 periods to play in the game) and its use was optional. The reasons considered for making it available only from the seventh period with options for using at the time were:

- It is better to let students have some experience about managing the game company themselves, so that they will be more clear about what advice they really need when consulting an advisory system;

- The performance of students before and after the use ADGAME can be compared if students' skills of playing the game are considered as not being improved over the first six periods.

Its use was made optional in order to make students feel it is fair for them to make their own choice. The reasons for choosing or not choosing to use ADGAME revealed some interesting points in the later survey (see section 7.2).

Apart from its use being optional, at the beginning it was also announced that a small "fee" would be charged for consulting ADGAME to be deducted from the company's profit made at the end of the game. This decision was made for the following reasons: 1. The way of paying for consultation was more like the real world; 2. To be fair to those teams which did not use it; 3. To control the number of the teams which could use it in order to carry out the comparison after the experiment. Since most of the student teams were not in a good state when ADGAME was available, the author thought that many teams might ask to consult ADGAME. That was why the third reason was considered, but it was soon realised that this was not necessary. The policy of charging for use was cancelled later in order to encourage more users, even so only six teams finally asked to use ADGAME.

### 6.2.3 The 1992B-experiment with individual players

The 1992B-experiment conducted in May 1992, was different from the previous two in that it was not carried out along with the student's course work. The candidates were chosen from three sources: experienced students (students who had played the game one month before), novices from doctoral students in ABS (Aston Business School), and lecturers in ABS, who were all paid for participating since the experiment was conducted purely for research purposes. In this case it was desired that the experimental design could be controlled easily. In order to stimulate the participants' motivation, the announcement that prizes would be awarded to the best players was made before the experiments. One prize was for the players without the help of ADGAME and another for the players aided by ADGAME.

The previous experiments of EXGAME were all in competition with students who had no experience of the business game. The 1992B-experiment was to demonstrate EXGAME's competence with experienced or aided competitors. Additionally, ADGAME was also updated after the 1992A-experiment and a further implementation was required (see section 6.4 for more detailed reasons for ADGAME). Therefore, the 1992B-experiment aimed to:

1. compare the performance of EXGAME with experienced people;
2. examine the effectiveness of the ADGAME advisory system between novices and experienced people;
3. compare the performance of EXGAME with the people aided by the ADGAME advisory system, and to see the effect of user intervention when using an expert system.

Ten people and two EXGAMEs participated in the experiment. Among them were 7 "experienced" students, two novices and one lecturer. In order to compare the different effects of ADGAME on novices and experienced people, the two novices and three experienced students who were selected based on their own desire at the beginning of the game were given the right to consult the ADGAME advisory system. In order to avoid the problem of a lack of motivation for using ADGAME, they were told that they could refuse to use it if they thought they did not need any help. One of the latter (team G1) who had used ADGAME in 1992A-experiment, only used ADGAME for one period with about 20% of his decisions following the suggestions of ADGAME, therefore he was excluded from the ADGAME users when analysing users' achievement. One EXGAME represented a company in each group. The game was run over twelve periods in about three weeks (not about eight weeks as in previous tests).

### 6.3 Experimental Results

This section presents the results of all experiments with EXGAME and ADGAME. The results are grouped and examined in two subsections, one of which is associated with EXGAME and the other with ADGAME.

#### 6.3.1 Results of EXGAME

In terms of the three evaluation dimensions discussed in section 6.1, the most important criterion is profit making. The original data of total profits that each company made over twelve periods in each experiment are shown in Tables 6.2, 6.3 and 6.4 respectively. Figures 6.1, 6.2 and 6.3 represent them in bar diagrams, so as to make the comparison more evident.

It can be seen that the results of the initial test of EXGAME were quite encouraging. All three companies managed by EXGAME made larger profits than any

**Table 6.2 The total profits in the 1991-experiment (Jan - Mar 1991)**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| A | -560016 | -562538 | -28557 | 212329* | -83442 | -1107695 |
| B | -121042 | -710792 | -958259 | -507582 | -544592 | 64537* |
| C | -661054 | -560368 | -235651 | -596913 | 276719* | -700695 |
| D | -599328 | -215376** | -837328 | -474 | -238976 | -616660 |

**Table 6.3 The total profits in the 1992A-experiment (Jan - Mar 1992)**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| A | 603668* | 184745 | 164335 | 236239 | -632745 | 416326 |
| B | 653042* | -75778 | 287972 | 213266 | 277320 | -2970729 |
| C | 624478* | -601478 | 455337 | -183856 | -45990 | -122782 |
| D | 729538* | 69844 | 313100 | -408640 | 296681 | -664781 |
| E | 568539* | -249570 | -1333631 | -505320 | -2581325 | -87765 |

**Table 6.4 The total profits in the 1992B-experiment (May 1992)**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| F | 659078# | -289074 | 514872 | 55621## | 330472# | 585327* |
| G | -276203 | 300967## | -440904 | 117744 | -626246 | 571207* |

*------ Company managed by EXGAME

**----- Company managed by the author

#------ Company managed by an experienced person with the help of the expert advisory system ADGAME

##----- Company managed by a novice with the help of the expert advisory system ADGAME

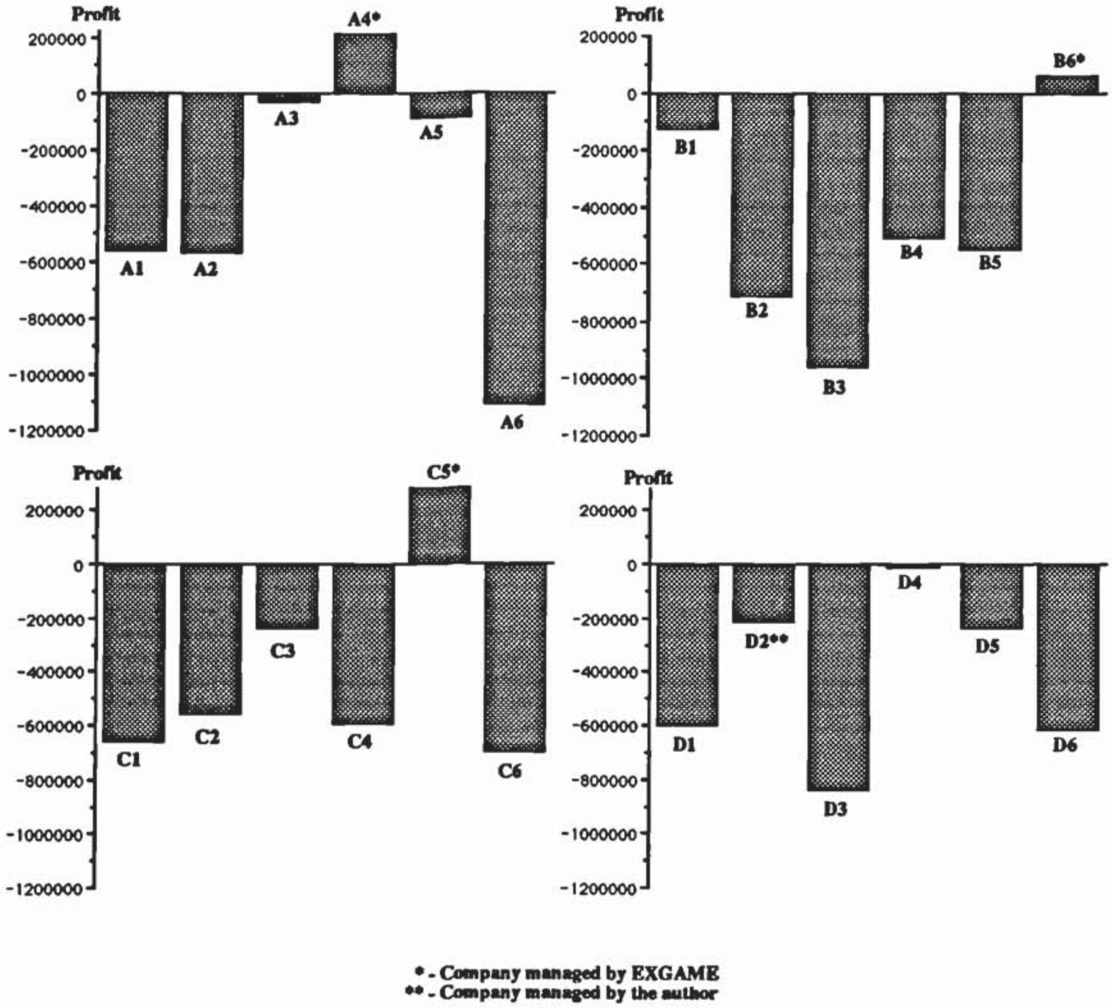



**Figure 6.1 The total profits at the end of the game (The 1991-experiment)**

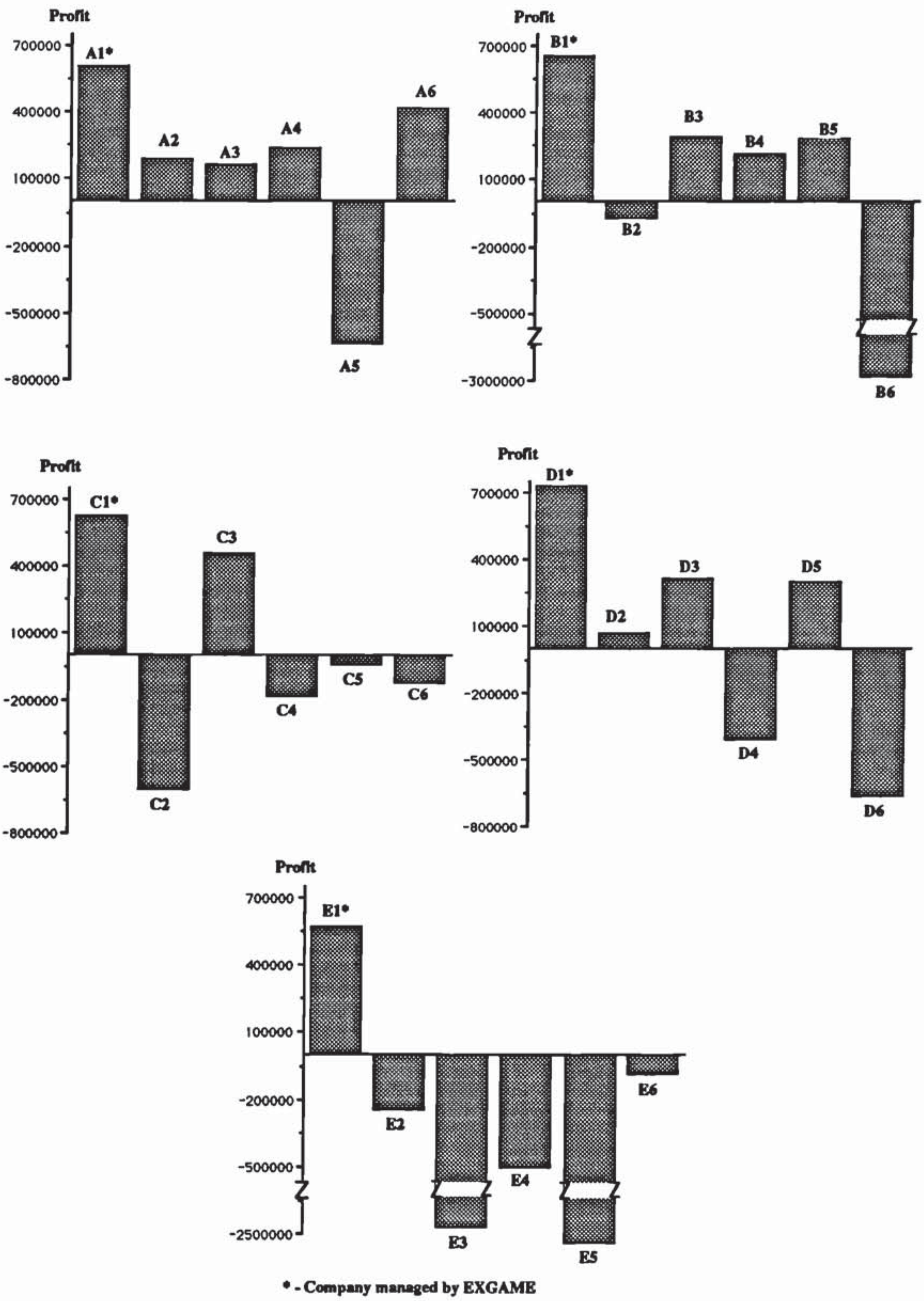



**Figure 6. 2 The total profits at the end of the game (The 1992A-experiment)**

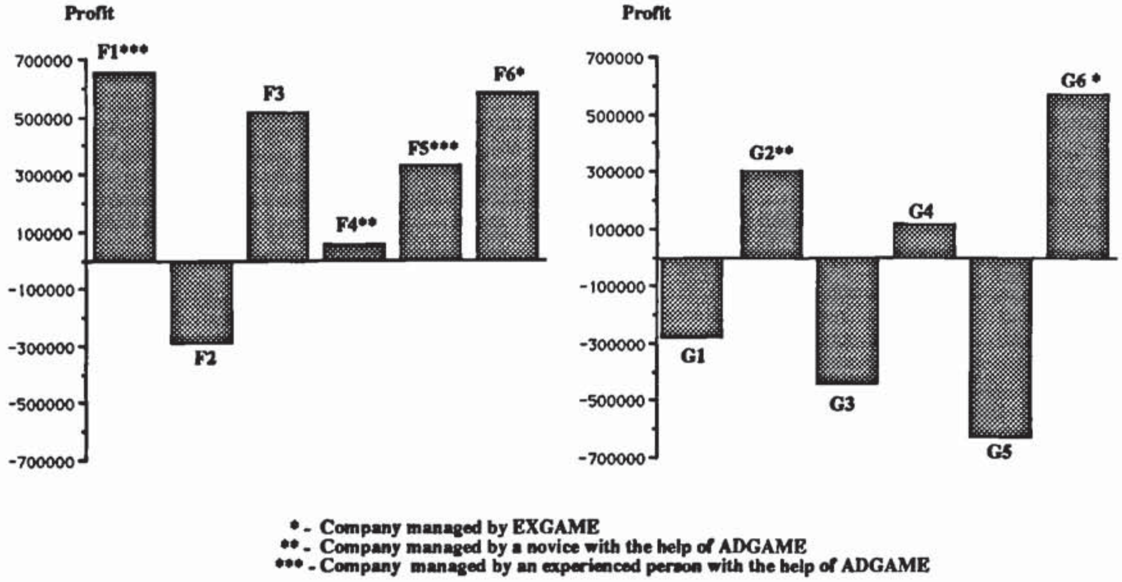



**Figure 6.3 The total profits at the end of the game (The 1992B-experiment)**

of those managed by student teams. In the 1992A-experiment, it is again clear that all five companies managed by EXGAME did better than those managed by student teams. So, EXGAMEs out-performed all student teams in both the 1991-experiment and 1992A-experiments and all other players except one experienced student who was aided by ADGAME in the 1992B-experiment. A summary of the profit analysis in all tests is presented in Table 6.5. The results of the South African case referred to in chapter four (Computer Mail, 1989) were similar, with the expert system clearly out-performing all the human "opposition" in profit making. However, in the 1991-experiment, the company managed by the author did not perform as well as EXGAME, although it did better than most of the student teams.

The second aspect of performance assessment is concerned with the player's performance in the process of the game. The process quality of all the teams was examined by analysing all the company information throughout the twelve periods of

**Table 6.5 Summary of profit making in three experiments**

| Experiment | Group | Best Team | | Next Best | | Average Profit of Each Group (Except EXGAME) | Average Profit of All other Teams Except EXGAME |
|---|---|---|---|---|---|---|---|
| | | Team | Profit | Team | Profit | | |
| 1991-experiment | A | EXGAME | 212329 | A3 | -28557 | -468450 | -511598 |
| | B | EXGAME | 64537 | B1 | -12104 | -568453 | |
| | C | EXGAME | 276719 | C3 | -235651 | -550936 | |
| | D* | D4 | -474 | D2** | -215376 | | |
| 1992A-experiment | A | EXGAME | 603668 | A6 | 416326 | 73780 | -301968 |
| | B | EXGAME | 653042 | B3 | 287972 | -453590 | |
| | C | EXGAME | 624478 | C3 | 455337 | -99753 | |
| | D | EXGAME | 729538 | D3 | 313100 | -78758 | |
| | E | EXGAME | 568539 | E6 | -87765 | -951522 | |
| 1992B-experiment | F | F1# | 659078 | EXGAME | 585329 | 254194 | |
| | G | EXGAME | 571207 | B2## | 300967 | -184928 | |

*------ No EXGAME used in this group

**----- Company managed by the author

#------ Company managed by an experienced person with the help of the expert advisory system ADGAME

##----- Company managed by a novice with the help of the expert advisory system ADGAME playing. The aim of this examination was to see how a company performed in a dynamic process, for example to see what kind of mistakes they made, did they fall into the typical traps that often happened in the game playing, etc. It is not possible to present all the original data here because of the large amount of data required for this purpose. However, Table 6.6 lists some typical mistakes and traps that often happened during game playing and checks these against the performance of student teams and EXGAME. A typical student team may fall into at least 50% of these traps when playing the game. Generally speaking, EXGAME managed the company in a stable process and did not fall into the traps that students did. It gained a competitive advantage and had a good market share with a sound price and adequate advertising expenditure throughout the game playing. However, EXGAME ran out of raw material occasionally in each experiment, the reason may be that the safe margin which was given by the author when calculating the demand for raw material was too small.

The third aspect concerns the company's performance towards the end of the game, mainly to see whether a company implements the "end of the world policy" to gain more profit. By examining the final report of the companies' status, it revealed that all EXGAMEs did not use the "end of the world policy" (EXGAME had no representation of a final period), but about 20% of student teams used or partly used this strategy. Additionally the companies managed by EXGAME maintained a better status than most of the companies managed by students in terms of the market shares, investment in advertising and R & D, production rate, market niches of products, etc. The detailed data about the final status of all the companies are attached in appendix 3.

**Table 6.6 A list of mistakes which happened in the game playing**

| | Students | Author | EXGAME | | |
|---|---|---|---|---|---|
| | | | 1st Test | 2nd Test | 3rd Test |
| . Forget to renew lease which causes the production to drop suddenly | O | X | X | X | X |
| . Arrange shift working wrongly | O | X | X | X | X |
| . Forget to set up the maintenance level | O | O | X | X | X |
| . Use overtime inappropriately | O | X | X | X | X |
| . Run out of raw material | O | O | O | O | O |
| . Too much raw material in stock | O | X | X | X | X |
| . Reduce prices too much to attract more orders, but as a result sell products as a loss | O | X | X | X | X |
| . Increase prices too much which results in a big drop in orders | O | X | X | X | X |
| . Too many representatives which results in a heavy wage bill | O | X | X | X | X |
| . Too many operators, or shortage of operators, which causes a very low production rate | O | O | O | X | X |
| . Heavy investment in advertising which leads to a low investment-return level | O | X | X | X | X |
| . Poor wage policy which results in many operators leaving the company | O | X | X | X | X |
| . Forget to recruit operators | O | X | X | X | X |
| . Heavy investment in R & D which leads to a lower investment-return | O | X | X | X | X |
| . Can not adjust investment levels according to competitors' behaviour | O | X | X | X | X |
| . Too many products in stock | O | X | O | X | X |
| . Too many unmet orders | O | X | X | O | X |
| . Can not adjust production capacity in terms of the market demands properly | O | X | X | X | X |
| . Set the training level unwisely | O | X | X | X | X |
| . Input wrong decisions by typing mistakes | O | O | X | X | X |

O - Happened X - Did not happen

By analysing the experimental results, it has been noticed that the performance of EXGAME improved gradually as it was modified many times after each test. Although EXGAME beat all the students in profit making in the 1991-experiment, the profits it made and the company's general status at the end were not entirely satisfactory. One thing which was especially not satisfied was its ability to respond and adjust its investments quickly in light of its competitors' behaviour. The problem was when some teams set a very high investment level, the other teams' relative position in the market would be affected significantly. In the 1991-experiment, although EXGAME adjusted its decisions in investment accordingly, the result was not quite satisfactory because its reaction to market position was slow and the change of its investment level was not quite adequate. It seemed necessary to modify the knowledge-base to ensure that companies managed by EXGAME made even better profits and stayed in adequate competitive conditions throughout.

The average profit of student teams was higher in the 1992A-experiment than in the 1991-experiment (-301968 compared to -511598, see Table 6.5). This fact indicated that students, in general, appeared to perform better in the 1992A test than in the 1991 test (tutors also noticed this and the surveys discussed in section 7.1 provide a positive support because students were more satisfied with their achievement in the 1992A-experiment), but EXGAME still out-performed them by big margins. The results suggested that the EXGAME's ability to make more profit and to maintain a company in a good situation had been improved since its knowledge base was updated after the 1991-experiment. Although the competition was thought to be tougher than in the 1991-experiment, the companies maintained a better competitive position, and more importantly, made higher profits.

The competition in the 1992B-test was tougher than any previous tests because it involved experienced and aided players. The results demonstrated EXGAME's ability to gain competitive advantage and make good profits, although one experienced student with the help of ADGAME made a higher profit than EXGAME.

In summary, EXGAME did better than all the student teams and all but one of the experienced individuals in terms of the three evaluation dimensions.

### 6.3.2 Results of ADGAME

ADGAME was used by game players in the 1992A and 1992B experiments. The survey results about the users' opinions are discussed in chapter 7. The users' achievements are presented here. Since the two tests were designed quite differently, the results are discussed separately in the following sections.

#### The first trial of ADGAME (1992A-experiment)

In the 1992A-experiment which was the first trial with ADGAME, ADGAME was made available for all the teams, but at the end of the game only six teams had used it. Looking at the users' achievements, a table of the final period's total profits does not explain the situation very clearly, because each team was in a very different state in the seventh period when ADGAME became available and their use of ADGAME varied. So, as the system recorded each team's usage (for how long and in which period), it is possible to represent how each team's profit changed when using and not using ADGAME. However, figures which exhibit the profit changes for all the teams which had used ADGAME in this test still cannot provide any conclusion since they vary too much (they are attached in the appendix 4). In order to compare with those teams not using ADGAME, the profit changes for the teams which had not used ADGAME in group A (A4 and A5) are also diagrammed (see the appendix 4). Unfortunately, there was a large variation in these profit changes and a comparison between them is difficult. Because it is impossible to know what the profit would have been if an ADGAME user had made decisions without any help, and to separate the real effect of ADGAME from the students' own behaviour, it is difficult to draw any conclusion from these figures. Some teams did make good profits when using ADGAME (A2, A6, C2 and E4), but some did not (A3 and D4). The fact that two teams' performance did not improve significantly during consulting ADGAME can provide two possible explanations: firstly, ADGAME was not a very effective decision making aid in this initial trial and further improvement was required; secondly, students did not use ADGAME consistently and implement its suggestions completely. In all experiments, the ADGAME system recorded information of when it was used and by whom, but it could not tell whether the decisions it suggested were followed or not.

**Need for further improvement**

Although the outcome of the first trial of ADGAME was generally satisfactory at the time, it still revealed some inadequacies both for the author and the users. The things which required further improvement are summarised as follows:

- The need for extending the knowledge base. The system's rules did not cover all the situations students would confront when playing the game; especially some extreme circumstances. For example, the system's ability to help a company get out of serious trouble and guide it to the right track was relatively weak.

- The need for clarifying the system's explanation and displayed contents. Users sometimes had difficulty in understanding the explanations and the general advice provided by ADGAME.

- The need for correcting some system errors. As not all of the rules in the knowledge base had been activated before, some of them did not work well when triggered during students' use. Some errors in the programme occurred during implementation. These are common problems for KBS/ES validation, but are not discussed enough in the literature (more discussions here in chapter 8).

Therefore, although the initial test of ADGAME provided positive results, as has been mentioned above, the system itself needed improvement and there were still some remaining questions which needed further research; such as what different effect does ADGAME have on experienced users and inexperienced ones?

Moreover, for the sake of a fuller testing of EXGAME, a further investigation into the ability of EXGAME when competing with experienced users, especially the good experienced ones, would also be very useful. The experimental design of the 1992B-experiment has been described in section 6.2.

**The second implementation of ADGAME (1992B-experiment)**

The survey showed that ADGAME users had consulted it for an average of eight decision periods and about 80% of their decisions followed the suggestions of ADGAME. The final period's total profits are shown in Table 6.3 and Figure 6.2 in section 6.3.1.

When analysing ADGAME's performance, one snag is the lack of a real expert in playing the business game, to act as the yardstick of expert performance. However, because EXGAME had out-performed all the students in the 1991 and 1992A trials and the author in the 1991 trial, and had also achieved better profits than all the other players except for one experienced player who was using ADGAME in the 1992B-experiment. it appears reasonable to regard EXGAME as an expert for this purpose.

The users' achievements in the first trial (1992A-experiment) of ADGAME were not very obvious from the final profits made, although the comments from student users gave positive support on this point. The comparison of the users' achievement in the 1992B-experiment was carried out by: 1. comparing with the companies who did not use ADGAME; 2. comparing with typical levels of student performance in 1992A-experiment. Since there are not enough figures to distinguish the difference between the effect on the performance of individual players and players as a group, the effect is assumed to be insignificant. One the one hand, individuals may be worse than a group because it is only one person's knowledge; on the other hand individuals may be better because there is no conflict.

**Table 6.7 Average total profits for different classes of player**

| | Average total profit |
|---|---|
| Novices with ADGAME (1992B-experiment) | 178294 |
| Novices unaided (1992A-experiment) | -301968 |
| Experienced with ADGAME (1992B-experiment) | 494775 |
| Teams involving these players (1992A-experiment) | -329105 |
| Experienced unaided (1992B-experiment) | -223511 |
| Teams involving these players (1992A-experiment) | -49215 |

Table 6.7 shows the average final profits for various classes of player. It can be seen that the profits achieved with the aid of ADGAME were much higher than those without, for both novices (178294 compared to -301968) and experienced players (494775 compared to -223511). The novices with the aid of ADGAME in fact did substantially better than the unaided experienced players. This is strong evidence, albeit based on a small sample, that the expert decision making aid made it possible for novices or less experienced people to perform at a level closer to that of an expert.

In addition, the experienced players using ADGAME improved far more in their second attempt at the game than the unaided players did (by an average profit of 818486 as opposed to 268647). It is clear that the expert advisory system greatly improved the performance of experienced people and made it possible to reach "expert" level. In table 6.4, company F1 was the best in that group and out-performed the expert system EXGAME in profit making.

### 6.4 EXGAMEs Competing With Each Other

Instead of setting EXGAME to compete with teams of students, other experiments were carried out where six EXGAMEs were set to compete with each other. Three experiments were actually conducted here. The first and second experiments were carried out after the 1991-test with EXGAME against students and the third experiment was arranged after all the tests of EXGAME with students.

The final profits in the 1991-experiment of EXGAME against student teams showed that companies managed by EXGAMEs made much better profits than those managed by the student teams. Two possible explanations can be suggested: one is that it proves that an expert system does a very good job in enabling the company to manage efficiently and gain a competitive advantage; another is that students may not have been very good at managing a company before they played the game. Therefore, by competing only with "experts", it was hoped that the experiments would provide more insight into the ability of EXGAME.

In the first experiment, the same EXGAME which played with the students was used without changing anything in the knowledge base, but the results revealed that some of the company's strategies did not work as well against "each other" as they had with the students. The total profits at the end of the game are shown in the first row of table 6.8. Therefore new functions were added to enable the company to change its strategy during the game in the light of different competitive conditions.

After amending the knowledge base and adding some new strategic policies, the second experiment was carried out. The total profits made from twelve periods are shown in the second row of table 6.8. The results illustrated that all companies made large profits and had a similar market share. They also indicate, as would be expected, that if a company revises its strategies according to the characteristics of its competitors, it will produce a better profit. The profitability of all the companies managed by expert systems in these experiments, in spite of the highly competitive export market, proves that the use of EXGAME enables the company to make sensible decisions.

**Table 6.8 The total profit at the end of the game (EXGAMEs competing with each other)**

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| First Experiment | 84788 | 70635 | 78565 | 164092 | 146404 | 156631 |
| Second Experiment | 444329 | 355123 | 344564 | 367528 | 287673 | 445317 |

The question raised here for the real world implementation is: would the wide use of ESs make competition even tougher? The answer seems to be that if many organizations employ the same expert system, the competitive advantage will be determined by how well an organization implements the strategy and decisions suggested by the expert system.

After all the three experiments with EXGAME against humans, the author saw a possibility of putting EXGAMEs to compete with each other, with each implementing a different strategic policy. This was to see how different strategic policies would affect a company's profit making and how sensitive a company was to strategic change. EXGAME is an ideal experimental tool to simulate the different policies of a company. This is another advantage of using the business game as an experimental vehicle.

EXGAMEs were set to compete with each other for the third time. Although there were 12 possible policies, six policies were selected, four of which represented all strategic policies and two of which showed the different financial policies. Table 6.9 explains the policy allocation for the six companies and displays the total profits made during the experimental periods. It shows there is little difference in the profits made among the six companies. One interesting finding is that the profits made by teams H1, H5 and H6 were increased as the financial restrictions became severer. Were these results caused coincidentally by the random factors in the game, or did the financial restrictions improve the profitability? Because one experimental result does not adequately answer this question, future work needs to be done to investigate this issue. Another question raised here is why different strategies show little difference. It may suggest two possible reasons: firstly, and also more probably, the game itself is not very sensitive to policy changes and, secondly, EXGAME's policies are not very different, but the author was not convinced by this last point.

**Table 6.9 Experimental results (EXGAME competing with each other in July 1992)**

| Team | Profit made | Strategic and Financial Policy |
|---|---|---|
| H1 | 670909 | Change the production capability when necessary and no financial restriction on the company's expenditure |
| H2 | 730679 | Maintain current production capability and no financial restriction on the company's expenditure |
| H3 | 663012 | Aim for high volume products with a low mark up and no financial restriction on the company's expenditure |
| H4 | 751837 | Aim for high quality products at a premium price and no financial restriction on the company's expenditure |
| H5 | 709340 | Change the production capability when necessary and slight financial restriction on the company's expenditure |
| H6 | 749548 | Change the production capability when necessary and severe financial restriction on the company's expenditure |

## 6.5 Discussion

### 6.5.1 Advantages of an expert system in decision making

All the results of the three experiments of EXGAME against students and two experiments with ADGAME proved that the EXGAME expert system did achieve its objectives and made higher profits than most of its human rivals; and ADGAME helped its users make better decisions. The question is why? The following explanations attempt to provide some answers to why an ES did a better job in these circumstances:

1. The ability to recognize the related information effectively.

First of all EXGAME and ADGAME know which information is related to the decision making and are able to analyze this information by using their expert knowledge and make an effective judgement on the basis of this analysis.

2. The ability to consider more factors when tackling problems.

An expert system has the ability to deal with more information and take into account more relevant factors in making a judgement than human players. An expert support system can enhance the effectiveness of a decision-maker in tasks involving a considerable amount of information processing and data manipulation.

3. The ability to store a large amount of knowledge and enable the system developer to modify and continually add to the knowledge rules.

The expert system could embody the knowledge of many experts and consolidate it all in one expert system. By modifying and adding new rules into the knowledge base of EXGAME and ADGAME many times, the expert system's performance can be continually improved.

4. The ability to make consistent decisions

EXGAME has the ability to make more consistent decisions than student decision makers. Once the rules have been put into the knowledge base, they will be executed without making mistakes and without being affected by stress or other negative factors.

Reviewing the student decisions, it seems that their decisions were not consistently made and some decisions contradicted each other or their overall policies. EXGAME and ADGAME did manage to reach their target by making consistent decisions in the light of the policies throughout the game playing without being affected by the user's behaviour during the experiment.

5. Fewer mistakes

Even the best human expert can make mistakes or may forget certain important points. Provided that the rules in an expert system are correctly formulated then it will be consistently correct. Apart from hardware failures, there is no reason why an expert system should lose information or behave oddly.

6. Conflicts solved within the system

Since EXGAME consists of six sub-ESs and takes over the general and divisional managers' jobs, the ways of solving conflicts between them are structured and represented by production rules in its knowledge base, therefore any conflicts in decision making were sorted out within the system itself and no conflicts existed between system and users. Whereas for humans, conflicts often exist among managers in different functional divisions.

7. Fast decision making

Apart from the above advantages, fast decision making is another advantage of EXGAME (this advantage does not apply to an ES for a decision support purpose). It can produce decisions very fast and save an expert's time. When playing the game, EXGAME can complete all the decision-making and input the decisions into the game system in ten minutes instead of more than one hour which was normally needed by a group of students and about 30 minutes by an expert.

One thing which needs to be mentioned is that the author did not perform as well as EXGAME in the 1991-experiment. It is believed that the absence of the advantages 2. Considering more factors in making judgement, 4. consistent decision making and 5. few mistakes mentioned above leads to the result. The author made mistakes in setting the maintenance level and was less consistent in some decisions and probably was less capable of dealing with a large amount of information and considering more factors compared with the expert system.

### 6.5.2 Knowledge base -- the difference between EXGAME and ADGAME

An interesting finding that emerged from the development of EXGAME and ADGAME is related to the differences between the functions and abilities of an ES as a decision maker and a decision making aid. EXGAME and ADGAME are different not only in terms of their user interface and the way of information input-output but also the knowledge in their KBs. The author gained this experience from the first test (1992A-experiment) of ADGAME. Since ADGAME was developed from EXGAME, at the beginning the rules of both systems were similar. When used by students in the middle of the game (from seventh period in the 1992A-experiment), because some companies were in a very bad condition and needed specific advice for guiding them out of different troubles, ADGAME's knowledge inherited from EXGAME was obviously insufficient.

ADGAME needed more skills to handle the difficult problems caused by the bad decisions students made. The author observed how ADGAME was used during the experiment and updated ADGAME's knowledge base many times as the experiment proceeded. It was realised that because EXGAME usually takes over the game company at the beginning of the game, it is only required to be able to manage the company smoothly. On the other hand, the situations ADGAME confronted were quite different from EXGAME. The users normally looked for help from ADGAME when they thought they were in trouble. The tasks an expert advisory system needs to handle are more difficult and complex. Its knowledge base contains more knowledge for "emergency" help than EXGAME does.

### 6.5.3 Other interesting points

By examining the performance of EXGAME throughout the game playing, it is seen that, to some extent, its behaviour is predictable and consistent. This is an advantage of an expert system, but on the other hand, it can also be a limitation. It shows that an ES is more suited to a relatively stable and predictable environment than a fast changing world. This suggests that an ES may lack flexibility. To improve such a system to handle the most complex cases and to work in a frequently changing environment may involve a considerable increase in the effort required in understanding the decision making in the domain and may result in a much larger system, with a much more complex representation of knowledge. To develop such high-performance systems may lead to a considerable increase in the complexity of the task and the maintenance effort, with a much greater risk of failure.

The feature that an expert system is more predictable and consistent may also provide an answer to why an experienced player aided by ADGAME performed better than EXGAME in the 1992B-experiment with EXGAME and ADGAME. The author believes that since the manager (in company F1) had learned from the ADGAME expert system (because when asked to rate the benefit that a user can gain from ADGAME in the survey, he gave the highest score to "Improve users' management skill"), he could use his knowledge more flexibly, for example, he could react to an abnormal situation and make a judgement more accurately, but EXGAME could not tackle any problems for which it had no knowledge. People can learn and change quickly, but ESs can not. This is a classic limitation of ESs at the current stage. The general question is will the users perform better after they have learned from expert systems? It is possible, because expert systems do not have the learning ability and cannot update themselves. So, in practice, when people have gained new knowledge, they need to update an ES's knowledge base frequently.

### 6.6 Summary

EXGAME is an expert system aiming to play the business game at an expert level, while ADGAME is an expert advisory system aiming to help students to play the game. Results obtained from three experiments, two of which were carried out along with students and one in a more controlled environment have been described. EXGAME was set to compete with various types of competitor: student teams without any decision making aid, student teams with the help of ADGAME, experienced individual players and individual novices with the help of ADGAME. All the results demonstrated that

EXGAME performed better in making profit, gaining competitive advantages and avoiding management mistakes than its human rivals and avoided any "end of the world" policies at the end of the game. It is believed that the advantages of EXGAME include: considering more factors in decision making, more consistent decisions made, less mistakes occurred, conflicts solved within the system and fast decision making ability.

ADGAME was tested twice: once with student teams and once with individual experienced users and novices. Both tests were assessed by analysing users' achievements and surveying their opinions. The assessment suggests that ADGAME helped its users to achieve better performance than those not using it. Other interesting findings include: 1. EXGAME performed better than the author in one experiment; 2. The predictability of an expert system may be an advantage in a predictable environment but a disadvantage in unstable conditions; 3. Expert systems performing different roles can have different knowledge even though in the same domain.

# Chapter Seven

## USERS' BEHAVIOUR AND OPINIONS ANALYSIS

This chapter presents an analysis of the students' decision making behaviour in the business game and ADGAME users' behaviour and opinions. Surveys of students' decision making behaviour in playing the business game are described and some analysis is presented. The users' opinions and behaviour towards the ADGAME expert advisory system are then discussed.

## 7.1 Investigation of Students' Decision-Making Behaviour

In the 1991 and 1992A experiments, a questionnaire was designed (see the appendix 5) and sent to students in order to examine the students' decision-making behaviour and their attitudes towards the MAS1 business game. The questionnaire was intended to investigate:

1. How students set up the company's policies;
2. How information was utilized in students' decision making;
3. How conflicts were resolved within a student team;
4. What attitudes were held towards the game system;
5. How they evaluated their performance and the role of different managers.

It was hoped that an understanding of the students' decision making process would not only lead to more insight into the role of the business game, but also help to understand the user requirement, and make ADGAME applications more successful.

<u>The first decision making behaviour survey (for the 1991-experiment)</u>

Thirty-eight of 180 students returned the questionnaire after the 1991-experiment which represents a 21% response rate. The returned forms include all the members of four student teams; two "good" teams (D4,A5) and two "bad" ones (B4,C4). Team D4 was the best in group D (no EXGAME in group D), while A5 was the second best in group A (except EXGAME). Teams B4 and C4 both had large losses.

The second decision making behaviour survey (for the 1992A-experiment)

The questionnaire was sent to students again after the 1992A-experiment. It was slightly modified from the one in the 1991-experiment. One hundred and forty five students returned the questionnaire, giving a response rate of about 85%.

The results of both surveys are analyzed using two different grouping methods. 1. Taking all respondents as a group. 2. Taking each team as a survey group.

Table 7.1 presents the results about students' decision making behaviour from both surveys. It can be seen that most teams (67% in the first survey and 71% in the second one) set their overall targets for performance at the beginning of the game and this was almost always done through the general team meeting (92% in the first survey and 90% in the second one, see again table 7.1). In response to the questions related to resolving conflicts, it seems that the degree of conflict is not severe. The conflicts were mainly (see question 7 in table 7.1) about resource allocation (e.g. money and labour) but the way of resolving them varied among "Majority vote in team meeting", "Formal discussion and find a balance between both sides", "Informal general agreement" and "By the general manager". Generally, the students in the second survey were more satisfied with their performance in the game than the first one (see question 9 in table 7.1). This backs up the general feeling that the students performed better in the 1992A-experiment which is mentioned in the last chapter.

**Table 7.1 Some survey results about the students' decision making behaviour**

| Questions | First survey | Second survey |
|---|---|---|
| 1. Did your company set overall targets for perfomance? | | |
| ___Yes, at the beginning | 67% | 71% |
| ___Yes, in the middle | 14% | 19% |
| ___Yes, towards the end | 25% | 4% |
| ___No | 0% | 12% |
| 2. How did you set the overall targets? Tick from the list below. | | |
| ___General team meeting | 92% | 90% |
| ___Face to face individually | 6% | 13% |
| ___Written message | 0% | 2% |
| ___Through the general manager | 17% | 18% |
| 3. How much did you discuss your decision making with other members of your company? (1 = very little to 5 = a lot) | 3.83 | 4.1 |
| 4. How much did you discuss your decision making with your tutor? (1 = very little to 5 = a lot) | 1.69 | 1.92 |
| 5. In what fonn did your discussions take? (tick as appropriate) | | |
| ___General team meeting | 92% | 92% |
| ___Face to face individually | 17% | 25% |
| ___Written message | 3% | 3% |
| ___Through the general manager | 14% | 18% |
| 6. Were there many conflicts between your decisions and other manager's decisions? (1 = none to 5 = many) | 2.56 | 2.12 |
| 7. What were the conflicts about? | | |
| ___Resources allocation (e.g. money and labour) | 89% | 60% |
| ___Absence of communication | 22% | 35% |
| ___Unclear about the overall policy of the company | 22% | 40% |
| 8. How did your company resolve the conflicts? | | |
| ___Majority vote in team meeting | 36% | 32% |
| ___Formal discussion and find a balance between both sides | 33% | 46% |
| ___Informal general agreement | 39% | 37% |
| ___by the general manager | 17% | 20% |
| 9. Are you satisfied with the results achieved by your company? Yes/No | 35%(Yes)<br>65%(No) | 56%(Yes)<br>44%(No) |

When analysing the survey results of different teams, the differences and similarities can be seen among teams surveyed:

1. Some answers varied among teams, but there was no obvious pattern for describing them in terms of their performance, such as "How did you set the overall targets?", "What form did your discussion with other members of your team take?", "How did you resolve the conflicts?", etc.
2. Some answers were similar in spite of the performance, such as information requirement, amount of conflict that existed, discussion with tutor and other members of the team, etc.
3. Some answers changed in terms of team's performance. The following are some examples. In the first survey, 94% of students in the good teams (D4,A5) said that they set overall targets for the performance at the beginning, but only 50% of students in bad teams (B4,C4) said so; 21% of students in bad teams answered that conflicts existed because they were unclear about the overall policy of the company, but none of the students in good teams thought so. In the second survey, in response to the question "Did your company set overall targets for performance?", 71% of respondents in the "best" teams said "Yes, at the beginning" and no one said "No", but only 58% in the worst teams said "Yes" and even 7% said "No". So, the survey indicated that setting up the target at the beginning and understanding the company's overall policy during decision making are essential to performing well. In response to the request "Rank your view how important was the general manager's contribution to the overall company's performance", the average score for the "best" teams was 4.3 (1 = least importance

to 5 = most importance) while it was 2.5 for the worst teams. Finally, their satisfaction with their performance differed among the good and bad performing teams and their attitudes towards the game systems were also different. Table 7.2 describes the results of their feelings about the game.

**Table 7.2 Results about the students' feelings with the MAS1 game (January - March 1992**

| | First survey (1991-experiment) | | | Second survey (1992A-experiment) | | |
|---|---|---|---|---|---|---|
| | All | Good teams | Bad teams | All | Best teams | Worst teams |
| Question: Did you find the game (tick up to three as you feel appropriate) | | | | | | |
| __Valuable | 22% | 9% | 41% | 27% | 38% | 7% |
| __Enjoyable | 47% | 59% | 47% | 46% | 61% | 21% |
| __Helpful | 47% | 71% | 21% | 42% | 63% | 49% |
| __Irrelevant | 14% | 7% | 19% | 24% | 8% | 29% |
| __Dull | 22% | 19% | 14% | 28% | 23% | 35% |
| __Stressful | 19% | 0% | 41% | 18% | 11% | 11% |

**7.2 Surveys About the Users' Opinions Towards ADGAME**

Along with the two experiments conducted with ADGAME, two surveys were carried out by issuing a questionnaire to ADGAME users. The intention of the surveys was to investigate:

1. The usage of ADGAME in the different stages of the game;
2. The users' perception on the usefulness of the advice generated by ADGAME both in general and in particular;
3. The users' satisfaction with the system's features;
4. The users' feelings and time spent in decision making (in second survey).

The first ADGAME survey (for the 1992A-experiment)

ADGAME was first tested in the 1992A-experiment. Although ADGAME was made available for all the twenty-five teams at the seventh period of the game, at the end only six teams had used ADGAME. A total of 45 students were included in these six teams, but not all of them used ADGAME personally (i.e. "hands-on"). At the end of the experiment, out of a total of 45 students, 35 students in the six teams returned the questionnaire (the questionnaire is attached in the appendix 5). Twelve of them actually operated ADGAME personally and others observed the procedure of using ADGAME and were involved in the discussion of the ADGAME suggestions. Some of the survey results are shown in table 7.3.

Analysing the survey result, at the end of the game, six teams had consulted ADGAME for an average of 3.5 decision periods out of a maximum of six and an average of 73% of their decisions followed the suggestions of ADGAME after their consultation (see table 7.3). The survey showed that users were broadly satisfied with ADGAME referring to its functions, user interface and the way recommendations were presented.

## Table 7.3 Some survey results (the 1992A-experiment)

### 1992A-Experiment

**1. Did your team use the advisory system ADGAME when playing the business game? 24%(Yes)/76%(No)**
**If "Yes" go to question 2.**
**If "No", could you explain the reasons please? Tick all of the following which apply.**

- 73%__a. We thought the team could perform well without using ADGAME.
- 3%__b. We don't know what an expert system is.
- 16%__c. We had no time to use it.
- 5%__d. The Access to ADGAME was not convenient.
- 0%__e. We were told it was not easy to use.
- 46%__f. We didn't think it was worth the charge for it.
- 21%__g. Others

**2. How did your team decide to use ADGAME?**

- 55%__a. Majority vote in the team meeting
- 48%__b. By the general manager
- 12%__c. According to individual interest in the team
- 3%__d. Others.

**3. Why did you decide to use ADGAME? Tick all of the following which apply.**

- 69%__a. We thought it would help make better decisions
- 46%__b. We thought it would save time
- 0%__c. We thought it would resolve disagreements
- 31%__d. We thought it would be good "value for money"
- 23%__e. We wanted to try something new
- 0%__f. We like using computers
- 8%__g. We thought we were expected to
- 54%__h. We thought we needed all the help we could get

**4. In how many periods did your team use ADGAME to help you make decisions? 3.46**

**5. Can you describe roughly what percentage of the decisions your team made followed the suggestions of ADGAME?**
**73% (0% --- did not take any decisions suggested by ADGAME, 100% --- took all decisions suggested by ADGAME)**

**6. What is your opinion about the benefit that can be gained from ADGAME? (1 = no benefit to 5 = great benefit). Tick all of the following which apply.**

- 3.58__a. Gain competitive advantage
- 3.40__b. Make efficient use of company's resources (labour, money, etc.)
- 2.96__c. Make more profit
- 2.27__d. Improve users' management skill
- 2.92__e. Make decisions quickly and save manager's time.

**7. How do you rate the benefit that each functional role obtained from ADGAME? (1 = no benefit to 5 = great benefit)**

- 3.09__a. General Manager
- 2.79__b. Production Manager
- 2.50__c. Sales Manager
- 2.54__d. Marketing Manager
- 2.59__e. Personnel Manager
- 2.66__f. R & D Manager
- 2.14__g. Financial Manager

**8. What is your general view about ADGAME as an aid for decision making? 3.18 (1 = not at all effective to 5 = very effective)**

**9. How easy was it to understand the data input questions in the data input window? 3.55 (1 = very difficult to understand to 5 = very easy to understand )**

**10. How easy was it to understand the other questions (apart from the data input questions) which ADGAME asked you to answer? 3.25 (1 = very difficult to understand to 5 = very easy to understand )**

**11. What was your opinion about the system's explanations? - were they?**

- 3.64__a. Clear (1 = not at all clear to 5 = very clear)
- 3.42__b. Helpful (1 = not at all helpful to 5 = very helpful)
- 3.00__c. The right amount (1 = too little explanation to 5 = too much explanation)

**12. Please rate the helpfulness of the different ways in which advice was presented ( 1 = not at all helpful to 5 = very helpful).**

3.83__a. Precise decisions 3.25__b. Decision ranges 3.00__c. General advice

The second ADGAME survey (for the 1992B-experiment)

ADGAME was tested again in May 1992 in a more controlled experiment (see description of experimental design in section 6.2). In this experiment the questionnaire was expanded to include more questions (see appendix 5). It includes some questions about the time spent, the usage of ADGAME at different stages of play, more choices about the benefits of ADGAME, etc. All four ADGAME users returned the questionnaire this time and the manager of team G1 who had used ADGAME in its 1992A test and tried it once in this test also returned the questionnaire. Some of the survey results are shown in table 7.4.

### 7.3 Analysis on Users' Opinions and Behaviour

Having explained the two surveys conducted, the following sections will examine the users' opinions in more detail based on three resources: the questionnaires returned, the comments students made and the author's observation of their use of ADGAME.

#### 7.3.1 User reluctance to use ADGAME

When ADGAME was first made available to 25 student teams in the middle of the game, many companies were not in a good condition; so, the author thought ADGAME would be welcomed by students and expected that most of the companies would like to ask for help from ADGAME (that is why a policy of charging for its use was announced at first, see section 6.2), but surprisingly, only six teams decided to use it. When asked to give the reasons why they were not using ADGAME, 73% of them said that "We thought the team could perform well without using ADGAME", 46% said "We didn't think it was worth the charge for it", 16% "We had no time to use it" and 21% of them mentioned other reasons such as "We didn't know it was available", "Couldn't get access to the system"; while a few people indicated other reasons listed in the questionnaire (see question 1 in table 7.3).

The responses from the students implies that people do not perceive that an expert system can provide useful advice before trying it. The main reason for such reluctance to use an expert system may be a lack of faith in its effect while it may also be true that people are reluctant to invest money for it. The satisfactory comments from users who did use ADGAME suggest that problems of interesting users in an expert system and persuading them of its benefits at the initial implementation stage is an important issue. People are unlikely to perceive the benefit of an ES until they actually use it. The system developers should realise that an ES development procedure has not been finished when the system is ready for use, they may confront other challenges from users' reluctance.

### 7.3.2 What kind of team decided to use ADGAME

As mentioned in the last section, when ADGAME was made available from the seventh period, only six teams out of twenty-five did decide to consult it. According to common sense, the worst teams should look for help from different sources more eagerly than those in a better management situation. The teams in worst positions were the most likely users of ADGAME, but by analysing the performance of the teams which intended

## Table 7.4 Some survey results (the 1992B-experiment)

### 1992B-Experiment

1. Did you play the game before? Yes/No ____**60%(Yes)/40%(No)**

If "Yes", do you think you performed better than you did before? Yes/No **100%(Yes)**

2. In how many periods did you use ADGAME to help you make decisions? ___**8**

3. Can you describe roughly what percentage of the decisions you made followed the suggestions of ADGAME in the different stages of playing the game? (0% --- did not use any decisions suggested by ADGAME, 100% --- took all decisions suggested by ADGAME)

**82**___a. During the first four periods
**78**___b. During the second four periods
**81**___c. During the last four periods

4. What is your opinion about the benefit that can be gained from ADGAME? (1 = no benefit to 5 = great benefit). Tick all of the following which apply.

**3.50**___a. Gain competitive advantage
**4.00**___b. Make efficient use of company's resources (labour, money, etc.)
**3.00**___c. Make more profit
**2.75**___d. Improve users' management skill
**3.75**___e. Make decisions quickly and save manager's time.
**4.25**___f. Make efficient use of the company's information
**3.60**___g. Help the manager to consider more factors before making decisions.
**3.80**___h. Provide more consistent advice for decision making

5. How do you rate the benefit that each department manager can obtain from ADGAME? (1 = no benefit to 5 = great benefit)

**4.0**___a. General Manager
**3.8**___b. Production Manager
**3.0**___c. Sales Manager
**3.8**___d. Marketing Manager
**3.6**___e. Personnel Manager
**3.8**___f. R & D Manager
**3.2**___g. Financial Manager

6. What is your general view about ADGAME as an aid for decision making? ___**4.2** (1 = not at all effective to 5 = very effective)

7. What is your general view about ADGAME as an aid for decision making at the different stages of playing the game? (1 = not at all effective to 5 = very effective)

**4.2**___a. At the beginning
**4.2**___b. In the middle
**3.4**___c. Towards the end

8. What was your opinion about the system's explanations? - were they?

**3.4**___a. Clear (1 = not at all clear to 5 = very clear)
**4.4**___b. Helpful (1 = not at all helpful to 5 = very helpful)
**3.6**___c. The right amount (1 = too little explanation to 5 = too much explanation)

9. Please rate the helpfulness of the different ways in which advice was presented ( 1 = not at all helpful to 5 = very helpful).

**4.2**___a. Precise decisions
**4.6**___b. Decision ranges
**3.2**___c. General advice

10. The time spent(in minutes)

**37**__ a. Average time of all players.
**57**__ c. Average time of players with the help of ADGAME
**27**__ d. Average time of experienced players with the help of ADGAME
**23**__ b. Average time of experienced players without help of ADGAME
**87**__ d. Average time of novices with the help of ADGAME

to use ADGAME at that time, it was found that not one of them was the worst team in its group, one of them was even the best, and most of them were in a fairly good status. It indicates that managers in the good teams are more anxious to seek effective advice in order to maintain the teams' competitive status, and like to get any help which is available to them (it seems a good manager will make right decisions at any time).

The problem that the worst users show more reluctance to use an expert system may cause problems in several aspects related to the ES development, validation and implementation if the use of an ES is compulsory in a real business. From the development aspect, insufficient understanding of the worst users' behaviour will result in domain incompleteness of the rule base, thus, the involvement of the worst users in the development stage is very important. From the application point of view, the problem will be how to make the different users interested in ESs as an ES's potential power will only be activated by the proper trust and use of its users.

### 7.3.3 Some comparison of two surveys

Because ADGAME was amended after the first survey, some comparisons based on its functions and benefits were made in order to see whether there is any significant difference between the two surveys.

Comparing the survey results, it seems that the average scores for measuring the system's benefit and functions in the 1992B-test are slightly higher than in the 1992A-test. In order to determine whether the results from the two surveys are significantly different, i.e., if the means of the measure in the second survey are higher than those in the first one, a statistical method, T-test, was employed using SPSS. Since the sample size in the second survey is small (5), the statistical results are only used to provide a general reference for analysis. Referring to "What is your general view about ADGAME as an aid for decision making? (1 = not at all effective to 5 = very effective), the means increased from 3.18 in the 1992A-experiment to 4.2 in the 1992B-experiment. T-test shows that at significant level 0.05, the mean of the second survey is significantly higher than the first. It suggests that the ADGAME users were generally more satisfied with the amended ADGAME in the 1992B-experiment. However, other ratings about the benefits a company can obtain and the role benefit (questions 5, 6 in table 7.1 and 4, 5 in table 7.3) from both surveys shown no significant differences by the T-test results.

Since ADGAME was updated specifically to provide better help for the companies which were in a poor position after its first trial, its improved performance was recognized by later users. In the second survey, several users pointed out that ADGAME was useful to guide the user on the right track at an early stage of the play and was good at helping the company to get out of difficult situations when the company ran into trouble (see comments in next section).

### 7.3.4 Functions of ADGAME

Here is a summary of how users see ADGAME:

1. ADGAME is most useful early on and in difficult situations:

*"The system helped to make sense of the mass of data on the reports early on, ......". "When I ran out of material as I tried to expand my market share, the system was very good at getting me out of trouble quickly."* (Comments from the manager of Company G2)".

*"To begin with, good guide to help get started. In middle - wanted pursue other aims not covered by ADGAME which lead to problems. Hence ADGAME useful at end of game to try and put right."* (Manager, Company F1)

*"Helped us reverse some poor decisions and get us on the right track."* (Sales Manager, Team C2)

*"Beginning is very helpful since not sure of what are doing, but towards end you have your own ideas of what's going on."* (Manager, Company F5).

*"We had had a hiccup in our decision making and the ADGAME sorted us out in 2 periods although I feel we could have done this ourselves."* (Sales Manager, Team A3)

The indication that ADGAME is helpful at the early stage and in difficult situations from students seems intuitively reasonable; these are the cases when assistance is most needed.

2. ADGAME as a "second opinion" to check proposed decisions:

> *"Although it was time consuming, ADGAME was particularly useful by providing support for decision already made, i.e. we would make decisions and compare them to those offered by ADGAME."* (Sales Manager, Team A2).

> *"Quite effective - added a different perspective and helped us to keep our objective - quality in mind."* (Assistant Managing Director A3).

> *"Compare to own decisions and compare tactics."* (Personnel Manager, Team A3).

Decision support is an important use of ESs. The above comments show that students are quite appreciate the effectiveness of ADGAME as a decision support tool.

3. ADGAME for helping to understand the decision making mechanism:

> *"ADGAME helped in method of explaining factors behind, e.g. pricing decisions in export market."* (Manager, Company F1).

> *"In the initial stage no one is very 'adventurous', so ADGAME isn't vital,*

*as no one is leading the market in any area yet. However, as the game progress, ADGAME helps you counter market leaders, and helps you understand and cope with greater divergence of the companies."* (Manager, Team G1).

Two ADGAME users in 1992B-experiment realized the benefit of using an ES for gaining more understanding of the decision making situations in the domain with the ES's explanation function. Their comments imply that an expert advisory system could improve the users' management skills, but from the rating they gave in the survey, only the manager in F1 thought that he gained the benefit "improve users' management skill" (rate = 4).

The followings are other comments from the students:

*"Using ADGAME we made a profit for the first time in many periods."* (Personnel Manager, Team E4).

*"It is effective, but it stops you from making your own decisions which results in you not knowing how well you could do."* (Financial Manager, Team E4).

*"The advice given by ADGAME was helpful to managers, but in order to know more about the usefulness of the decisions would have had to use it more."* (Marketing Manager, Team E4).

*"Increased competitive advantage, i.e. market niches (R&D) -- all rose to above average levels."* (R & D Manager, Team A3).

*"It takes long time to work through the information and it should be provided earlier in the game. It is useful for individual department, e.g. especially Production."* (General Manager, Team A2).

### 7.3.5 Do users feel more confident with the help of ADGAME

Do users with the help of ADGAME feel more confident in decision making than those not using it? Figures 7.1 and 7.2 display the confidence changes in each period in response to "How confident do you feel about the decisions you have made for the next period (1 = no confidence to 5 = highly confident)?" and "How confident do you feel that you can do well in the future?" in the second survey. It was thought that users with the help of expert systems would feel more secure and remain highly confident, but the statistical tests (T-test) show that the two groups of people were not significantly different. This indicates that users' confidence in making decisions may not be affected by whether they are using an expert decision making aid or not. This phenomenon may be due to the users' insufficient trust of an expert system, or possibly the users' cognitive style which may also determine their feelings, but the latter issue is beyond the research purpose of this project.

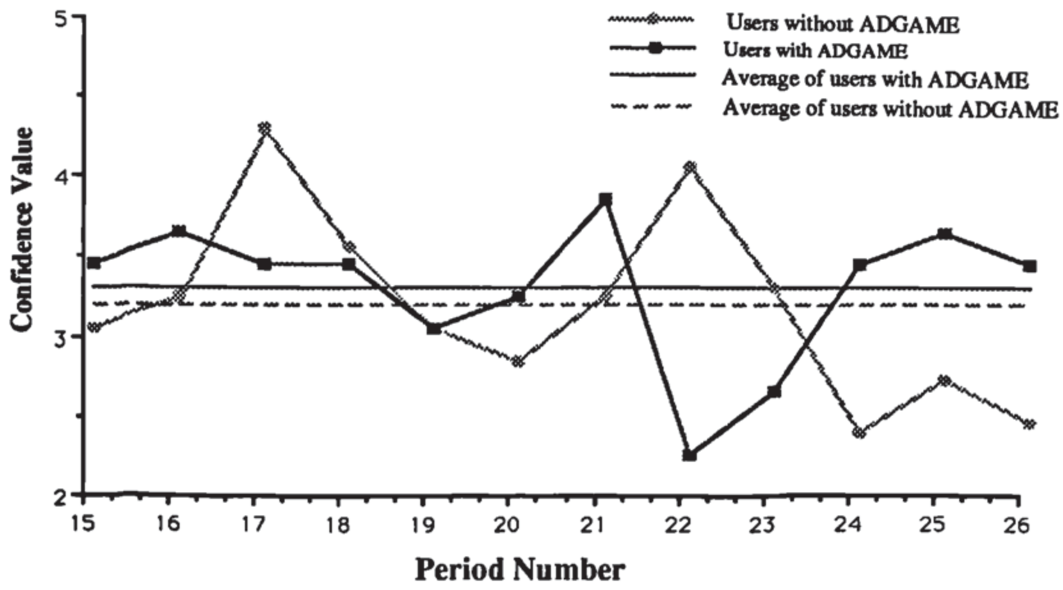



**Figure 7.1 Changes of Confidence about the Decisions Made for the Next Period**

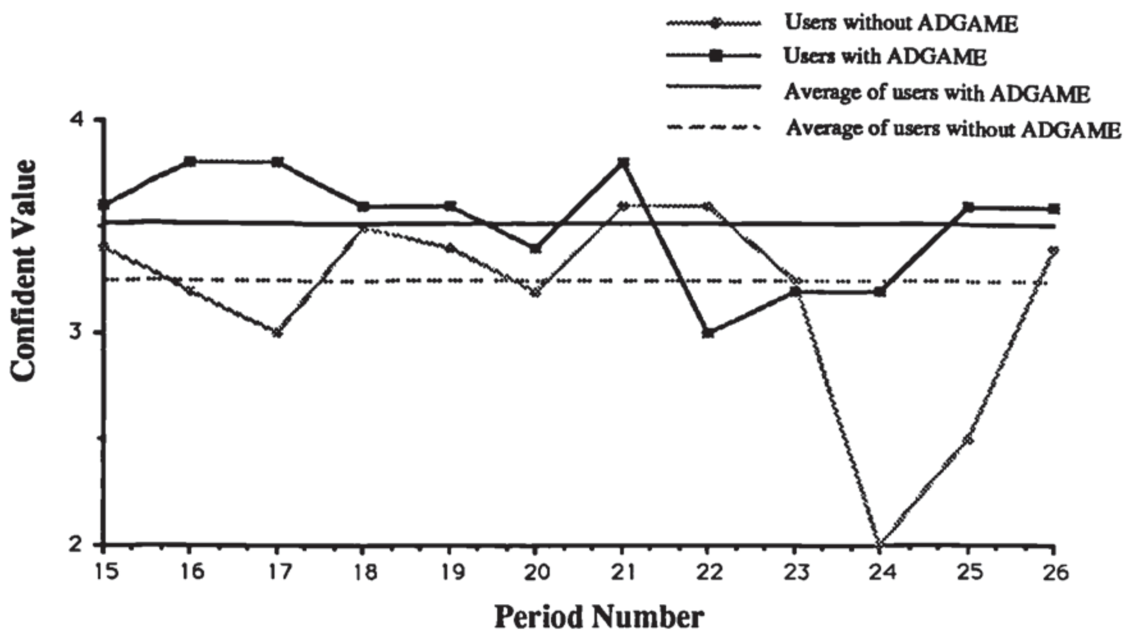



**Figure 7.2 Change of Confidence about Doing Well in the Future**

### 7.3.6 Issues associated with ESs for strategic decisions

From the comments ADGAME users made, it seemed that some of them were not very satisfied with ADGAME in view of its function to cover a wide range of strategic directions. Some users pointed out:

> *"The ADGAME was not able to advise in view of what our aim and strategy was."* (Personnel Manager, Team D4).

> *"For the one period ADGAME was used, a high profit was made, however we did not agree with the direction the system suggested"* (General Manager, Team E4).

> *"...... In middle - wanted pursue other aims not covered by ADGAME which lead to problems. ......"* (Manager, Company F1)

Two problems are implied from these comments: 1. ADGAME is not able to advise users in view of their own strategy; 2. Although ADGAME is good at guiding the users at the beginning of the game and help the users when they are in trouble, once the company is running smoothly, ADGAME is not able to encourage the users to explore other policies. To solve the first problem, more choices would have to be embedded into ADGAME, but it would be very difficult to define all the possible directions a user may like to pursue. So, it is wise to provide those which are deemed feasible and reasonable. The policies provided in ADGAME are those that the author believed that were the good ones and, in fact, worked well in the game playing.

Referring to the second problem from the users' comments and the performance analysis of an ES in section 6.4 which shown that an experienced person had achieved higher profits than EXGAME, it may be true that an expert system in the strategic level is not very flexible or good at reacting to the competitors' behaviour and adjusting its policies quickly, frequently and accurately. More discussion on the use of an ES for strategic decisions is presented later in chapter eight.

### 7.3.7 Users' perception on benefits

To the question "What is your opinion about the benefit that can be gained from ADGAME?" (1 = no benefit to 5 = great benefit), users gave the highest rating to "Gain competitive advantage" in the first survey and "Make efficient use of the company's information" in the second survey with the lowest rating given to "Improve users' management skill" in both surveys (see question 6 in table 7.3 and question 4 in table 7.4). The results of the game do indicate that users' performance had been enhanced, but that users do not perceive that their management skill can be improved by an expert advisory system. A more detailed discussion is presented in the following chapter (section 8.12).

In response to "How do you rate the benefit that each departmental manager can obtain from ADGAME?" (1 = no benefit to 5 great benefit), both surveys show that users gave the highest rating to "General Manager" (see tables 7.3 and 7.4). This may suggest that students see an expert advisory system has made the general manager's job easier because ADGAME has transferred and encoded the company's overall policy into each operational division and thus put some of the co-ordination and conflict solving tasks into the expert system. It thus gave the general manager better control of the company and also provided him/her with a complete picture of the company's management situation without talking to each divisional manager.

### 7.3.8 Does an expert advisory system save a user's time?

In replying to "Why did you decide to use ADGAME?" in the first survey, 46% of respondents said "We thought it would save time.", but by calculating the average time spent for different groups of users (see results in question 10 of table 7.4), in fact the ADGAME users (include both novices and experienced users) spent more time in decision making than those experienced users not using it (57 minutes compared to 23 minutes). The average time spent by inexperienced users with ADGAME is much more than those experienced users with ADGAME (86 minutes compared to 27 minutes). This may be due to the information input feature of the question-and-answer dialogue of ADGAME. Some of the students' comments realised this problem after they used it (see comments from General Manager and Sales Manager in Team A2 in section 7.3.4).

### 7.3.9 Will users get bored with an ES?

When users have used an ES many times, will they get bored with it? It was observed at the beginning of using ADGAME, users were very curious about it; they wrote down the important information and explanation provided on screen and paid full attention to it. But after using it for several periods, they had learned from it and became less patient with its explanations (they stopped reading them most of the time, or even jumped over some information). A user made a comment which said: "...... *but once the company was running smoothly, it was very much the same old thing." (Manager of Team G2).* Thus, in practice it is possible that once users think that they know what they are going to do (actually this means that they may have learned from an expert system although most of the users do not perceive this), they will get bored and may stop using it, or only use it when they meet difficult tasks that they have never met before.

### 7.3.10 Issues related to user interface

As described in chapter five, the advice provided by ADGAME is represented in three forms: 1. General advice; 2. Decision ranges; and 3. Precise recommended decisions. The general advice in ADGAME provides more explanations about the decision making situation and how and why to make certain decisions. It is believed that this type of advice can help users to understand the decision making mechanism and gain knowledge about the domain. It was thought that general advice would be more useful to users, as it tends to help users to develop their own knowledge, so that they can make decisions themselves without the help of ADGAME in the future. However, in response to "Please rate the helpfulness of the different ways in which advice was presented ( 1 = not at all helpful to 5 = very helpful).", both surveys gave the lowest rating to "General advice". It seems that users of an advisory system prefer "Precise decisions and Decision ranges" to "General advice". Chapter 8 will present more discussion concerning this point.

### 7.3.11 Another potential risk

Another problem experienced is a user's ability to check the recommended decisions. With some novices, if they only want to get answers from the system and have no intention of acquiring the knowledge of the domain, they will not have the ability to check the decisions suggested by an advisory system. A typical example is when the user inputs wrong information or wrongly passes on ADGAME's decisions; the wrong decision will be implemented and will cause trouble for the company. Company G4 in the 1992B-experiment is a example of this.

## 7.4 Summary

This chapter has described two types of survey: one concerned with the students' decision making behaviour in playing the game, the other with the ADGAME users' opinions and behaviour towards its use. The former survey aimed to help to gain a better understanding of the way students play the game; while the latter one attempted to gain more insight into the users' perception of the function and benefits of an expert advisory system. Most of the discussion lays particular emphasis on the ADGAME survey.

The results of the ADGAME survey suggests that ADGAME was seen as offering good advice and was easy to use. In particular, it was seen as being most useful when users were in the early stages of the game and could help users solve the difficult problems when in trouble. Users highlighted its important features of supporting and checking up functions, but were less satisfied with its function in relation to strategic directions.

The initial discussion of the EXGAME and ADGAME implementations has revealed some interesting findings related to the use of expert systems in decision making and the next chapter will draw together all the discussions from both EXGAME and ADGAME implementations.

# Chapter Eight

## DISCUSSION

This chapter summarises and discusses the various points that have been revealed in the course of this research. The chapter begins by restating the original objectives of the work and reviewing the research approach adopted, and outlining the experiments conducted and the general results obtained. It summaries the expectations of the experiments and surveys and explains whether or not these expectations are supported by the research results. Then it discusses some general issues recognized through the literature survey, the development of EXGAME and ADGAME expert systems and the experiments with them, and furthermore specific problems drawing largely upon the experiments and surveys.

## 8.1 Reviewing the Research Approach

The research work that was undertaken here revealed some insights into the use of ESs in decision making. This chapter will draw together the important issues that were identified during the course of the research and will present them formally. Before presenting these discussions, it is necessary to review some of the important background elements to the research work. The research focuses on the use of expert systems, either as a replacement of a human decision maker, or a decision making aid to humans in organizations. The overall work emphasised the application issues rather than technical problems. The original objectives of the research were stated in chapters 1 and 4. The research method and plan which were formulated and subsequently implemented to meet the objectives have also been reported in the previous chapters.

In order to reach these objectives, a framework was chosen to examine the decision making activities in an organization (see section 2.4), and then a simulated organizational environment, the MAS1 business game, was used and a game company was selected as an experimental company. The basic essence of the research approach comprised computer simulation and experimentation. The most important advantages of the research approach which have been stressed throughout the thesis is that experiments which are difficult to carry out in the real world can be undertaken, controlled and repeated more easily in a simulated environment.

The specific aims and plan based on the research method chosen were formulated and have been described in detail in chapter 4. They can be briefly restated as:

- to develop two ESs, EXGAME and ADGAME, to manage the game company, either in a replacement role or as an advisor.
- to test EXGAME against human players, and ADGAME as a decision making advisor of human players.
- to evaluate the systems' effectiveness from different aspects, and investigate the ADGAME users' opinions and behaviour.

It was realised that some application issues, such as the impact of ESs on organizations, would not be investigated by this research method.

The framework combining Anthony's (1965) and Simon's (1977) concepts for viewing the organization decision making activities helped in analysing the control and decision making process in organizations and designing the basic communication and control structure of the expert system. As the framework helps define the contents of the knowledge base and clarify the control within an organization, it is seen as an adequate framework for developing an expert system for decision making in organizations.

The overall essence of the original objectives, and the subsequent work, was that both general issues and specific problems related to the use of ESs in decision making were to be addressed; general issues such as the role of ESs, their actual effectiveness and ESs deployment within an organization; specific problems such as the linking issues of ESs in different divisions, user reaction to ESs and difficulties in ES evaluation.

A second essential characteristic of the research was the testing of an expert system in a environment which did not have irrelevant factors which may affect the real effects of expert systems. In practice, it was impossible to implement the decisions made by an ES fully and compare the results with human decisions in the same situation, because of the unrepeatable features of real life events, but within this research, it was possible to conduct this comparison, and other related comparisons more easily.

A further important feature of the research is that it emphasizes the use of a system and not its construction. The systems EXGAME and ADGAME were fully implemented, and discussions were mainly approached from the application point of view.

**8.2 Reviewing the Experiments Conducted**

The objectives were met by building expert systems that consisted of several sub-ESs, testing them and assessing their performance and users' opinions.

Two expert systems were developed: EXGAME and ADGAME. EXGAME is an expert system for playing the business game itself with little user intervention. It consists of a set of sub-ESs each responsible for different management tasks. Its development procedure is described in detail in chapter 5. ADGAME is an expert system which was designed to act as an advisor to help users to manage the simulated company. ADGAME is not a decision maker itself. It was built on the basis of EXGAME, but has more user intervention and explanations and also different information input and output methods (see first part of chapter 6).

All experiments conducted are reported in chapter 6. Briefly, EXGAME was tested three times; twice against student teams and once against individuals, including experienced and inexperienced, aided and unaided players. All companies managed by EXGAME gained an adequate competitive advantage and made more profit than all but one of the companies managed by human players. Two experiments were carried out with ADGAME: one with student teams and another with individual experienced, and inexperienced, users. Both the performance and surveys show that ADGAME did help its users perform better, and the ADGAME users were generally satisfied with its functions.

Having reviewed the research approach adopted in this work and the formulation and execution of the plan for research, the remainder of the discussion concentrates upon the experience gained and the actual research findings that emerged. As was mentioned earlier in this chapter, the research addressed both general and specific issues pertaining to the use of ESs in decision making. Firstly, the more general issues are discussed. This discussion draws from all the research sources involved, the literature review, the organization decision making analysis within the framework adopted, the construction of the expert systems, the experiments and the surveys. The essence of this general discussion is to highlight the important issues concerning the ESs' uses. The second part of the following discussion centres on more specific issues, drawing largely upon the direct experience gained from the experiments and surveys.

## 8.3 Discussion on confirming the expectations of the experiments and surveys

*Expectation 1: EXGAME would replace the game players completely in making decisions for running the game.*

As described in section 5.3.1, it was intended to replace the game players at the beginning of the research, but when actually building the system, it was found that it was difficult or impossible to achieve this task owing to the many factors that would have to be covered when designing the rules for strategic decisions, including the behaviour of competitors. The research experience showed that EXGAME is not suitable to replace a human at the strategic level, and thus this expectation is not supported by the research.

*Expectation 2: EXGAME would perform as well as the good student teams and individual players and make decisions faster than them.*

As analyzed in chapter 6, EXGAME was tested three times competing with different human players, and the results demonstrated that it did better than all the student teams and all but one of the experienced individuals aided by ADGAME. EXGAME also made decisions much faster than student teams and individuals. Therefore, this expectation is strongly supported by the experimental results.

*Expectation 3: The knowledge bases of EXGAME and ADGAME would contain the same knowledge, i.e. ADGAME could use EXGAME's KB directly in advising its users.*

This expectation was contradicted by the research experience (see section 6.5.2). It was found that EXGAME and ADGAME are different not only in terms of the systems' user interfaces but also the knowledge bases they require. The knowledge ADGAME inherited directly from EXGAME was obviously inadequate. The ADGAME knowledge base needs to cover more complex situations which the different kinds of user may face and to be able to provide a wider range of help.

*Expectation 4: ADGAME users would perform better than non-users*

ADGAME was tested twice with novices and experienced people. As analyzed in section 6.3.2, the evidence that ADGAME helped students performed better in the 1992A-test is not clear-cut, partly because those who chose to use ADGAME were not the worst users. In fact, ADGAME users did better when using ADGAME, but they were also doing better beforehand because they were not worst teams. However in the 1992B-test, there is strong evidence, albeit based on a small sample, that ADGAME made it possible for novices and less experienced people to perform much better than un-aided people and improved the performance of experienced people to that of an expert level. The recent research carried out by Oz *et al* (1993) (see section 8.12 for more details) which was only published when this thesis was nearly complete provides the same result.

*Expectation 5: ADGAME users would make their decisions quicker than non-users.*

This expectation is not supported by the research results (see section 7.3.8). On the contrary, in the survey conducted in the 1992B-test, it was found that ADGAME users spent more time to reach their decisions than non-users, although ADGAME users expected that using an expert advisory system would save time. The Oz et al (1993) research reached the same conclusion. This backs up the general belief that a decision support tool aims to enhance the effectiveness of decision making rather than its efficiency.

*Expectation 6: Most of the student teams would be willing to use ADGAME, and the worst teams would be more likely to seek help from ADGAME.*

This expectation is not supported by the research results (see sections 7.2.1 and 7.2.2). Strong user reluctance was shown when introducing ADGAME to students during the middle stage of the game play; 76% of student teams did not want to use ADGAME, even though most of them were performing badly at the time. Among the teams which used ADGAME, not one of them was the worst team in its group. This demonstrated that the worst users are less likely to use an expert system even though they can potentially gain more benefit than better users (see more discussion on this in section 8.11).

*Expectation 7: ADGAME users would perceive that ADGAME could improve their management skill.*

This expectation is not supported by the research results (see section 7.2.6). The literature survey suggests that one of the benefits of using an expert advisory system is that it improves the user's skill even though the system is not build for training purposes. It was thought that this benefit would be clearly recognized by the ADGAME users. However, the two survey results showed that users did not perceive that their management skill could be improved by using ADGAME (see section 8.12 for discussion).

*Expectation 8: ADGAME users would prefer the general advice to the specific recommendation provided by ADGAME.*

This expectation is not supported by the research results. It was assumed that users would like to learn from an expert system, and so they would prefer the general advice to the specific recommendation because the general advice is intended to help users understand the domain better. This would be consistent with the general belief that explanation is a vital part of the expert systems. However, the results of the two surveys revealed that users think that the precise decision or decision range is more useful than the general advice (see section 7.3.10 for the analysis of results and section 8.13 for more discussion).

*Expectation 9: ADGAME users would feel more confident in decision making than those non-users.*

Again, this expectation is not supported by the research results (see section 7.3.5). It was thought that people with the help of an expert advisory system should feel more confident because they were being helped by an "expert", but the statistical tests showed that the two groups of people were not significantly different. Coincidentally, Oz et al (1993) set up the same hypothesis, and found their experimental result did not support it either. The reason for this phenomenon is not quite clear, but it may be due to the users' insufficient trust of expert systems.

*Expectation 10: It would be possible to link several ESs in different divisions to work together*

This expectationis not supported by the research result. EXGAME and ADGAME consist of six sub-expert systems each one of which is responsible for different functional area. Each sub-ES is a complete expert system. They have separate databases and also share a database. Each divisional sub-ES is controlled by the top level ES. The results showed that the linked system EXGAME and ADGAME worked satisfactorily.

## 8.4 General Questions Related to ESs for Decision Making

General questions raised when considering the use of ESs in decision making can be stated as follows:

- At which organizational level? The framework adopted in this research suggests that the decision making activities in an organization can be divided into three levels, strategic, tactical and operational. The problems encountered vary from unstructured to structured between strategic and operational levels.
- With what functions? ESs can be designed for different purposes, to support or replace a human in general, and how to support or replace a human in specific.
- In what kind of working environment? An ES can be used as a stand alone system or linked to other computer systems, e.g., other expert systems or decision support systems.

These issues will be addressed in the following sections according to experience from the research work.

## 8.5 The Role of Expert Systems in Decision Making

As it has been stated in previous chapters, An ES can be developed for two purposes: in a support role, such as giving advice or helping an expert in analysing a problem, or to replace a human decision maker.

It is certain that an expert system can be a useful tool to help an organization's managers maintain, externalize and share the most important knowledge within the organization, and to manage an organization more efficiently and effectively, but in the real use of an ES there are some application issues to be considered, such as: what are the different functions of an ES at different levels, where will the ESs be most successful and how will the users treat an ES when it is available to them?

According to Beerel's (1987) description of information technology and management, she indicates in her diagram that the potential use of ESs will be in the strategic level, and part of the tactical level, but O'Leary and Turban (1987) point out that since expert systems are designed for tasks in narrow domains, the greatest use of expert systems will occur in operational control type decisions, and ESs will be used least readily in strategic planning because many tasks in strategic planning involve broad domains and many variables. Lin (1986) had the same opinion as O'Leary and Turban. He argued that routine, repetitive decisions are the best candidates for expert systems and since there are more routine, repetitive decisions at the lower levels of management, it can be predicted that many expert systems will be for operational planning and control; few systems will be designed for strategic planning which is not highly repetitive.

As mentioned in chapter 3 (section 3.3.4), surveys (Doukidis 1988, Connell and Powell 1990) show that the ES users are more typically at a low organizational level. Since a DSS is seen as a system with a focus on decision support at the higher organizational level, if an ES also can be an effective decision support tool, it should be reasonable to expect that ESs can be used in the higher level with a support purpose although in practice they have not been used widely at the higher level.

The problems encountered by top managers have a high uncertainty and are unstructured. As most firms have to face turbulent, and sometimes unpredictable markets, their managers have not only to be careful about their product-market strategy, but must also consider their internal capability in order to achieve the fit needed between the firm and its environment. It is hard to replace the top manager's job completely, because the consequences of the strategic decisions are extremely vital for the company and it is always wise to have an expert to check and control the final decisions. The ES here can act as a tool rather than as a replacement for strategic planning personnel. For example, the applications of ESs in the strategic level which are mentioned in chapter 3 (section 3.3.4) are all advisory systems. So, it is wise to use an ES as an analytical instrument, as well as a training tool in the strategic formulation process. People cannot expect an ES to act as a colleague in this level. In this research, the author attempted to let EXGAME replace the player completely, but found that it was too difficult for EXGAME to make all the strategic decisions. So, both EXGAME and ADGAME helped the player to select strategic policies for the game company instead of letting the system select them automatically.

At the tactical level, the manager's functions are mainly to formulate the sub-policies for each functional division and translate them downwards. The main difficulty existing for ES development is how to solve the conflicts among the different operational divisions and act as a communication channel. In large organizations there may be several middle managers with similar responsibilities; an ES should capture the group knowledge. There seems a need for an ES to deal with group decisions. The purpose of an ES here might be either for supporting decisions or replacing managers. For example, the tasks of acting as an information communication channel and allocating resources could be done by an expert system, but it would be more difficult to take over the task of dealing with conflicts, especially if the conflict-resolution involves a lot of negotiation.

In the business game, these conflicts are considerably reduced, first because of the small size of the company simulated, and secondly because the simulated organization has no workforce. (These conflicts are not removed completely, as anyone observing a student team in action will soon realize!). Thus, when an expert system approach is applied it is possible to replace some of the middle manager's job. The middle manager's job is structured and separated down into each division by the EXGAME and ADGAME expert systems. The survey result that the ADGAME users thought that ADGAME is most useful to the general manager suggests that users have realised this benefit of making the general manager's job easier by giving him/her more control and reducing the conflicts among divisions.

At the operating level the control can be readily broken down into specific tasks with narrow domains, so it is more suitable for the application of an ES. The results of EXGAME's game playing show that the ES can do a good job at this level, and to some extent, can replace the decision makers and work as a colleague of humans. The experience appears to support the viewpoint of O'Leary and Turban (1987) and Lin (1986) and agree with the survey results reported by Doukidis (1988), Connell and Powell (1990).


**Figure 8.1 The use of expert systems in an organization**

Therefore, EXGAME was used in a supporting role at the strategic level and in a replacement role at the operational level. The implementations of EXGAME and ADGAME suggest that ESs can be applied at any organizational level with different functions (see Figure 8.1), but will be more effective in the operational level than the strategic level. However, no matter where ESs are going to be used or what roles they will play, the most important thing is to understand fully how the experts work else ESs will not be successful.

One thing is certain, the time is not ripe for the prediction by Harmon and King (1985) that problem solving and decision making will be automated just as surely as production lines are ..., and expert systems will be the 'robots' of middle management.

### 8.6 Advantages of Using Expert Systems for Decision Making.

Benefits of ESs in organizations have been stressed by many people from different points of view. Chapter 3 has summarised these benefits which emerged from the literature review. The discussion here does not repeat these issues again, but emphasizes some understandings from the EXGAME and ADGAME implementations.

The experience with EXGAME and ADGAME shows some advantages of an ES when compared with a human decision maker:

1. An ES is able to deal with a large amount of information and take into account far more factors in making judgements.
2. An ES is able to store a large amount of knowledge and enable the system developer to modify and add to the knowledge rules continually.
3. An ES makes fewer mistakes and more consistent decisions.
4. An ES can make decisions very fast when used to replace humans for certain tasks and save an expert's time.

The results from the EXGAME and ADGAME applications demonstrated that benefits produced by using ESs in decision making can be addressed in terms of their roles, i.e. to replace or support.

When used as a replacement of a human decision maker, an expert system can perform better than a human decision maker (both novices and experienced people). It can work effectively and efficiently.

When used as a decision making aid, the experimental results with ADGAME demonstrated its ability as a helpful decision making tool for both experienced and inexperienced people. It enabled novices to perform at a level closer to that of an expert and improved the performance of experienced people to the expert level. Not surprisingly, it was felt to be most useful early on and in difficult situations, however, in two cases the users' evaluation runs counter to the performance evidence (see sections 7.3.7 and 7.3.8 for detail). First, it did not save user's time, even though many users expected it to. Second, the author believed that it could help improve users' management skill, but they were not aware that it could. This last point is an important point to be considered in the practical implementation of expert systems.

There is no doubt that an expert system can improve the decisions made by non-experts (Ansari and Modarress 1990), but it is argued here that an expert system could improve the decision making performance of experts. An expert system can sometimes perform better than even the expert who supplied the knowledge to it. The experience with EXGAME and ADGAME suggests that an expert system could act as an enhancer of expertise mainly because of the advantages discussed above. The support for this point of view came from the facts that ADGAME helped an experienced player out-perform the "expert" EXGAME and EXGAME out-performed the developer of its knowledge base.

The disadvantages experienced from the experiments include the difficulty of stopping an expert system producing misleading answers in an unfamiliar situation and the difficulty of updating the knowledge base by its users When ADGAME was used for the first time, it tended to provide inadequate advice in some extremely bad situations which were not covered by its knowledge base. An expert system tends always to produce an answer and does not know its limitations very well, thus, there is a general tendency to over-prescribe.

Another problem during ADGAME's and EXGAME's development and experiments was the learning abilities of an expert system, i e. how to give the ESs the ability to learn from implementation. This is a major weakness of current ESs and may limit their applications. One of the characteristics of human experts is their ability to update and improve their knowledge by learning from their past experience It enables human experts to be flexible in their decision making and able to apply their existing knowledge to new cases, but almost all of the ESs in practical use today do not have this ability. This means that the knowledge bases of ESs still need to be updated and frequently maintained by human experts and/or knowledge engineers.

### 8.7 Organizational Deployment of ESs

One of the original objectives of the research was to explore the issues of deploying several expert systems together as a coordinated system in an organization, since it is believed that most of the ES applications so far have been restricted to a specific aspect of an organization, not an organization-wide deployment of ESs. Here the organization-wide deployment of ESs means how several ESs, each of which is responsible for a different decision making area, can work together like human experts do. The linking issues, such as the communications and negotiations between them are the critical problems for their interconnections, but there is no discussion about this in the literature yet. The difficulty lies in how to extract knowledge from the experts about the communication and negotiation between different operational divisions and organizational levels and encode it into the knowledge base. Because the simulated company in the business game included several functional divisions, it enabled the research to address this issue by developing a small prototyping expert system which consisted of a set of ESs and conduct experiments with it. Each sub-ES is responsible for an individual division and makes decisions in its own decision domain. A sub-ES is a complete expert system, and if the user inputs the top level policies and information about other divisions' decisions into it, it can be used separately, but this is more time consuming.

The work reported provides some insight into the use of organization-wide ESs. Firstly, the success of EXGAME demonstrated that it is feasible to deploy ESs into an organization in different areas and link them to work together. Secondly, once the way of conflict-resolution can be expressed in the form of knowledge representation and encoded into the KB, the conflicts can be sorted out within the system and there will be no conflict between the user and the system. This will save time for tactical managers in communication and negotiation.

## 8.8 Information Utilization and Conflict Solving by an Expert System

From the viewpoint of decision making in organizations, before building an expert system to simulate the expert decision making process, people must analyze the way experts employ organizational information and their knowledge to reach decisions, and how the experts in different functional divisions work together to manage the whole organization. Since the game company includes nearly all the basic divisions of a manufacturing company, through the whole procedure of developing the EXGAME expert system it was possible to understand more about the expertise, expert decision making and control process within it.

The information exchange within an organization, both hierarchically and horizontally is very important for decision making. No division should set its own decisions without knowing the company's policies and what happens in other divisions. Generally, the strategic level receives internal information from the tactical level and then develops policies which are passed back to the tactical level for implementation. The tactical level clarifies the targets and allocates resources to the operational level.

Once the overall strategic policy is made by the top manager, it must be carried out within divisions. During the implementation of this strategic policy each division should make its own decision-making policies which are consistent with the strategic policy, however, many conflicts do exist between hierarchical levels and between different divisions. Hage (1980) suggested three kinds of conflict: organizational conflict (conflict between groups); role conflict (conflict between social positions); interpersonal conflict

(conflict between individuals).

In EXGAME, the reasons that cause conflict are all linked with the resources (money and labour) and target allocation. Whenever there is a conflict, the way to solve it is to see how it can be sorted out in a way that is consistent with the overall strategic policy by finding a sound balance between the two sides. As has been already discussed in section 8.3, the mechanism of conflict solving in the game company came from both consulting the expert and the author's own experience, and was structured and built into the knowledge bases of the operational expert systems.

At the operational level in EXGAME, some of the decisions to be made are strongly influenced by company policies, e.g. changing the production units, changing the number of operators or representatives, setting the price, setting advertising levels, etc. The sub-ESs in EXGAME were built to have the ability to cope with all kinds of policy built into the strategic level. Some decisions are strongly influenced by other divisions' decisions, e.g. to specify shift working, to change the number of operators and representatives, and some are not. For those decisions which depend on each other, the tactical manager acts in a mediatory role and he/she has to use organizational information and his/her own knowledge to make a satisfactory decision.

**8.9 Difficulties in ES Validation**

Experience in validating EXGAME and ADGAME revealed some general difficulties for ES validation. One problem is how to test all the rules embedded into the knowledge base. Normally there are two features that need to be tested: correctness and completeness of the rule base, but these tests are not easy to undertake in practice. For EXGAME and ADGAME, two major difficulties occurred: one was the *incompleteness* of rule base and another was the *errors* within the rules themselves, such as syntax errors, dead-end rules, conflicting rules and rule chains, missing values, etc.

The incompleteness of the rule base means that the system did not cover all the situations the system (for EXGAME) or students (for ADGAME) would confront when playing the game. It might be more precise to call this kind of incompleteness *domain incompleteness*, because it concerns whether the rule base covered all the domain problems likely to be encountered by users. For example, before the ADGAME system was put into use, it was unlikely that anyone could imagine all the situations that could be created by students' decisions and thus conceive the kind of help students would need. After the first test of ADGAME, it was found that it did not provide enough help for guiding students out of serious trouble. This was due to the system not having enough knowledge about what it should do when the game company was in an extremely bad position.

The problem of rule errors is difficult to find out manually. For EXGAME and ADGAME, not all the rules in the knowledge base had been activated during development stage, some errors were triggered during "real" implementation. This is very dangerous for real world applications where high risk is involved, because if an expert system makes serious mistakes and the end user is not able to detect them, the consequences of a wrong decision could be enormous. This is a potential danger that expert systems must avoid.

The difficulty of testing the rule base of EXGAME and ADGAME fully before being used in practice are common problems for all ES validation from the system design aspect. This kind of test can be called a logical test. It is impossible to avoid logical problems completely, but they can be reduced by designing the rules carefully and in a well organized manner and involving the logical test in the early construction and throughout the overall system development. The importance of logical testing is stressed here and the need for a formal method seems necessary.

Having presented some general discussion above, the following four sections discuss some issues related to the users' aspect.

### 8.10 User Involvement

To build an expert system that actually works, you need to have committed involvement from the users. The earlier in the cycle you get the end-user involved the better, especially if you want a useful application (LaPlane 1990).

The importance of user involvement in developing an expert system has been mentioned by some researchers (Beerel 1987, Bright 1989, Mumford and MacDonald 1989, Gupta 1991, Kloppenborg and Plath 1991) but it still needs more emphasis. The experience gained in this research has strongly emphasised the importance of user involvement during the expert system development. There was little user involvement before the first test of ADGAME because it was difficult to get undergraduate students involved at that stage. When ADGAME was used by students, some problems were revealed, such as: some explanations were not easy to understand by users; some parts needed more explanation; the system did not cover all the situations students may confront during their playing. After several trials of ADGAME, the system was amended to suit the users' requirements and the feedback from them showed they were more satisfied after the amendments had been implemented (see chapter seven). From this practice, the benefits of user involvement can be outlined as follows:

1. Quick feedback about the users' attitudes towards the system;
2. Help developers to amend the system to suit the users' requirements better;
3. Help users to build up trust and confidence in the use of the system.

So, involve the end-users as early, as often and as much as possible.

### 8.11 User Reluctance in ESs Implementation

The experience from this research shows that the introduction of expert systems into the organizations will face a certain resistance from users, especially from the worst users. User reluctance is a major obstacle to ES implementation. It is a phenomenon which must be, as the experiments indicate, treated seriously and ES implementors need to be aware of this.

As described previously (chapter 7), when ADGAME was made available to 25 student teams in the experiment, only 6 teams decided to use it, while none of them was the worst team in each group. The major reason for not choosing to consult it was that the users thought that the team could perform well without the help of ADGAME (73% of respondents said so). Another reason was that they thought it was not worth the charge for using it (with 46% of respondents), even though they did not know its functions at all (because they had not actually tried it). This may indicate two things: users were over-confident about their decision making abilities and do not have any faith in the advice provided by expert systems; users are not willing to "pay" for something when they do not know what it does.

Expert systems require considerable trust from the user. If users are required to use an ES, it will result in the lack of motivation and thus, the effectiveness of the system will be paled. The experiments in this research highlight the point that to be successful an ES implementation requires substantial time and effort in the initial stage to motivate the users and, more importantly, those users who ought to need the expert help the most. The results stand as a reference for additional work needed on this aspect.

Another problem shown in the experiments is that the developer overestimated the attraction of the system. User reluctance often comes as a surprise to the implementors who, satisfied that what they offer is great value, naively believe that users will view the system with the same attitude. In practice, such underestimate of user resistance may seriously compromise the success of an implementation project. The behaviour demonstrated by the experimental subjects is a significant indicator to the issues of user reluctance associated with ES applications. Apparently, an expert decision making aid can only have real benefit if users believe it has. Another survey result that users with the help of the expert advisory system did not feel more confident during their decision making provides an insight into another aspect of user behaviour with an expert advisory system. This latter finding contradicts the general feeling that the ES users should feel more confident during decision making because they are being helped by a "simulated expert".

## 8.12 Users' Perception of an ES for Improving Their Skill

One of the original aims of developing ADGAME was to improve users' management skill in the domain, but the survey results shown that users did not perceive this. It may be because users did not realise that the system's advice enabled them to learn better (as well as perform better) than they otherwise would. Although it was believed that ADGAME can improve users' management skills through its explanation and help facilities and the experiments have also demonstrated that the performance of novices was improved, however, it is difficult to prove that their skill was improved as well by using ADGAME.

Although the experiment conducted in this research could not prove that the ES can improve the users decision making skill, the experiments conducted by Oz et al (1993) provide a evidence that an ES can be a effective training tool, whether or not it is intended for use in a training session. They carried out an experiment which used students as a experimental subjects. The aim of their study is to measure the ES benefit in improving quality, speed and confidence in decision making. They showed that subjects who used ES improved the quality of their decisions more then did those who did not use the ES. However, the ES did not enhance the efficiency of decision making and there were no difference in confidence between users and non-users. They also showed that ES has longer term impacts, in that novice users produce higher quality decisions than non-users even when they no longer have access to the ES.

The literature survey also gives some support to the fact that ESs are effective training tools when used by novices even though they are not designed solely for training purposes. For example, in "The Expert System Opportunities Series" which describe successful applications of expert systems in UK-based industries and organizations, by describing the benefits, some cases show:

> "Improvement in the expertise of users through familiarity with the cases dealt with by TRANAID" (TRANAID - Regulation and Classification Advice in Transport Safety) (British Nuclear Fuels plc 1990, page 12).
>
> "SCAMP has proved an effective training tool, particularly in improving the knowledge and performance of new recruits to the support group" (SCAMP - Fault Recovery Management) (The Inland Revenue 1990, page 10).
>
> "VAT training given to general auditors through VATIA explanation and help facilities" (VATIA - Professional VAT Advice) (Ernst & Young 1990, page 12).

Carr (1992) point out that properly designed, a performance support system could not only support performance but develop the skills of the performers. Individuals learn from expert systems, even when learning was not part of the design.

The survey by Touche Ross (1992) indicates that because KBS/ES can explain why they have made certain judgements or decisions, they can also help people to understand problems better. Linked to this benefit is the additional use of KBS/ES as a training tool (which was mentioned by 16% of respondents)

It is possible to carry out further experiments to prove this benefit by using ADGAME in the MAS1 business game. For example, firstly to divide novices into two groups with one group using ADGAME, then to let them compete for certain periods, then to take ADGAME away and let all novices compete again for certain periods. The differences in results of the two competitions can show whether users with ADGAME have learned from it and performed better in the later competition. This work was not done with student teams because the game playing was part of their assessed coursework. It was considered unfair to those teams without the help of expert systems. It can be done, in future research, by students participating apart from their normal coursework.

## 8.13 Design of User Interface

Design of a good useful user interface is another important issue associated with an expert support system. People argue that most expert systems which have been produced have poor or inadequate user interfaces because of a lack of a good understanding of the users' behaviour and requirements (Bright 1989, Wensley 1989). The user interface is like the face of the computer system and the face which talks to the users. To design a good user interface people need to understand the user's requirement first. Without developing a clear understanding of users and the tasks which have to be performed through system use, there is likely to be a considerable gap between the designers' assumptions of the system requirements, and what is actually required by users.

In the context of human-computer interaction and user interface design, an important and allied idea is that of the user's conceptual model of the system, or *user model* in short (Bright 1989). The user interface is a sophisticated topic for system development in computer science and is well documented. Some interesting experience from the present research related to this issue follows.

Because the author attended many team meetings during the experiments and watched the decision making procedure of the students, some "first hand" knowledge about the students' decision making behaviour was gained and the common problems and difficulties for which students may need help were recognized. Therefore, when designing the user interface of ADGAME, this experience was considerably helpful. Observing how the users fulfilled the tasks was recognized as an effective way of understanding and capturing a user's requirements in order to design a prototype system and generally good user interface, but this experience is limited and the user involvement is seen as more important than observation.

One finding related to the user interface design from the survey is the way advice was presented. In response to "Please rate the helpfulness of the different ways in which advice was presented: Precise decisions; Decision ranges and General advice" (1 = not at all helpful to 5 = very helpful), users gave the lowest rating to "General advice" (see Tables 7.1 and 7.3 in chapter 7). Trying to explain the reason for this result, it was found that the preference for the way advice was presented seemed to depend on the aim of consulting the system. If the users just aim to get the exact instruction then they definitely prefer precise advice which they can use immediately. If the users' aim is not only to obtain decisions from the system but also to gain some general knowledge of the decision making process in the domain concerned, they may prefer general advice. As far as considering the survey result that users of ADGAME did not perceive that their expert advisory system could improve a user's management skill, it seems that because users did not believe that ADGAME could improve their skills, they did not intend to learn from it; therefore, their attitude towards using ADGAME was just to take the precise advice ADGAME suggested. Thus it is not surprising that they thought that general advice was not very helpful.

Although ADGAME did not have any explicit explanation facilities, the general advice could be seen as an explanation of its decision making. The result that users are not very fond of general advice provides a different opinion to the general belief of ES developers that an explanation function is important. The result suggests that if users do not perceive that ESs can improve their skill their attitudes towards an expert system will be just to get what they want from it and precise recommendation will be seen as more useful than other types of information. Therefore they would not appreciate the explanations and find they are not as useful as precise recommendations.

## 8.14 Summary

This chapter has brought together the experience gained during the research and attempted to derive from that experience a comprehensive view of the use of expert systems for decision making. The discussion concerned the following aspects:

1. The role of ESs in decision making,
2. Advantages of using ESs for decision making,
3. Organizational deployment,
4. Information utilization and conflict solving by an expert system,
5. Difficulties in ES validation,
6. User involvement,
7. User reluctance in ESs implementation,
8. Users' perception of an ES for improving their skill,
9. Design of user interface.

The next chapter will summarise all the research experience and findings obtained throughout the research work described in this thesis.

# Chapter Nine

## CONCLUSIONS

This chapter presents a final summary of the experience and findings that emanated from the research. Extension of the research findings into the real world, the limitations of the research and recommendations for further work are also indicated.

## 9.1 A Final Overview of the Research Work

The research undertaken in this thesis concerns the use of expert systems for decision making in organizations. Expert systems have spread from their traditional domains, such as diagnosis and fault-finding, and penetrated into different areas of our society. Although decision making has been seen as a complex process and difficult to simulate, the success of ESs in other applications has drawn people's attention to the use of ESs in the decision making area. Although the subject of ESs has been well documented, as far as ESs for decision making are concerned, some important issues still remain unclarified. These include:

1. The effectiveness of ESs when used in different roles: to replace a human or to advise a human.
2. The users' behaviour and opinions towards using an expert advisory system.
3. The possibility of organization-wide deployment of expert systems and the role of an ES in different organizational levels.

In order to obtain a clear insight into these issues, two expert systems EXGAME and ADGAME performing different roles in the same domain have been developed to manage a simulated manufacturing company in a competitive business game environment. As the game is played annually by students as a part of their management course, it made the competition of expert systems against human rivals possible.

The overall research work focused on the application issues, not the technical problems relating to the development of ESs. Three experiments and several surveys executed subsequently yielded some interesting results and useful experience. Since the research covered nearly all stages of an ES development from defining the task to implementing the prototype system, the experiences gained are also related to several aspects of ES development and implementation. The following section summarises the major findings and experience discussed in this thesis.

## 9.2 Research Findings and Experience

The following section groups the research findings according to the research objectives, although some findings are actually related to more than one objective.

### 9.2.1 The effectiveness of expert systems in different roles

**EXGAME can replace a human decision maker at the operational level.**

The experience suggested that EXGAME was able to replace a human at the operational level, but had difficulty at the strategic level. EXGAME therefore did not have a built-in strategic knowledge base, and the selection of the strategy was left to the human user. The fact that EXGAME performed well in all experiments indicates that when used as a replacement for a human decision maker, an expert system can do as well as a human at the operational level, but has difficulty or finds it impossible to do so at the strategic level (sections 5.3.1, 6.3.1, 6.3.2 and 8.5).

**EXGAME can perform much better than student teams and individual players and makes decisions faster than them**

The three experimental results showed that EXGAME did much better than all student teams and all but one of the experienced individuals aided by ADGAME. It also made decisions faster than student teams and individual players (sections 6.3 and 6.5.1).

**ADGAME can improve a human decision maker's performance**

The research demonstrated that ADGAME as an expert advisory system:

- Enabled novices to perform much better than unaided experienced people.
- Improved the performance of experienced people to the "expert" level.

(section 6.3.2).

**EXGAME and ADGAME needed different knowledge bases**

ADGAME is not simply an extension of EXGAME. It was found that ADGAME faced many problems which EXGAME never did. The knowledge base inherited from EXGAME was insufficient to solve all the problems students had. Thus ADGAME needed more knowledge to cover the situations users may confront and to provide "emergency" help. Thus two expert systems in the same domain needed different knowledge bases to reflect their different roles (section 6.5.2).

**ADGAME does not save a user's time**

An expert system saves an expert's time, but this research suggests it does not save a user's time when used as a decision making aid. When an ES is developed for replacing an expert, it can free an expert from some routine work and save his/her time for more creative activities. However, when it is used by end-users, many of them think that using an expert system may save their time, but in fact the ADGAME users spent more time in decision making when using ADGAME than those not using it. The result that an advisory ES does not save a user's time is also consistent with the belief that decision support systems in general aim to improve effectiveness rather than efficiency (section 7.3.8).

### 9.2.2 Users' opinions of ADGAME and their behaviour

**Users are reluctant to ADGAME**

Users, especially the worst users in the game playing, showed a strong reluctance to use an expert advisory system or to pay for its use before they actually tried it. This is mainly because they thought that they could perform well without an ES's help and also they were unwilling to "pay" for it when they were not sure of its functions. Some management problems with user involvement emerged because of user reluctance to use an expert system. One of them was how to involve the worst users. For ADGAME, most of the worst users appeared to be more reluctant to use expert systems. So, they might also be reluctant to get involved in the ES development if they were required. The use of ADGAME was voluntary, but the real world situation can be different. Real business requirements may make the use of an expert system compulsory. The worst users might be more likely to need to use an ES and derive most benefit from using it.

The reluctance of user involvement, especially the unwillingness of worst users, can also cause problems for ES validation, because an ES should cover all the problems the users may face and help them get out of difficulties caused by any bad decisions they made. Thus, it should be stressed that to involve the users is important and to involve the worst users is even more important for a useful ES, even though it appears more difficult (sections 7.3.1, 7.3.2 and 8.11).

**Users do not perceive that ADGAME can improve their management skill**

Most users do not perceive that an expert advisory system can improve their management skill although it is generally believed to be so, and one paper (Oz *et al* 1993) reports that using an ES does improve users' skill. The fact that users will get bored with an expert system (see the last point in this section) when they think that they know what it is going to do suggests that users can learn from the system although they do not realise this fact (sections 7.3.7 and 8.12).

**Users prefer the specific forms of recommendation**

The users of ADGAME prefer precise decisions or decision ranges provided by the system rather than general advice. This is because of their attitudes towards the advisory system. They did not intend to learn from the system, and thus showed less interest in the general advice. This is also noteworthy in that the general advice in ADGAME is equivalent to the explanation facility which is often cited as one of the essential parts of an expert system (sections 7.3.10 and 8.13).

**Users' confidence in decision making**

It was found that users with the help of an expert advisory system do not feel any more confident about their decisions than non-users during decision making (section 7.3.5).

**The functions of ADGAME**

From the users' comments, they saw an expert advisory system as

- Most useful early on and in difficult situations.
- Good as a "second opinion" to check proposed decisions.

(section 7.3.4).

**ADGAME advice on strategic decisions is limited**

From the comments ADGAME users made, some users were not very satisfied with ADGAME in terms of its functions to cover a wide range of strategic directions. They pointed out that ADGAME was not able to advise all users in the light of their own strategies, and once the company was running smoothly, ADGAME was not able to encourage the users to explore other policies. It was realised that it is impossible to find all the possible directions which users may wish to pursue at the strategic level as it involves too many factors with high uncertainty. The experimental results and the users' comments also indicate that an ES as an advisor at the strategic level is not very flexible at reacting to the competitors' behaviour and adjusting its policies quickly, frequently and accurately (section 7.3.6).

**Users would get bored with an ES**

User opinion and observation suggested that once users know what it is going to do, they will get bored with it and stop using it or only use it when they meet difficult tasks that they have never met before (section 7.3.9).

### 9.2.3 The possibility of organization-wide deployment of ESs and the role of an ES in different organizational levels

**It is possible to link several ESs to work together**

The research work showed that several sub-ESs had been linked together to work successfully. The result suggests that organization-wide ESs could save time for tactical managers in communication and negotiation and reduce the number of them. The organization-wide deployment of ESs is believed to be an inevitable outcome of ES application, but it is still an area which needs further investigation. The present work made an effort to tackle this issue and demonstrated its technical feasibility (section 8.7).

**The role of an ES in different organizational levels**

An ES can be used as a replacement of a human at the operational level and an advisor at the strategic level. An ES is more effective at the operational level than strategic level. The knowledge base of an ES as an advisor needs to be different from that of an ES as a human replacement (section 8.5).

### 9.2.4 Another interesting finding

**Difficulties in ES validation**

Difficulties experienced particularly in this work for ES validation were checking the correctness and completeness of the rule base. The correctness and completeness of the rule base is an important issue, but not easy to undertake in practice. To find rule errors manually before actual use is difficult. During the EXGAME and ADGAME implementations, it was impossible to activate all the rules before the system was delivered to users, so some errors were triggered during the "real world" implementation. In real world practice, this appears dangerous if the end users are not able to detect serious mistakes. The consequences of a wrong decision could be enormous when the tasks involve high risk. Automated (computer-based) checking tools are therefore highly desirable. Some ES shells, such as Xi-plus, have checking functions which can find several types rule errors before moving the system into the field testing. However, these checks can only detect logical errors (such as contradictions or unused conclusions), not the completeness of the domain knowledge. The domain incompleteness was caused by insufficient knowledge of user behaviour and demand. A better user involvement during the design stage would avoid this problem, but how to get the most demanding users involved reveals another challenge to ES developers (section 8.9).

## 9.3 Extension of the Research Findings to the Real World of Business

Moving to the real world, when implementing ESs in organizations, it is expected that they will gain an benefit of improved decision making effectiveness by using ESs either to replace low level staff or advising its staff at different levels, but they can not expect that an ES, as an advisor, will improve the efficiency of a decision maker. It would be impossible to replace strategic managers, and difficult to develop a satisfactory advisory system to help strategic staff due to the high uncertainty and complexity at this level. When used in the same domain but performing different roles, the knowledge base of an ES as an advisor needs to be different from that of an ES as a human replacement. The knowledge base of an advisor should cover the wider range of problems users may confront and provide effective help in more difficult situations, thus more effort is required in building an expert advisory system.

Considering the users' opinion and behaviour, although the research has used students as the experimental subjects, to some extent it is reasonable to assume that the students and real managers are not different in that they are all, by definition, inexperienced in the domain where the advisory system operates and their reactions to the computer aided tool should therefore be similar. So, the insight gained into the users' opinions and behaviour stands as a valuable guide for the successful ES applications in real world business. When introducing an ES, the most important lesson learned here is that the company would face a strong user reluctance. Although the worst decision makers are likely to get the most benefit from ESs, they may be the ones least likely to use them. If users are required to use an ES, it will result in the lack of motivation and thus, the effectiveness of the system will be reduced. The experiments in this research highlight the point that to be successful an ES implementation requires substantial time and effort in the initial stage to motivate the users and, more importantly, those users who ought to need the expert help the most. The user reluctance will cause problems related to the user involvement, system validation and implementation management. If managers do not perceive that they can learn from an ES advisor, they may show little interest in the explanations and general advice provided by the system.

The work on linking several ESs to work together as the organization-wide deployment of ESs is very much a preliminary effort to address this issue. The experience gained from the work is limited and more research is definitely required before moving the organization-wide ESs to real organizations.

## 9.4 Limitations of the Research and Recommendations for Future Work

Although this research has demonstrated the effectiveness of the expert system either as a replacement or as an decision advisor and provides some useful findings about the use of ESs in decision making, there are certain constraints and limitations in relation to the research method and the time allowed which need to be mentioned.

Since the research used an experimental method in a computer simulated environment, some limitations were inevitable. Firstly, it was impossible to investigate all aspects associated with the use of ESs in decision making, such as the organizational impact of ESs' applications, the delivery and maintenance of the ESs. Secondly, although the issues were examined in a "laboratory-like" environment, they were not explored thoroughly, such as the issues concerning the communication and negotiation between several independent expert systems in different organizational levels, or between different functional divisions of an organization. The experiments demonstrated the ability of a set of ESs working together, but these ESs were linked to work as one system. Although they could also work independently, they were not used separately in the experiments. Thirdly, EXGAME and ADGAME are not ready to be used in real organizations. Some issues were not fully tested because of the time limit, such as how to prove that an expert advisory system could improve the users' skills.

Future work is recommended in two ways. One is to investigate more factors related to ESs in decision making on the basis of the two ESs developed in this research and the simulated company. On the basis of the EXGAME and ADGAME systems developed in this research, further investigations can be carried out to examine more factors, such as:

- Comparing ADGAME with a human advisor by organising different experimental designs within the MAS1 business game environment,
- Analysing the users' evaluations according to their management roles or their skill levels,
- When managers in different levels and functional divisions use expert systems designed only for their own tasks, examining how managers work together to solve the conflicts and follow the suggestions of expert systems,
- Investigating whether an expert advisory system can improve a user's skill or not.

Another way would be to move the research into the "real-world" environment by using the basic structure of the ES here, but with different knowledge rules, to analyze the real world effects and the impact of human factors on ESs' applications.

Finally, the EXGAME and ADGAME systems are expert systems in a simulated environment. Although the experiments have shown the effectiveness of an expert system, many problems which are related to not only technical issues, but also to social issues need to be tackled before deploying expert systems on a large scale in real organizations. It is believed that this research has provided some useful experience and valuable insights into the successful use of expert systems for decision making.

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# APPENDIX 1

## THE MAS 1 BUSINESS GAME - 1992

### YOUR TASK

You are about to play a decision-making game in which your team manages an industrial company. You take over from a group of managers who have begun an attempt to gain a greater share of their export market. There will be time to assess the company's position and then you manage it for a game year. There will be several separate games (identified by a letter eg game A, game B etc). Six teams will compete in each game. Each team playing the game will therefore have an identity that consists of a letter indicating the game and the team number eg A5, B2 or E1. Your team identity will be used to gain access to the information held by your company and should be used to identify any document that you prepare for your company or as part of the course assessment.

At the end of the year you will be required to assess the state of the company, its prospects and give an outline in as much detail as possible of the management strategy to be adopted for the coming year. Your aim is to develop the company so that it is well placed to prosper in the future.

In this game there are only a limited range of market related decisions that you may make. In this respect it differs significantly from the Pedigree Petfoods Project of last term. The emphasis here is on making sure that the basic activities of your company are well managed. There is considerable scope for improvement as the companies that you take over are operating inefficiently. You are encouraged to take the view that there is no point in branching out into other areas until you have significantly improved current practice.

### COMPANY OUTLINE

Your company makes vehicle exhaust systems from sheet metal which is purchased as raw material. It is cut to shape, pressed/moulded to create the required form and joined along the edges to create the final product. The company rents the large machines on which most of these processes are performed. The company has enough factory space for 14 of them. At present there are 10 on hire, with lease agreements ending at various times during the coming months. Preparing material, operating the machine and finishing off requires a team of between 8 and 15 people to work effectively - too few people results in the machine not being able to work as fast as it is physically able and too large a number results in some people having little to do for much of the time. The machines could not make more than 125 units in an hour even when everything is operated at the top limit of its capability (something that it is very difficult to do for long periods).

Approximately 100 units can be made from one tonne of raw material; this figure will be lower if the work force are ill-trained or the factory supervisors do not have the required knowledge to organize the factory to be highly productive. There is a theoretical maximum of approximately 130 units/tonne that might be approached if appropriate research and development were undertaken. A potential problem you face if planning to strive for high material utilisation and a fast production process is the maintenance of quality standards. With care it should be possible to keep the scrap rate to 5% or less. If you were to devote a large amount ot time and money to process research and development you could expect to improve on this figure still further, although by the time you were below 2% or so further improvement would not be easy.

The finished product is sold to motor manufacturers as ORIGINAL EQUIPMENT (O/E) and to dealers and the public as replacement PARTS. Several companies are making the product, but each is based in a different country and has a near-monopoly in its HOME MARKET. The competition in the home market is the motor manufacturers (your customers) who could decide to make the product themselves rather than buy it in. If you lose these customers it will be hard to win them back as they will have made a substantial investment in their own production lines. They will then be able to compete in the parts market as well. Your home market is determined by your team identity number.

There is an EXPORT MARKET created by a developing assembly and distribution industry in the countries concerned. As there are no independent manufacturers of components in this market at present, all companies in a particular game compete in it. There is no brand loyalty in any market.

THE TIMING OF YOUR DECISIONS

Game time will be advanced in four week periods. The decisions you make for your company will be implemented for the full four week period, beginning at the end of the four week period in which you make the decisions. The schedule of dates and times when each game period begins and ends will be given to you separately.

As you make the decisions for your company you are always in the middle of a game period. You will be making decisions that will be implemented in the following game period. The information that is available to you is complete for all game periods prior to the one that you are in. As the current period has not ended the company does not know, for example, how many orders were received in it or how many units were made during the period. There is therefore only partial information available for the current period. This will be updated when time is advanced to the next period. You will therefore be making decisions for the next period before you know the outcome of the current period. You may find this tiresome and difficult but it reflects a significant feature of practical management.

In each period you have decisions to make in the following areas:

Production
Sales
Marketing (advertising)
Personnel
Research and Development
Finance and Accounting.

To help you start you will have a guide to the nature of the decisions, the constraints, and an indication of the things that you might consider when making the decisions. Most of the decisions will be implemented in the following period although there is a longer lead time for some. The exceptions are identified in the guide to the decisions.

## THE COMPANY MANAGEMENT INFORMATION SYSTEM

Your company has a management information system which records the results achieved by your decisions. It also collects information about the market place, which includes information describing the activities of your competitors. This information is available to you via the computer system on which it is stored, in this case the CLUSTER, and the company username and password which will be given to each team. The CLUSTER will also record and store your decisions in each game period.

You will not need great computer skill to use the system. So long as you can logon and follow simple instructions to make selections from various menus of options you will have access to everything you need.

## GAME ADMINISTRATION

The calculations that are made at the end of each period to determine how well each team has done are shared between the CLUSTER and a PC. You may enter and modify your decisions for the coming period as many times as you wish before the deadline marking the end of the current period. However once a new period has been started it is impossible to modify a decision. The reason for this is simple: the game is interactive and your decisions through the competition in the market place affect the results of the other teams. While a change may suit you, the knock on effect on others may require them to reconsider decisions already made. So there will be no retrospective changes to decisions and silly decisions will be implemented in full. Take care!
As no game or simulation of this type can fully reflect reality you should not use direct comparisons with industry as a prescriptive guide to your decision making. You may use the real world as a source of ideas but remember the only hard evidence that you have concerning the nature and behaviour of your company and its market is that which you obtain from the information system during the game. In particular, the numbers involved have been scaled down for ease of use and do not reflect the very much larger figures that may be involved in practice.

The game is concerned with principles rather than recognised facts and practices. It is not for example a vehicle for testing to see if you can produce a set of standard accounts but you should expect to use accounting principles in some of your calculations. You should also recognize that your interactions as a management team are just as important as any technical analysis that you may be able to do. If your company fails it is most likely to be due to a failure of people to communicate and negotiate effectively. Failure to use a particular method or technique hardly ever determines whether or not a company survives and prospers.

Most people do not seem to take notice of this so I will say it again. If your company fails it is most likely to be due to a failure of the people involved (and especially a lack of communication) and not the lack of a particular method or technique.

## YOUR TARGET

You are required to run your company for a year with a view to making as much profit as you can without jeopardising its performance in future years. You must produce a report describing the performance of your company and its prospects in the coming year. As well as summarising the decisions you made, you should comment on the thinking that was behind them. Your plan for the coming year should be similarly supported and include a realistic assessment of its likely success.

Overall it is more important that you understand what went wrong and how to put it right rather than being able (perhaps by chance) to make a profit. Do both and you are well away.

PRODUCTION DECISIONS

1. Specify one, two or three shift working
2. Allocate overtime
3. Production unit maintenance level (hours per period)
4. Increase or decrease the number of production units
5. Order raw material

1. Specify the number of production units to be worked on a one, two or three shift basis. Notice that you are planning how to use the machines - whether for one, two or three shifts each day and not deciding how many machines work in any one shift. Each shift gives 160 production hours per period and needs between 8 and 15 operators to work it. The total number of units on one, two and three shifts cannot exceed the number of units available. For example if you have 6 machines you could allocate them 2, 2 and 2 meaning that 2 would work one shift, 2 would work 2 shifts and 2 would work 3 shifts and you would need operators for 12 shifts/day. It would not mean that you had 2 machines on shift one and 2 on shift two and so on.

2. Allocate overtime (hours per single shift worker)
Overtime shifts may be worked by production units and operators on single shift working to provide extra production. The maximum amount of overtime that can be worked in a period is 80 hours per shift (because the operators may not work more than 80 hours overtime in a period). Enter the amount of overtime to be worked by every operator on single shift working.
(Maximum value = 80 x No of machines on single shift working)

3. Maintenance of the production units (hours per period)
The cost of maintenance is £30 an hour plus the lost production time. There is no limit to the amount of maintenance that can be carried out.

4. Increase or decrease the number of production units
You will need (at the appropriate time) to renew production unit contracts; you may lease them on a one (12 period) or two year (24 period) basis. They will not be delivered and ready for use until the second period after deciding to lease them. In order to replace a machine you must take ouf a new lease in the period before the existing lease is shown as coming to an end (as shown in the information for the current period in your company information system). You may take out a new lease for additional production units at any time.
A two year lease may be canceled (on payment of the penalty cost of £6000) at one period's notice. If there are 2 year contracts with different periods to run, those with longest to run are cancelled. A one year lease cannot be terminated.

5. Order raw material
Order the amount required (in tonnes). It will be delivered on the last day of the next period. For every 100 units made approximately 1 tonne of raw material is required.

INFORMATION IN THE PRODUCTION REPORT

1. Total production
2. Total number of scrapped (sub-standard) items
3. Raw material received in the period
4. Scheduled work hours for the period
5. Number of production hours worked in the period
6. Number of workers per machine
7. Number of production units
8. Number of units on 1 year lease
9. Number of units on 2 year lease
10. Period-end material stock

## SALES DECISIONS

1. Set the price in each market
2. Allocate sales reps to the markets
3. Define dispatch priorities for each market

### 1. Set the price in each market

You may set the price at any level you decide. It may be different in each market.

### 2. Allocate sales reps to the markets

Sales reps may be deployed at your discretion in any of the four markets.

### 3. Define dispatch priorities for each market

Should you have insufficient goods to meet the market demand, you may assign an order of importance to determine which orders take priority. Input a number for each market on a scale 1-9 (1 = high priority, 9 = low priority). You may assign equal priorities. The number you assign only influences the way the dispatchers work and except in clear cut cases will not give a numerically exact response.

## INFORMATION IN THE SALES REPORT

1. Goods supplied in each market
2. Orders received in each market
3. Payments received
4. Payments owing
5. Goods in stock at period end
6. Number of outstanding orders in each market

## MARKETING (ADVERTISING) DECISIONS

1. Set home market advertising expenditure in:
   - Generally available papers journals and magazines
   - Trade Journals
   - TV
   - Public Posters and
   - Direct Mail to the Trade
2. Set export market advertising expenditure in:
   - Generally available papers journals and magazines
   - Trade Journals
   - TV
   - Public Posters and
   - Direct Mail to the Trade

Expenditure of less than £1000 has little effect in any form and TV advertising requires a minimum of about £5000 to be effective.

## INFORMATION IN THE MARKETING REPORT

1. A delivery reputation index in each market
2. The total sum committed to marketing R & D
3. Estimates of the current size of each market

The delivery reputation index describes customers perception of the companies promptness in supplying orders. A value of 1 is good, representing supply expected within one period. Smaller values reflect delays in supply.

## PERSONNEL DECISIONS

1. Set the wage rate for machine operators
2. Set the salary of the sales reps
3. Specify training for machine operators and sales reps.
4. Increase or decrease the number of machine operators
5. Increase or decrease the number of sales reps

1. Set the wage rate for machine operators
2. Set the salary of the sales reps
3. Specify training for machine operators and sales reps.

You may adjust the rates of pay and training (hours/period) at will. Operator training hours are lost from production hours. Operator training is given to each shift (so the training hours are multiplied by the number of machines and the number of shifts on which they are worked).

4. Increase or decrease the number of machine operators

Input the planned changes (using a negative number for reductions). They will take effect in the period after next. New operators are given basic on the job training which gives them the basic skills needed to operate the machinery. No more that 50% of existing operators may be laid off at any one time.

5. Increase or decrease the number of sales reps

Input the changes as for the operators. They will be hired (or will leave) in the period after next. They will undergo training for three periods. After the first period they begin field work and make some contribution to the work of the sales force. The are fully trained the end of their third period of training.

## INFORMATION IN THE PERSONNEL REPORT

1. Total number of machine operators currently employed
2. Number of fully trained sales reps employed
3. Number of machine operators giving notice in the period
4. Number of machine operators working their period of notice
5. Number of sales reps with one or two periods of training
6. Number of sales reps in initial training
7. Number of sales reps giving notice
8. Number of sales reps in third/second/first period of notice
9. National average wage in the engineering industry
10. National average salaries for sales reps (all industries)

Machine operators work one period of notice and receive on the job training. Sales reps work three periods of notice and receive training for the first three periods of their employment. They begin to contribute to the sales effort after six weeks.

## RESEARCH AND DEVELOPMENT DECISIONS

Allocate a sum for research and development of
1. The production process
2. The product and its market appeal

### 1. Production R & D

Production R & D refers to research and study of production methods and may be directed towards

Process Speed:
Efficiency of material use
Production quality/reliability

This is best allocated in units of £1000 as £500 buys very little research/analysis time.

### 2. Marketing R & D

Marketing R & D refers to research and analysis of the product design, its suitability for customer needs, and its performance in service. Also best allocated in multiples of £1000, it may be directed towards:

Physical Strength - resistance to stones / vibration etc
Product Performance - noise suppression / emission control etc
Product Lifetime / Durability - resistance to corrosion etc

## INFORMATION IN THE RESEARCH AND DEVELOPMENT REPORT

1. Maximum production speed (units/hr) achieved
2. Best scrap rate achieved (%)
3. Best material use achieved (units/tonne)
4. Relative market position re: Performance
5. Relative market position re: Strength
6. Relative market position re: Durability

Relative market position is reported as an index:
1 is average,
less than 1 is below average and
greater than 1 is better than average.

FINANCE AND ACCOUNTING INFORMATION

There are no accounting decisions that are required by the information system each period. The role of the accounting function is to monitor the costs and profitability of the company and to influence any decision that has a financial implication. There is a summary of the financial constraints given below.

| | | |
|---|---|---|
| Production unit hire costs | 1 year contracts | = £2000/period |
| | 2 year contracts | = £1500/period |
| Cancellation costs (2 year contracts only) | | = £6000 |
| Production unit maintenance costs | | = £30/hr/unit |
| Basic shift duration | | = 160 hrs |
| Basic rate of pay (single shift) | = basic | = your decision |
| | Overtime rate | = £ basic x 1.5 |
| | Shift working rate | = £ basic x 1.5 |
| Sales reps overheads (car, equipment etc) | | = £1000/period |
| Starting costs (paid in period of starting) | | |
| | - operators | = £750 |
| | - sales reps | = £2500 |
| Termination costs for those laid off | | |
| | - operators | = £2750 |
| | - salesmen | = £5500 |

These are made with final payment of wage or salary

| | | |
|---|---|---|
| Cost of raw material | | = £300/tonne |
| Interest rate charged on -ve cash balance | | = 1% /period |
| Overhead costs | - fixed | = £10000/period |
| | - variable/production unit | = £ 2500/period |
| | - export overhead costs | = £0.35/item exported |

The information available for the finance and accounting function is a summary of the bank transactions for the period.

1. Bank deposits
2. Overhead payments
3. Production unit rentals
4. Cost of lease cancellations
5. Maintenance payments
6. Cost of raw materials
7. Operators wages
8. Salaries of sales reps
9. Recruitment costs
10. Redundancy payments
11. Advertising costs
12. Market development R & D
13. Production process R & D
14. Export overheads
15. Interest charges
16. Bank balance

A SHORT GUIDE TO DECISION MAKING IN THE MAS 1 MANAGEMENT GAME

## PRODUCTION DECISIONS

1. Specify one, two or three shift working

   Remember that you decide how to operate the machines -you allocate them to be worked on a one, two or three shift basis. A machine on a one shift routine cannot also be working a two or three shift routine - although there will be times when the different machine work at the same time. Remember too that you need an additional set of workers for each shift.

2. Allocate overtime

   Your freedom to decide here is limited by the resources available to you - the people and the machines. Your overall aim is to make the best use of the resources available while meeting the production target that your company has agreed on.

3. Production unit maintenance level (hours per period)

   You balance the direct cost and loss of production time against the improvement in the production process that may result.

4. Increase or decrease the number of production units

   You may need simply to renew the lease agreements in order to maintain the status quo or you may make adustments up or down to match your future production capacity to anticipated demand or to meet future targets that the company has set.

5. Order raw material

   You will wish to minimise your holding of raw material stock (to keep your costs down) but you will want to avoid limiting your production by running out of material before the next delivery.

## SALES DECISIONS

1. Set the price in each market

   You will want to ensure that the price covers the cost and to maximise the gain for the company. However the competition and the value for money perception of your customers must be taken into account.

2. Allocate sales reps to the markets

   You will wish to deploy your reps where they are most effective. How you interpret this depends on the aims of your company. You may be aiming to make the most of a buoyant market or you may be trying to be the first into an as yet undeveloped market.

3. Define dispatch priorities for each market

   This will only be important if you have difficulty producing enough to satisfy the orders you receive. If this is the case you may wish to protect your reputation in a particular market or to avoid nullifying the effect of an earlier marketing effort.

## MARKETING (ADVERTISING) DECISIONS

1. Set home market advertising expenditure
2. Set export market advertising expenditure

   You will make these decisions on the basis of the extent to which you wish to stimulate demand and of the choice of market and advertising medium that satisfies that requirement.

## PERSONNEL DECISIONS

1. Set the wage rate for machine operators
2. Set the salary of the sales reps

   The wage rate / salary will determine your ability to attract and retain reliable workers and reps. In general you will wish to avoid a high rates as this will affect your competitiveness but you will recognize the need to pay the rate for the job, especially if you want good performance. You will be guided by the National figures in making your assessment.

3. Specify training for machine operators and sales reps.

   You will expect to get better performance from your workforce if you train them. There is however a limit to the improvements that can be made. You will need to monitor the effects of any training given to ensure it is money and time well spent.

4. Increase or decrease the number of machine operators
5. Increase or decrease the number of sales reps

   These decisions will be based on the production plan for the future and the number of machines/shifts that you intend to operate.

## RESEARCH AND DEVELOPMENT DECISIONS

1. R & D - production process

   If training and maintenance is not enough to gain a competitive edge in the market place you may plan to develop the manufacturing process so that your potential productivity is greater. Analysis of your operations may indicate whether to attempt to improve on all fronts or whether to be selective.

2. R & D - product development and its market appeal

   As the competition is likely to improve its product you may be obliged to do so simply to stay in business. Analysis of qualities of the competition relative to your product may suggest the best area in which to make the development.

## FINANCE AND ACCOUNTING DECISIONS

The decisions in this area involve and relate to many of the above areas of decision making. You will need to monitor costs and the overall profitability of the company and to alert and negotiate with other parts of the company to ensure that decisions are compatible and contribute to company viability (now and in the future). You will be as concerned to reduce costs as you will be to maximize income generated from sales. However, there will be constraints and interests to be balanced such as the need to invest for future benefits and the making of adjustments to adapt to market conditions.

THE MAS 1 BUSINESS GAME - 1992

## INSTRUCTIONS FOR USING THE COMPANY INFORMATION SYSTEM

Logon to the CLUSTER (eg KIRK) and at the $ prompt type GAME and <return>. Respond to the request TEAM PASSWORD = ? by typing your company password.

The system will then check your response and if it is accepted will display an initial message. At the start this will be a simple welcome message but later on there could be important information as well. You should always check before pressing <return> as instructed.

The system will then make some additional checks on the consistency of your company information, summarise the current status and provide a menu of options as illustrated below. In all the examples below it is assumed that the current period is Period 8. Your screen will look like this:

```
.----------------------------------------------------------------------.
| CURRENT PERIOD NUMBER IS 8                                           |
| RESULTS ARE AVAILABLE FOR PERIODS 1 TO 7                             |
| DECISIONS FOR PERIOD 9 ARE REQUIRED                                  |
| ------------------------------------------                           |
|                                                                      |
| SELECT AN OPTION  (TYPE A NUMBER BETWEEN 1 AND 6 )                   |
|                                                                      |
|  1   VIEW COMPANY RESULTS FOR A SELECTED PERIOD                      |
|  2   VIEW MARKET INFORMATION FOR A SELECTED PERIOD                   |
|  3   VIEW STATUS AT THE START OF THE CURRENT PERIOD                  |
|  4   VIEW A SUMMARY OF THE LAST SIX PERIODS                          |
|  5   MAKE DECISIONS                                                  |
|  6   FINISH                                                          |
|                                                                      |
| SELECTION IS .............. ?                                        |
'----------------------------------------------------------------------'
```

Type a number to indicate your choice. If your selection could refer to information for a number of periods you will be asked to identify the period that you are interested in as shown below:

```
.----------------------------------------------------------------------.
| TYPE <RETURN> TO SELECT PERIOD NUMBER 7                              |
| OR A NUMBER BETWEEN 1 AND 7  ?                                       |
'----------------------------------------------------------------------'
```

You will then be given a second, more specific, menu of options that describe particular sets of information. Type another number to identify the information you wish to see. Each display of information will have a heading as a reminder of your selection. The second menus identify the specific information that you wish to view and are therefore very similar for each of the choices in the main menu. As an example if you type 1 at the main menu you will see the following second menu:

```
 TEAM F4 ----- VIEW COMPANY RESULTS FOR A SELECTED PERIOD

 PERIOD 7 ...... THE OPTIONS AVAILABLE

      1     PRODUCTION DECISIONS
      2     SALES DECISIONS
      3     MARKETING DECISIONS
      4     PERSONNEL DECISIONS
      5     RESEARCH AND DEVELOPMENT DECISIONS
      6     PRODUCTION REPORT
      7     SALES REPORT
      8     MARKETING REPORT
      9     PERSONNEL REPORT
      10    RESEARCH AND DEVELOPMENT REPORT
      11    SUMMARY OF BANK STATEMENT
      12    FINISH

 TYPE A NUMBER BETWEEN 1 AND 12  . . . ?
```

By typing a number between 1 and 11 you will be able to see the chosen information.

The format of the information displayed varies according to your choice from the main menu. An outline of the different types of display is given below.

---

1 VIEW COMPANY RESULTS FOR A SELECTED PERIOD

This display shows the decisions that were implemented in the selected period and the results that followed.

```
 TEAM F4 ----- INFORMATION AT THE END OF PERIOD  7

 PRODUCTION DECISIONS

      UNITS ON  ONE  SHIFT WORKING        10
      UNITS ON  TWO  SHIFT WORKING         0
      ...   etc  ...

                                         TYPE <RETURN> TO CONTINUE?
```

---

2 VIEW MARKET INFORMATION FOR A SELECTED PERIOD

Information related to your competitors is shown. The information available is a subset of the information that you have for your own company.

```
 TEAM F4 ----- INFORMATION AT THE END OF PERIOD  7

 SALES DECISIONS

 COMPETING COMPANY NO        1         2         3         4         5
 PRICE HOME -   O/E      21.00     21.00     21.00     21.00     21.00
             - PARTS     22.00     22.00     22.00     22.00     22.00
  ...   etc  ...

                                         TYPE <RETURN> TO CONTINUE?
```

3 VIEW STATUS AT THE START OF THE CURRENT PERIOD

This display shows the information that is known at the start of the current period. It does not contain any information that reflects activities or performance in the current period. Some of the figures shown may be updated at the end of the period. It is then the new value which is available through option 1 or 4 in the later periods.

```
.------------------------------------------------------------------------.
| TEAM F4 ----- INFORMATION AT THE MIDDLE OF PERIOD  8                   |
|                                                                        |
| PRODUCTION DECISIONS                                                   |
|                                                                        |
|   UNITS ON 1 SHIFT         10                                          |
|            2 SHIFT          0                                          |
|     ...   etc  ...                                                     |
|                                                                        |
|                                      TYPE <RETURN> TO CONTINUE?        |
'------------------------------------------------------------------------'
```

Option 3 is the only option that allows you to check up on the periods when the leases for the production units will come to an end. That particular display shows the number of leases that will finish at the end of the current period and at the end of the next 11 periods in the case of one years leases and the next 23 periods in the case of two year leases.

```
.------------------------------------------------------------------------.
| TEAM F4 ----- INFORMATION AT THE MIDDLE OF PERIOD  8                   |
|                                                                        |
| SCHEDULE OF LEASE ENDS                                                 |
|                                                                        |
| ONE YEAR LEASE ENDS                                                    |
|  2  0  0  1  0  0  0  0  0  5  0  0                                    |
| TWO YEAR LEASE ENDS                                                    |
|  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  2  0  0  0000  0  0      |
|                                                                        |
|                                      TYPE <RETURN> TO CONTINUE?        |
'------------------------------------------------------------------------'
```

The display above shows that in the case of one year leases, two production units will be given up at the end of the current period (period 8), one more will be given up at the end of period 11 and 5 will be given up at the end of period 17. Two two year leases will finish at the end of period 23.

===========================================================================

4 VIEW A SUMMARY OF THE LAST SIX PERIODS

This option displays the same information as option 1. It differs from option 1 by collecting information for the last six periods and displaying it as a historical record. The period to which any column relates is shown in the first row of each display.

```
.------------------------------------------------------------------------.
| TEAM F4 ----- INFORMATION AT THE END OF PERIOD  7                      |
|                                                                        |
| PRODUCTION DECISIONS                                                   |
|                                                                        |
|          PERIOD        2         3         4         5        6      7 |
| UNITS ON 1 SHIFT      10        10        10        10       10     10 |
| UNITS ON 2 SHIFT       0         0         0         0        0      0 |
|  ...   etc  ...                                                        |
|                                                                        |
|                                      TYPE <RETURN> TO CONTINUE?        |
'------------------------------------------------------------------------'
```

5 MAKE DECISIONS

The Decision making option has a form of its own. It displays the value of the decision that is currently being implemented and the value that will be implemented in the next period unless you change it. If you wish to change it then type in a new value at the question mark otherwise type <return> and no change will be made. When you have passed the last question mark on the screen the display will be updated and the question marks will disappear. You then type <return> to move on just as you would with any other display.

```
.-------------------------------------------------------------------------.
| TEAM F4                                 DECISION ENTRY FOR PERIOD 9     |
|                                                                         |
| PRODUCTION DECISIONS                                                    |
|                                                                         |
| UNITS ON 1 SHIFT        10          10                  ?               |
|          2 SHIFT         0          0                   ?               |
|             :                                                           |
| MATERIAL ORDERED       100          100                 ?               |
|                                                                         |
|                                         TYPE <RETURN> TO CONTINUE?      |
'-------------------------------------------------------------------------'
```

---

You move on from each display by typing <return> as requested. When you are finished with any one of the menus you are given the opportunity to make a print file of the information you have just been looking at. You type a name for the file that you wish the information stored in otherwise a <return> will take you back to the main menu. The filename should be at least three characters long.

```
.-------------------------------------------------------------------------.
| IF YOU WANT A PRINT FILE OF THE LAST SET OF INFORMATION THEN            |
| TYPE THE NAME OF THE FILE THAT YOU WANT IT IN ---- OTHERWISE            |
| TYPE <RETURN> .................... ?                                    |
'-------------------------------------------------------------------------'
```

---

You leave the information system by typing 6 (or a <return> only) at the main menu.

---

DECISION SHEET FOR COMPANY ___ MADE IN PERIOD ___ FOR IMPLEMENTATION PERIOD ___

| PRODUCTION DECISIONS | | PERSONNEL DECISIONS | |
|---|---|---|---|
| UNITS ON ONE SHIFT WORKING | _______ | HOURLY WAGE RATE FOR OPERATORS | _______ |
| UNITS ON TWO SHIFT WORKING | _______ | MONTHLY SALARY FOR SALES REPS | _______ |
| UNITS ON THREE SHIFT WORKING | _______ | HOURS OF TRAINING FOR OPERATORS | _______ |
| HOURS OF OVERTIME PER UNIT | _______ | HOURS OF TRAINING FOR SALES REPS | _______ |
| TOTAL HOURS OF MAINTENANCE | _______ | CHANGE IN NO OF OPERATORS + or - | _______ |
| NEW UNITS (1 YEAR LEASE) | _______ | CHANGE IN NO OF SALES REPS + or - | _______ |
| NEW UNITS (2 YEAR LEASE) | _______ | | |
| lEASE TERMINATIONS (2 YR ONLY) | _______ | | |
| RAW MATERIAL ORDERED | _______ | | |

| SALES DECISIONS | | RESEARCH AND DEVELOPMENT DECISIONS | |
|---|---|---|---|
| PRICES IN - HOME MKT - O/E | _______ | R & D RE - PROCESS SPEED | _______ |
| PRICES IN - HOME MKT - PARTS | _______ | R & D RE - MATERIAL USE | _______ |
| PRICES IN - EXPORT MKT - O/E | _______ | R & D RE - QUALITY CONTROL | _______ |
| PRICES IN - EXPORT MKT - PARTS | _______ | R & D RE - STRENGTH | _______ |
| SALES REPS - HOME MKT - O/E | _______ | R & D RE - PERFORMANCE | _______ |
| SALES REPS - HOME MKT - PARTS | _______ | R & D RE - DURABILITY | _______ |
| SALES REPS - EXPORT MKT - O/E | _______ | | |
| SALES REPS - EXPORT MKT -PARTS | _______ | | |
| DISPATCH PRIORITY HOME O/E | _______ | | |
| DISPATCH PRIORITY HOME PARTS | _______ | | |
| DISPATCH PRIORITY EXPORT O/E | _______ | | |
| DISPATCH PRIORITY EXPORT PART | _______ | | |

| MARKETING DECISIONS | | NOTES AS REMINDERS FOR THE DECISION MAKERS: |
|---|---|---|
| ADS IN HOME PAPERS AND MAGAZINES | _______ | |
| ADS IN HOME TRADE JOURNALS | _______ | 1. |
| ADS ON HOME TV | _______ | |
| HOME PUBLIC DISPLAY POSTERS | _______ | 2. |
| MAIL ADS TO THE HOME TRADE | _______ | |
| ADS - OVERSEAS PAPERS & MAGAZINES | _______ | 3. |
| ADS IN OVRSEAS TRADE JOURNALS | _______ | |
| ADS ON OVERSEAS TV | _______ | 4. |
| OVRSEAS PUBLIC DISPLAY POSTERS | _______ | |
| MAIL ADS TO THE OVERSEAS TRADE | _______ | 5. |

# APPENDIX 2

## The Knowledge For Decision Making Within EXGAME

The following sections describes in detail the decision making methods which have been embedded in EXGAME at the operational level.

### 1. Production decisions

For production decisions, EXGAME needs to:

1. Specify one, two or three shift working
2. Allocate overtime
3. Production unit maintenance level(hours per period)
4. Increase or decrease the number of production units
5. Order raw material

The system is usually set for one shift working because if two or three shift working is adopted, operators' wages will be increased by 50%. Normally this is not worthwhile, but there is an exception when the demand grows dramatically and the company needs to produce more products as soon as possible. When the demand increases quickly, the policies to extend the production capability in EXGAME are: firstly, to increase the overtime, if the overtime limit per period is reached, without meeting the demand, then to increase the numbers of machine units one by one (the limit of machine units is 14 for each company). The new machine units should be on two year contract hire because it is cheaper than one year.

Although the production decisions are made according to customers' demands, decisions to make more products should be appropriately made at the same time when the marketing or sales division are making an effort to increase the customers' orders. Otherwise if the company only enhances production capability when a large number of orders are received, it will be too late and the company will lose the market because of the delay in product delivery. Allocating overtime or hiring new production units mainly depends on the expected orders in the period. If there is a large increase in demand, then unmet orders may exist. If the company can not satisfy the demand except by overtime, it may consider to hire new machines. A change in the number of machines usually is decided very carefully, because once you hire a machine you can not cancel a one year lease and the cancellation cost of a two year lease is quite high.

The company rarely cancels a lease, but may attempt to extend the market. If it is necessary to reduce the machine units, the best way may be to stop replacing production units.

The policy of setting maintenance here is to maintain the longer work hours of a machine by keeping to a higher maintenance level. The choice of the exact maintenance hours in a period comes from the manager's knowledge. Usually it is set to be an hour per unit.

Ordering raw material depends on the production capability not the demand. Since in some periods, especially the early periods, the demand is lower than the later periods, but potential demand in the next few periods may be high and production may need to produce more goods in advance, so the company may required to provide enough raw material in advance. The company would try to avoid limiting the production due to a shortage of material in any given time. There may be also a small amount of surplus stock of raw material.

**2. Sales decisions**

In the sales division, the decision need to be made includes:

1. Set the price in each market
2. Allocate sales reps to the markets
3. Define the dispatch priorities for each market

According to the manager's knowledge, the price for the home market will remain stable because the home market is very sensitive to price changes. Once the company loses the home market, it will be hard to win it back because customers could make the product themselves rather than buy it in. So, the prices for the home market stay mainly at the same level and may increase a little at a later period or when the product costs increase greatly. Because the company has a near-monopoly in its home market, normally the company does not need to consider reducing its price.

Setting the prices for the export market takes into account not only the cost, the profit and the last period price, but also the competition. Usually the company takes the average price of its competitors, but if the company has a large market share and it does not mind losing some customers, or the loss of some market share can be covered by an increased price, then the company may consider raising the price a small amount each time. The price of parts (PARTS) will always be a little higher than the price of original equipment (O/E) according to the common knowledge about price setting.

Allocation of sales reps to each market depends on the company's market policy and the number of reps available at a given time. From the manager's experience, the home market is not sensitive about the number of reps, usually one rep can work effectively. So, the rest of the sales reps should be allocated to the export market, mainly in the O/E market.

Defining the dispatch priorities for each market takes into account the company's marketing policy and the sensitivity to delivery of each market. From the author's experience, the home O/E market should be given first consideration, then the export O/E market and finally the parts market. Of course, the priorities only apply when the company has difficulty in producing enough to satisfy the orders received.

**3. Marketing(advertising) Decisions**

The decisions to be made in the marketing division are:

1. Set home market advertising expenditure in:

Generally available papers, journals and magazines

Trade Journals

TV

Public Posters

Direct Mail to the Trade

2. Set export market advertising expenditure in:

Generally available papers, journals and magazines

Trade Journals

TV

Public Posters

Direct Mail to the Trade

These decisions are made on the basis of the company's strategic policy, the financial situation and the maximum production capability. The demand in the home market has a limit and there needs to be a cost-effective analysis between the advertising expenditure and the orders which can be gained. The manager needs to compare the orders he/she has with the maximum demand and set the expenditure for advertising; it is usually between £1000 to £2000 in EXGAME. This amount of money will stay mainly at a fixed level. Because the export market has a high potential demand and advertising is an effective tool to stimulate the demand, the company need to try its best to win this market. Normally, at the beginning of the whole running period, the company managed by EXGAME will input a high investment in this market, such as £5000 or more, and increase it gradually later.

Normally the company's manager decides in which way to put the advertisement by his/her previous knowledge. EXGAME allocates its money mainly to papers, journals and magazines in the home market and papers, journals, magazines and direct mail to the trade in the export market. The finance division will limit the sum of marketing expenditure when the company runs into a very bad financial situation.

### 4. Personnel decisions

Decision making in the personnel division includes:

1. Set the wage rate for machine operators
2. Set salary of sales reps
3. Specify training for machine operators and sales reps
4. Increase or decrease the number of machine operators
5. Increase or decrease the number of sales reps

EXGAME will set the wage and salary levels higher than the national average and will raise them gradually in order to attract and retain reliable workers and reps. It adopts a high payment policy, because once the operators or the reps leave the company, it will cost a lot to train new operators and reps. Also, the company may adjust the payment when the number of employees leaving grows too quickly.

The training hours of operators will affect the production rate and the scrap rate. The monitoring of the training hours is based on the margin between the production rate achieved and the maximum potential production rate indicated by the R & D division. The training of reps will affect partly the orders received, so its change is decided in terms of the difference between the orders received and the orders expected. Of course, there are the basic training hours for workers and reps which are determined by the manager's experience. All the monitoring of the training is on the basis of these basic values, however there is a limit to the improvement that can be made. EXGAME does some calculation to ensure that all the changes result in time and money being well spent.

In general, EXGAME does not dismiss staff, especially at the beginning of the running period. If the company plans to reduce the number of workers, the best way is not to recruit when some workers leave. The number of workers on each machine unit mainly affects the production rate and too many workers or too few will cause production rate being reduced, as a result there is an optimum number of workers per unit and if this number is not maintained the production rate will go down. Any increase in the operators should take into account the future production plan, the total numbers of operators at present and the most efficient number of them per unit. Usually the student teams have too many operators in their company. In EXGAME, when the company hires new machine units or some workers give leaving notice, the decision at first is not simply to add new workers, but to check the current number of workers per unit and then determine how many new workers will be employed or even no recruitment in order to reach more efficient production rates. The change of reps is decided by the sales division.

**4. Research and Development decisions**

The decision in the R&D division is to
Allocate a sum for research and development of

1. The production process
2. The product and its market appeal

In the game, the effort the company gives to improving the production process is to make the company's potential productivity greater but not the real productivity. If the company's real index in production process, i.e. real values of process speed, material use rate, scrap rate, are close to the potential value indicated by R & D, then an increase of expenditure in R & D is necessary. Alternatively, if the differences between the real index in the production process and the potential index are big, then an improvement in training and maintenance in production division and extending R & D expenditure is unnecessary.

The company's product quality policy determines the product market position. Information systems provide the current relative market positions of products. Generally, EXGAME sets the company's product quality in an average position. Any change of the money input is controlled by the margin of the real position and the ideal market position. However, the finance also controls the total sum of money available in this division.

## APPENDIX 3

### The 1991-experiment (January - March 1991)

**Table 1 The summary of company results in group A at the end of the game (1991)**

| | Team A1 | Team A2 | Team A3 | Team A4* | Team A5 | Team A6 |
|---|---|---|---|---|---|---|
| Production | 14229 | 12483 | 12239 | 11322 | 21829 | 17482 |
| Number of Production units | 12 | 9 | 10 | 10 | 14 | 14 |
| Raw Material In Stock | 46 | 389 | 14 | 62 | 246 | 18 |
| Average Price in Home Market | 22.25 | 23.75 | 22.5 | 22.55 | 22.5 | 25 |
| Average Price in Export Market | 23.25 | 23.75 | 23 | 22.78 | 23.125 | 23 |
| Orders From Home Market | 4833 | 3518 | 6254 | 6882 | 7193 | 3197 |
| Orders From Export Market | 5702 | 4786 | 4011 | 5485 | 6303 | 6238 |
| Finished Goods In Stock | 36915 | 12115 | 11801 | 9504 | 13395 | 58552 |
| Total Unmet Orders | 0 | 0 | 0 | 0 | 0 | 0 |
| Number of Employed Operators | 149 | 118 | 128 | 146 | 184 | 210 |
| Operators Going to Leave | 9 | 16 | 9 | 5 | 22 | 31 |
| Total Reps Employed | 6 | 6 | 6 | 4 | 7 | 5 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.81 | 11.46 | 10.19 | 9.77 | 10.23 | 10.44 |
| Best Scrap Rate Achieved | 5.75 | 7.31 | 8.01 | 6.97 | 8.59 | 7.16 |
| Maximum Units Per Ton Of Material | 104.4 | 100.87 | 100.29 | 98 | 98.27 | 100.41 |
| Market Niche - Strength | 1.236 | 0.783 | 0.81 | 0.672 | 0.996 | 1.09 |
| Market Niche - Performance | 1.194 | 0.786 | 0.642 | 0.935 | 0.917 | 1.079 |
| Market Niche - Durability | 1.193 | 0.773 | 0.666 | 0.924 | 0.945 | 1.013 |
| Market R & D | 27000 | 16500 | 3000 | 18700 | 30000 | 21000 |
| Production R & D | 12000 | 14000 | 12000 | 13500 | 12000 | 21000 |
| Bank Balance | -462414 | -462023 | 67521 | 250710 | 18184 | -1000000 |
| | | | | | | |
| Total Profit | -560016 | -562538 | -28557 | 212329 | -83442 | -1107695 |
| Average Profit per period | -46668 | -46878 | -2380 | 17694 | -6954 | -92308 |

* ---- Company managed by the expert system EXGAME.

**Table 2 The summary of company results in group B at the end of the game (1991)**

| | Team B1 | Team B2 | Team B3 | Team B4 | Team B5 | Team B6* |
|---|---|---|---|---|---|---|
| Production | 11631 | 11877 | 15097 | 12720 | 6342 | 11473 |
| Number of Production units | 10 | 10 | 14 | 12 | 12 | 10 |
| Raw Material In Stock | 78 | 71 | 166 | 155 | 150 | 83 |
| Average Price in Home Market | 20 | 23 | 25.5 | 23 | 23 | 22.55 |
| Average Price in Export Market | 21 | 24 | 26.5 | 23 | 22.75 | 22.55 |
| Orders From Home Market | 4946 | 4249 | 2115 | 6368 | 2950 | 6873 |
| Orders From Export Market | 6810 | 6260 | 5345 | 5305 | 3029 | 6075 |
| Finished Goods In Stock | 19506 | 15138 | 38996 | 8097 | 4035 | 12705 |
| Total Unmet Orders | 0 | 0 | 0 | 0 | 0 | 0 |
| Number of Employed Operators | 149 | 130 | 218 | 192 | 168 | 147 |
| Operators Going to Leave | 10 | 18 | 17 | 39 | 6 | 3 |
| Total Reps Employed | 8 | 10 | 6 | 5 | 4 | 4 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.22 | 9.97 | 9.9 | 9.86 | 10.41 | 9.97 |
| Best Scrap Rate Achieved | 7.57 | 8.1 | 7.05 | 8.55 | 8.6 | 6.88 |
| Maximum Units Per Ton Of Material | 99.88 | 95.93 | 99.26 | 96.84 | 96.89 | 98.67 |
| Market Niche - Strength | 1.036 | 0.852 | 0.961 | 1.089 | 0.73 | 1.028 |
| Market Niche - Performance | 1.186 | 0.804 | 0.921 | 1.011 | 0.658 | 1.11 |
| Market Niche - Durability | 1.159 | 0.949 | 0.997 | 1.177 | 0.704 | 0.698 |
| Market R & D | 18000 | 11000 | 12000 | 9500 | 7500 | 11400 |
| Production R & D | 12000 | 7000 | 9000 | 4000 | 9000 | 14000 |
| Bank Balance | -23440 | -610280 | -862181 | -469201 | -442966 | 172232 |
| | | | | | | |
| Total Profit | -121042 | -710792 | -958259 | -507582 | -544592 | 64537 |
| Average Profit per period | -10087 | -59233 | -79855 | -42298 | -45383 | 5378 |

* ---- Company managed by the expert system EXGAME.

**Table 3 The summary of company results in group C at the end of the game (1991)**

| | Team C1 | Team C2 | Team C3 | Team C4 | Team C5* | Team C6 |
|---|---|---|---|---|---|---|
| Production | 11337 | 0 | 14216 | 15314 | 12075 | 21163 |
| Number of Production units | 11 | 10 | 13 | 15 | 10 | 14 |
| Raw Material In Stock | 203 | 734 | 0 | 29 | 117 | 314 |
| Average Price in Home Market | 23.25 | 22.45 | 25.5 | 22.75 | 22.55 | 23.5 |
| Average Price in Export Market | 21.25 | 22.2 | 28.5 | 24.24 | 23.68 | 26 |
| Orders From Home Market | 3660 | 4259 | 4785 | 3845 | 6908 | 5054 |
| Orders From Export Market | 7531 | 5059 | 3684 | 5632 | 6456 | 4362 |
| Finished Goods In Stock | 22321 | 1673 | 0 | 10554 | 15214 | 29791 |
| Total Unmet Orders | 0 | 0 | 280 | 0 | 0 | 0 |
| Number of Employed Operators | 151 | 141 | 183 | 169 | 150 | 176 |
| Operators Going to Leave | 11 | 17 | 11 | 19 | 11 | 9 |
| Total Reps Employed | 8 | 4 | 4 | 6 | 4 | 6 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.63 | 9.75 | 10.38 | 9.85 | 10.02 | 10.09 |
| Best Scrap Rate Achieved | 6.29 | 7.34 | 6.68 | 7.4 | 7.55 | 8.12 |
| Maximum Units Per Ton Of Material | 103.17 | 95.25 | 101.95 | 97.49 | 97.39 | 97.87 |
| Market Niche - Strength | 0.919 | 0.81 | 1.161 | 0.952 | 0.846 | 0.924 |
| Market Niche - Performance | 0.856 | 0.867 | 1.077 | 0.897 | 1.041 | 0.872 |
| Market Niche - Durability | 0.88 | 0.763 | 1.124 | 0.805 | 0.998 | 1.012 |
| Market R & D | 12000 | 12000 | 18000 | 12500 | 12600 | 11000 |
| Production R & D | 3000 | 7000 | 18000 | 9000 | 14500 | 6500 |
| Bank Balance | -563452 | -459853 | -139573 | -558532 | 378345 | -593000 |
| | | | | | | |
| Total Profit | -661054 | -560368 | -235651 | -596913 | 276719 | -700695 |
| Average Profit per period | -55125 | -46697 | -19638 | -49743 | 23060 | -58391 |

* ---- Company managed by the expert system EXGAME.

**Table 4 The summary of company results in group D at the end of the game (1991)**

| | Team D1 | Team D2** | Team D3 | Team D4 | Team D5 | Team D6 |
|---|---|---|---|---|---|---|
| Production | 10228 | 12644 | 0 | 14113 | 8700 | 12243 |
| Number of Production units | 10 | 10 | 9 | 13 | 10 | 7 |
| Raw Material In Stock | 88 | 210 | 0 | 110 | 0 | 0 |
| Average Price in Home Market | 20.75 | 22.5 | 23 | 22.625 | 23 | 23.5 |
| Average Price in Export Market | 24.375 | 23.45 | 24.5 | 23.9 | 223.75 | 22.25 |
| Orders From Home Market | 5977 | 6471 | 3278 | 5326 | 4880 | 3121 |
| Orders From Export Market | 6956 | 5701 | 4126 | 5750 | 4321 | 5504 |
| Finished Goods In Stock | 14314 | 0 | 0 | 9693 | 19583 | 16260 |
| Total Unmet Orders | 0 | 452 | 4978 | 0 | 0 | 0 |
| Number of Employed Operators | 177 | 147 | 184 | 168 | 154 | 160 |
| Operators Going to Leave | 13 | 8 | 17 | 8 | 15 | 8 |
| Total Reps Employed | 5 | 4 | 6 | 6 | 5 | 6 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.14 | 9.56 | 9.98 | 9.96 | 10.22 | 9.97 |
| Best Scrap Rate Achieved | 7.49 | 7.3 | 7.94 | 8.32 | 8.7 | 7.83 |
| Maximum Units Per Ton Of Material | 100.09 | 94.35 | 98.84 | 97.92 | 96.48 | 97.87 |
| Market Niche - Strength | 1.071 | 1.015 | 0.872 | 1.141 | 0.895 | 0.869 |
| Market Niche - Performance | 1.201 | 0.945 | 0.872 | 1.101 | 0.863 | 0.865 |
| Market Niche - Durability | 1.057 | 1.109 | 0.818 | 1.019 | 0.882 | 0.91 |
| Market R & D | 12000 | 8000 | 4500 | 9000 | 7000 | 9000 |
| Production R & D | 12500 | 5000 | 9000 | 8000 | 5400 | 5500 |
| Bank Balance | -501726 | -114861 | -741250 | -37907 | -137350 | -508965 |
| | | | | | | |
| Total Profit | -599328 | -215376 | -837328 | -474 | -238976 | -616660 |
| Average Profit per period | -49944 | -17948 | -69777 | -40 | -19915 | -51388 |

** ---- Company managed by the author.

## The 1992A-experiment (January - March 1992)

**Table 5 The summary of company results in group A at the end of the game (1992A)**

| | Team A1* | Team A2# | Team A3# | Team A4 | Team A5 | Team A6# |
|---|---|---|---|---|---|---|
| Production | 13508 | 7088 | 12829 | 8020 | 12816 | 10963 |
| Number of Production units | 10 | 6 | 11 | 10 | 10 | 10 |
| Raw Material In Stock | 71 | 18 | 30 | 0 | 157 | 113 |
| Orders From Home Market | 6975 | 6822 | 7037 | 6583 | 7210 | 6915 |
| Average Price in Home Market | 22.5 | 22.5 | 22 | 22.5 | 22 | 23 |
| Average Price in Export Market | 21.6 | 22 | 20.5 | 22.5 | 19 | 23 |
| Orders From Export Market | 5779 | 5392 | 6194 | 4007 | 6948 | 5936 |
| Finished Goods In Stock | 3 | 3 | 10521 | 10987 | 19043 | 2 |
| Total Unmet Orders | 2386 | 7994 | 0 | 0 | 0 | 892 |
| Number of Employed Operators | 106 | 110 | 119 | 129 | 120 | 120 |
| Operators Going to Leave | 6 | 13 | 0 | 10 | 11 | 4 |
| Total Reps Employed | 4 | 5 | 6 | 4 | 6 | 6 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.11 | 9.86 | 9.93 | 9.65 | 10.68 | 9.93 |
| Best Scrap Rate Achieved | 6.91 | 6.87 | 103.11 | 7.81 | 6.1 | 97.82 |
| Maximum Units Per Ton Of Material | 99.35 | 98.04 | 5.37 | 100.76 | 102.74 | 8.04 |
| Market Niche - Strength | 0.892 | 0.805 | 1.065 | 0.818 | 0.99 | 1.088 |
| Market Niche - Performance | 0.932 | 0.812 | 1.059 | 0.684 | 1.125 | 1.104 |
| Market Niche - Durability | 0.926 | 0.872 | 1.109 | 0.855 | 0.818 | 1.042 |
| Market R & D | 19900 | 20500 | 23700 | 13500 | 18000 | 21500 |
| Production R & D | 10500 | 11500 | 11400 | 7500 | 18000 | 3000 |
| Bank Balance | 1024450 | 695272 | 637598 | 696242 | -149893 | 864879 |
| | | | | | | |
| Total Profit | 653042 | 184745 | 164335 | 236239 | -632745 | 416326 |
| Average Profit per period | 50234 | 14211 | 12461 | 18172 | -48672 | 32025 |

# ---- Company used ADGAME occasionally

* ---- Company managed by the expert system EXGAME.

**Table 6 The summary of company results in group B at the end of the game (1992A)**

| | Team B1* | Team B2 | Team B3 | Team B4 | Team B5 | Team B6 |
|---|---|---|---|---|---|---|
| Production | 14114 | 16933 | 9898 | 13264 | 11776 | 4931 |
| Number of Production units | 10 | 14 | 13 | 7 | 10 | 31 |
| Raw Material In Stock | 80 | 433 | 161 | 39 | 412 | 0 |
| Average Price in Home Market | 22.5 | 21.5 | 23 | 23 | 22.5 | 25 |
| Average Price in Export Market | 21.75 | 21 | 22 | 21 | 22.5 | 25 |
| Orders From Home Market | 6577 | 6800 | 6106 | 6366 | 6155 | 790 |
| Orders From Export Market | 6644 | 6897 | 5755 | 7396 | 6245 | 0 |
| Finished Goods In Stock | 3 | 7261 | 2 | 2988 | 2231 | 6589 |
| Total Unmet Orders | 7034 | 0 | 9095 | 0 | 0 | 0 |
| Number of Employed Operators | 112 | 152 | 109 | 131 | 127 | 659 |
| Operators Going to Leave | 3 | 10 | 6 | 12 | 10 | 18 |
| Total Reps Employed | 4 | 8 | 8 | 8 | 6 | 8 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.03 | 10.08 | 9.89 | 9.8 | 10.34 | 10.16 |
| Best Scrap Rate Achieved | 6.5 | 6.07 | 7.7 | 8.26 | 8.83 | 8.29 |
| Maximum Units Per Ton Of Material | 100.21 | 99.24 | 98.48 | 98.82 | 98.71 | 98.39 |
| Market Niche - Strength | 1 | 1.145 | 0.86 | 0.986 | 1.077 | 0.713 |
| Market Niche - Performance | 0.883 | 1.192 | 0.921 | 0.937 | 0.968 | 0.764 |
| Market Niche - Durability | 0.969 | 1.05 | 0.863 | 0.882 | 1.015 | 0.944 |
| Market R & D | 12080 | 13500 | 10000 | 13200 | 17000 | 6000 |
| Production R & D | 10000 | 12000 | 6000 | 5400 | 8500 | 8500 |
| Bank Balance | 1073820 | 434749 | 756235 | 673269 | 760172 | -2522176 |
| | | | | | | |
| Total Profit | 653042 | -75778 | 287972 | 213266 | 277320 | -2970729 |
| Average Profit per period | 50234 | -5829 | 21767 | 16405 | 21332 | -228517 |

* ---- Company managed by the expert system EXGAME

**Table 7 The summary of company results in group C at the end of the game (1992A)**

| | Team C1* | Team C2# | Team C3 | Team C4 | Team C5 | Team C6 |
|---|---|---|---|---|---|---|
| Production | 14168 | 19133 | 14171 | 5692 | 20027 | 8909 |
| Number of Production units | 10 | 12 | 10 | 10 | 11 | 12 |
| Raw Material In Stock | 0 | 110 | 16 | 0 | 249 | 0 |
| Average Price in Home Market | 22.5 | 23 | 22.99 | 22.75 | 22.5 | 22.75 |
| Average Price in Export Market | 22.25 | 22 | 23.25 | 23 | 21.95 | 22 |
| Orders From Home Market | 6797 | 5790 | 6954 | 4329 | 6041 | 6044 |
| Orders From Export Market | 6029 | 3523 | 6652 | 4738 | 7042 | 5378 |
| Finished Goods In Stock | 2 | 23799 | 6776 | 5026 | 12957 | 1868 |
| Total Unmet Orders | 5312 | 0 | 0 | 0 | 0 | 0 |
| Number of Employed Operators | 112 | 156 | 115 | 140 | 163 | 178 |
| Operators Going to Leave | 5 | 1 | 0 | 11 | 12 | 16 |
| Total Reps Employed | 4 | 7 | 8 | 8 | 16 | 5 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.05 | 9.86 | 10.11 | 9.96 | 10.17 | 10 |
| Best Scrap Rate Achieved | 6.94 | 7.06 | 6.35 | 7 | 6.36 | 8.05 |
| Maximum Units Per Ton Of Material | 98.54 | 97.76 | 101.57 | 101.74 | 102.87 | 97.6 |
| Market Niche - Strength | 0.942 | 0.965 | 1.045 | 0.866 | 1.077 | 0.897 |
| Market Niche - Performance | 0.922 | 0.845 | 1.016 | 0.66 | 1.445 | 0.814 |
| Market Niche - Durability | 0.967 | 0.885 | 1.075 | 0.793 | 1.062 | 0.969 |
| Market R & D | 17194 | 10000 | 18000 | 12000 | 15000 | 15000 |
| Production R & D | 10000 | 9000 | 12000 | 15000 | 10000 | 11000 |
| Bank Balance | 1045250 | -90951 | 928600 | 276147 | 436862 | 325771 |
| | | | | | | |
| Total Profit | 624478 | -601478 | 455337 | -183856 | -45990 | -122782 |
| Average Profit per period | 48036 | -46267 | 35026 | -14143 | -3538 | -9445 |

# ---- Company used ADGAME occasionally

* ---- Company managed by the expert system EXGAME

**Table 8 The summary of company results in group D at the end of the game (1992A)**

| | Team D1* | Team D2 | Team D3 | Team D4 | Team D5 | Team D6 |
|---|---|---|---|---|---|---|
| Production | 16211 | 11342 | 9901 | 8366 | 19920 | 13049 |
| Number of Production units | 10 | 8 | 6 | 7 | 16 | 11 |
| Raw Material In Stock | 22 | 306 | 172 | 97 | 0 | 59 |
| Average Price in Home Market | 22.5 | 22.25 | 22.5 | 23.5 | 24 | 22.5 |
| Average Price in Export Market | 22.75 | 22.5 | 22 | 22.25 | 24 | 22.75 |
| Orders From Home Market | 6892 | 6980 | 7012 | 5096 | 6369 | 5987 |
| Orders From Export Market | 6310 | 6086 | 6398 | 3738 | 6007 | 4926 |
| Finished Goods In Stock | 3 | 5243 | 3 | 2 | 9015 | 8402 |
| Total Unmet Orders | 248 | 0 | 1420 | 23632 | 0 | 0 |
| Number of Employed Operators | 112 | 137 | 107 | 119 | 191 | 209 |
| Operators Going to Leave | 5 | 12 | 6 | 8 | 10 | 16 |
| Total Reps Employed | 4 | 8 | 8 | 10 | 9 | 8 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.1 | 9.67 | 9.6 | 9.66 | 9.99 | 10.39 |
| Best Scrap Rate Achieved | 6.95 | 7.84 | 8.13 | 8.49 | 5.92 | 6.98 |
| Maximum Units Per Ton Of Material | 99.82 | 94.75 | 95.21 | 98.97 | 95.59 | 99.73 |
| Market Niche - Strength | 0.949 | 0.787 | 0.836 | 0.87 | 1.344 | 0.951 |
| Market Niche - Performance | 0.965 | 0.997 | 0.851 | 0.778 | 1.202 | 0.888 |
| Market Niche - Durability | 0.93 | 0.955 | 0.866 | 0.785 | 1.213 | 0.953 |
| Market R & D | 11301 | 19000 | 15000 | 15000 | 19500 | 13000 |
| Production R & D | 10000 | 4000 | 7000 | 7000 | 8500 | 10000 |
| Bank Balance | 1150310 | 580371 | 786363 | 51363 | 779533 | -216228 |
| | | | | | | |
| Total Profit | 729538 | 69844 | 313100 | -408640 | 296681 | -664781 |
| Average Profit per period | 56118 | 5373 | 24084 | -31434 | 22822 | -51137 |

# ---- Company used ADGAME occasionally
* ---- Company managed by the expert system EXGAME

**Table 9 The summary of company results in group E at the end of the game (1992A)**

| | Team E1* | Team E2 | Team E3 | Team E4# | Team E5 | Team E6 |
|---|---|---|---|---|---|---|
| Production | 15180 | 17395 | 17023 | 9274 | 8158 | 8168 |
| Number of Production units | 10 | 14 | 15 | 14 | 14 | 7 |
| Raw Material In Stock | 0 | 28 | 99 | 0 | 233 | 363 |
| Average Price in Home Market | 22.5 | 22.75 | 20 | 21.25 | 21 | 22.5 |
| Average Price in Export Market | 21 | 21 | 18.5 | 20.25 | 19 | 21.5 |
| Orders From Home Market | 6912 | 7231 | 6308 | 6752 | 7400 | 6872 |
| Orders From Export Market | 5620 | 5822 | 5952 | 5158 | 6901 | 4905 |
| Finished Goods In Stock | 2 | 23743 | 64240 | 6193 | 40644 | 1679 |
| Total Unmet Orders | 1147 | 0 | 0 | 0 | 0 | 0 |
| Number of Employed Operators | 112 | 183 | 212 | 188 | 123 | 142 |
| Operators Going to Leave | 5 | 17 | 25 | 14 | 134 | 11 |
| Total Reps Employed | 4 | 8 | 6 | 8 | 18 | 8 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.06 | 9.86 | 10.11 | 10.21 | 10.23 | 9.92 |
| Best Scrap Rate Achieved | 6.66 | 5.55 | 7.43 | 7.37 | 6.99 | 7.61 |
| Maximum Units Per Ton Of Material | 99.48 | 100.23 | 99.75 | 100.86 | 98.95 | 100.02 |
| Market Niche - Strength | 1.001 | 1.14 | 0.808 | 0.839 | 1.07 | 1.017 |
| Market Niche - Performance | 0.988 | 0.926 | 0.799 | 0.924 | 1.175 | 0.981 |
| Market Niche - Durability | 1.009 | 1.09 | 0.85 | 0.763 | 1.156 | 0.98 |
| Market R & D | 14350 | 14000 | 3000 | 11000 | 18000 | 9000 |
| Production R & D | 10000 | 9000 | 3000 | 11250 | 11000 | 3000 |
| Bank Balance | 989311 | 260957 | -860368 | -45317 | -2132772 | 360788 |
| | | | | | | |
| Total Profit | 568539 | -249570 | -1333631 | -505320 | -2581325 | -87765 |
| Average Profit per period | 43734 | -19198 | -102587 | -38871 | -198563 | -6571 |

# ---- Company used ADGAME occasionally
* ---- Company managed by the expert system EXGAME

**The 1992B-experiment (May 1992)**

**Table 10 The summary of company results in group F at the end of the game (1992B)**

| | Team A1** | Team A2 | Team A3 | Team A4** | Team A5** | Team A6* |
|---|---|---|---|---|---|---|
| Production | 13242 | 13405 | 13861 | 13587 | 11173 | 11128 |
| Number of Production units | 10 | 13 | 11 | 10 | 13 | 12 |
| Raw Material In Stock | 117 | 144 | 258 | 49 | 373 | 231 |
| Average Price in Home Market | 22.5 | 25.5 | 22.05 | 22.5 | 22.5 | 22.5 |
| Average Price in Export Market | 23 | 27.5 | 22.65 | 24.1 | 23 | 23 |
| Orders From Home Market | 6518 | 2073 | 7304 | 6210 | 6599 | 6784 |
| Orders From Export Market | 5480 | 3251 | 6461 | 4896 | 5683 | 6260 |
| Finished Goods In Stock | 1038 | 10931 | 4528 | 1 | 2 | 2 |
| Total Unmet Orders | 0 | 0 | 0 | 11172 | 11469 | 1881 |
| Number of Employed Operators | 118 | 147 | 128 | 114 | 124 | 117 |
| Operators Going to Leave | 7 | 12 | 11 | 3 | 8 | 5 |
| Total Reps Employed | 4 | 6 | 6 | 4 | 4 | 4 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.05 | 9.99 | 9.98 | 9.79 | 9.94 | 9.90 |
| Best Scrap Rate Achieved | 7.25 | 7.23 | 6.33 | 6.73 | 8.95 | 7.42 |
| Maximum Units Per Ton Of Material | 96.42 | 98.11 | 97.02 | 97.46 | 95.41 | 98.21 |
| Market Niche - Strength | 0.963 | 0.647 | 1.272 | 0.972 | 0.986 | 1.003 |
| Market Niche - Performance | 0.978 | 0.706 | 1.159 | 1.059 | 0.926 | 0.989 |
| Market Niche - Durability | 0.972 | 0.628 | 1.213 | 1.056 | 0.968 | 0.97 |
| Market R & D | 9000 | 0 | 9000 | 12700 | 12000 | 12040 |
| Production R & D | 7000 | 6000 | 7000 | 9700 | 3750 | 11000 |
| Bank Balance | 1079850 | 221453 | 988138 | 515624 | 813328 | 1033880 |
| | | | | | | |
| Total Profit | 659078 | -289074 | 514872 | 55621 | 330472 | 585327 |
| Average Profit per period | 54923 | -24090 | 42906 | 4635 | 27540 | 48777 |

** ---- Company with the help of the expert advisory system ADGAME.

* ---- Company managed by the expert system EXGAME.

**Table 11 The summary of company results in group G at the end of the game (1992B)**

| | Team B1 | Team B2** | Team B3 | Team B4 | Team B5 | Team B6* |
|---|---|---|---|---|---|---|
| Production | 6650 | 14769 | 12275 | 8877 | 10833 | 12623 |
| Number of Production units | 15 | 10 | 10 | 10 | 12 | 11 |
| Raw Material In Stock | 134 | 118 | 1371 | 0 | 134 | 171 |
| Average Price in Home Market | 24 | 22.5 | 25 | 23.5 | 22 | 22.5 |
| Average Price in Export Market | 24 | 23.75 | 25 | 22 | 22 | 24.09 |
| Orders From Home Market | 7133 | 7292 | 4192 | 6959 | 5671 | 7193 |
| Orders From Export Market | 6685 | 6683 | 2973 | 6655 | 3225 | 6282 |
| Finished Goods In Stock | 17493 | 3154 | 1 | 6257 | 3 | 2 |
| Total Unmet Orders | 0 | 0 | 4240 | 0 | 40202 | 546 |
| Number of Employed Operators | 127 | 118 | 110 | 117 | 123 | 118 |
| Operators Going to Leave | 0 | 2 | 0 | 2 | 4 | 0 |
| Total Reps Employed | 9 | 7 | 8 | 7 | 6 | 4 |
| Reps Going to Leave | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum Production Speed Achieved | 10.25 | 9.97 | 10.51 | 9.55 | 10.23 | 10.04 |
| Best Scrap Rate Achieved | 7.37 | 6.83 | 6.62 | 8.67 | 6.21 | 7.18 |
| Maximum Units Per Ton Of Material | 99.71 | 100.33 | 102.43 | 97.15 | 101.28 | 99.14 |
| Market Niche - Strength | 1.658 | 0.774 | 0.808 | 0.755 | 0.757 | 0.779 |
| Market Niche - Performance | 1.622 | 0.811 | 0.768 | 0.751 | 0.792 | 0.777 |
| Market Niche - Durability | 1.637 | 0.777 | 0.783 | 0.737 | 0.833 | 0.73 |
| Market R & D | 66000 | 42000 | 15000 | 48000 | 9000 | 36000 |
| Production R & D | 7500 | 12000 | 8000 | 0 | 6000 | 10000 |
| Bank Balance | 144569 | 811494 | 32363 | 577747 | -153206 | 1019760 |
| | | | | | | |
| Total Profit | -276203 | 300967 | -440904 | 117744 | -626246 | 571207 |
| Average Profit per period | -23017 | 25080 | -36742 | 9812 | -52187 | 47601 |

** ---- Company with the help of the expert advisory system ADGAME.

* ---- Company managed by the expert system EXGAME.

## APPENDIX 4

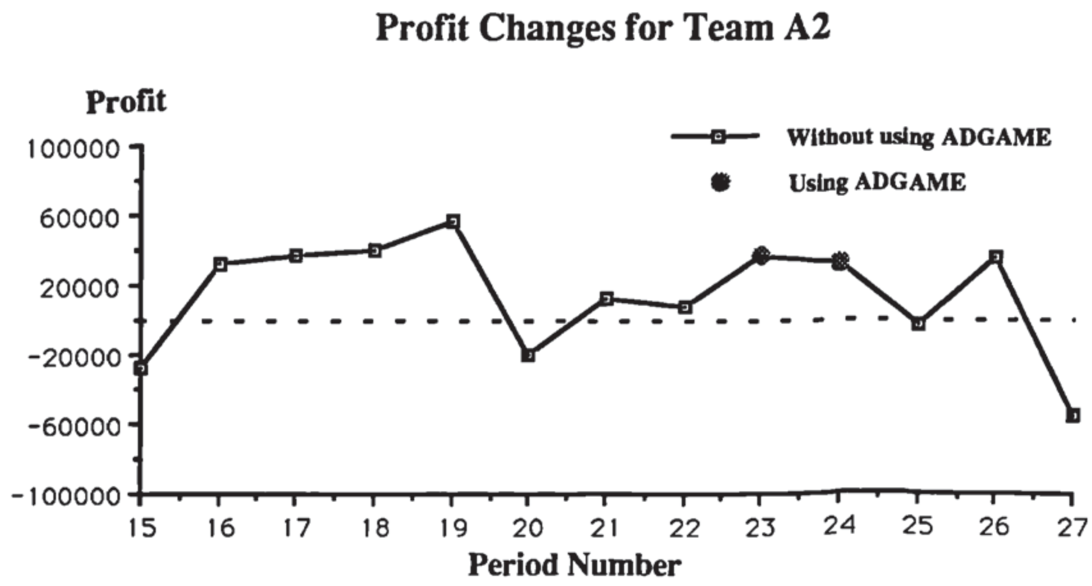


**Figure 1**

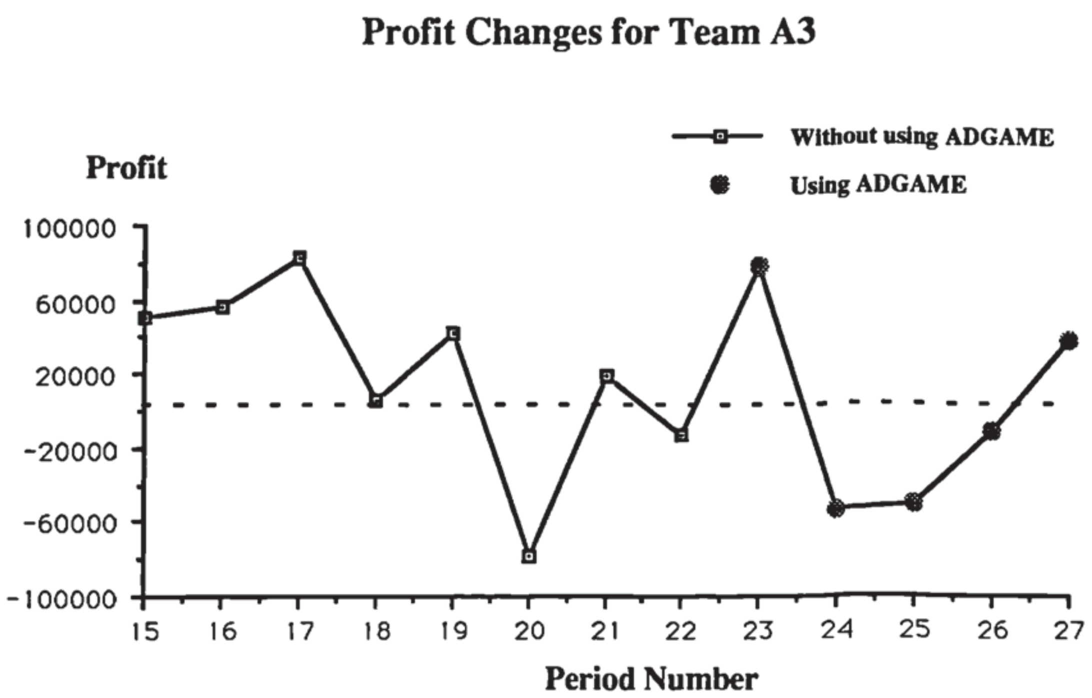


**Figure 2**

## Profit Changes for Team A6

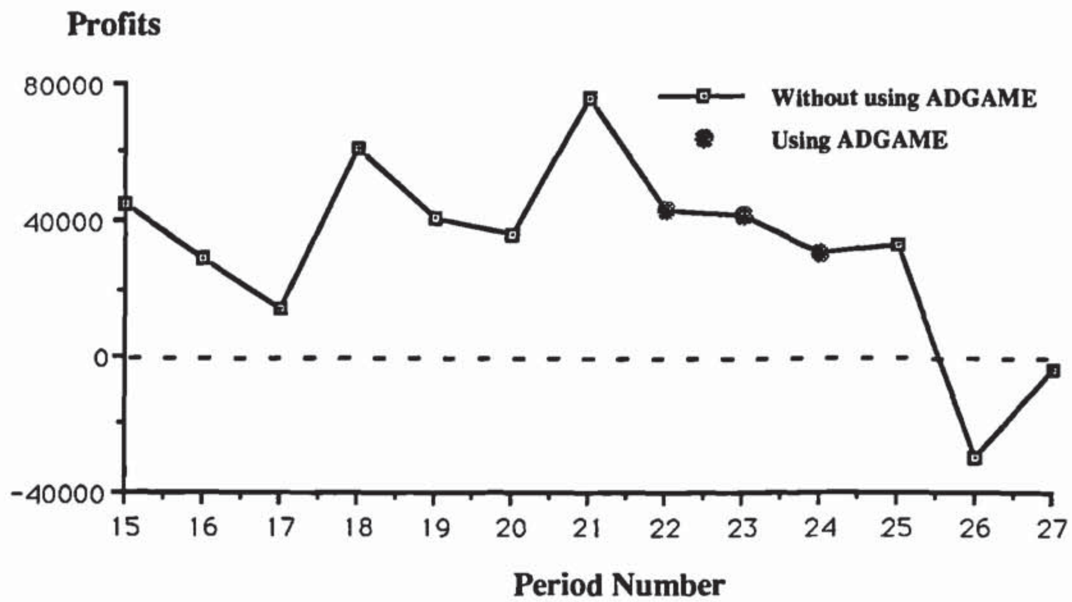


Figure 3

## Profit Changes for Team C2

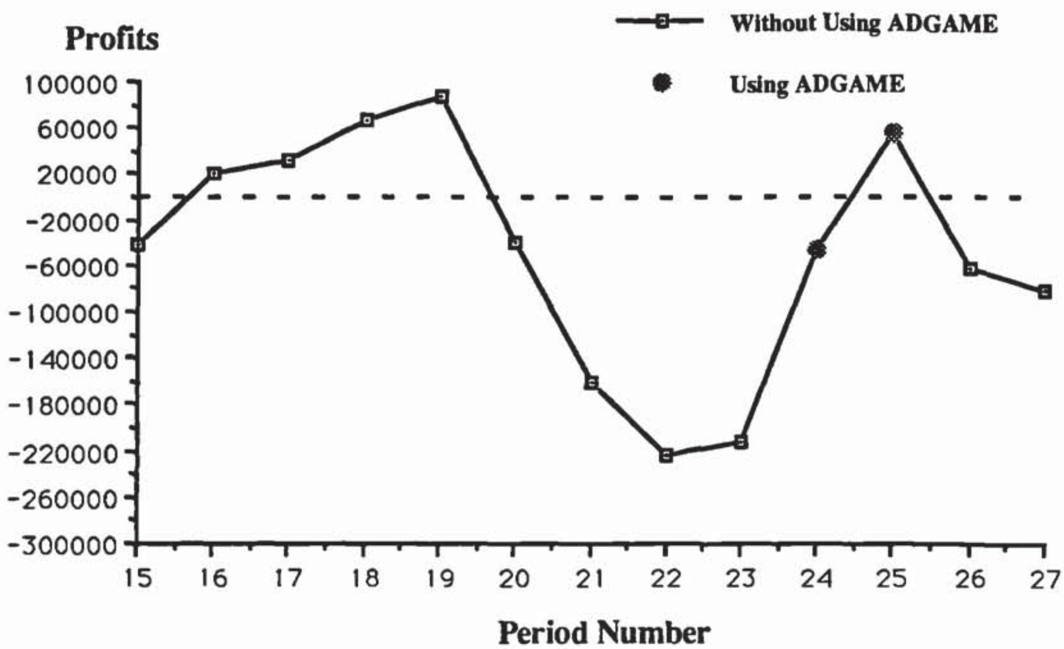


Figure 4

## Profit Changes for Team E4

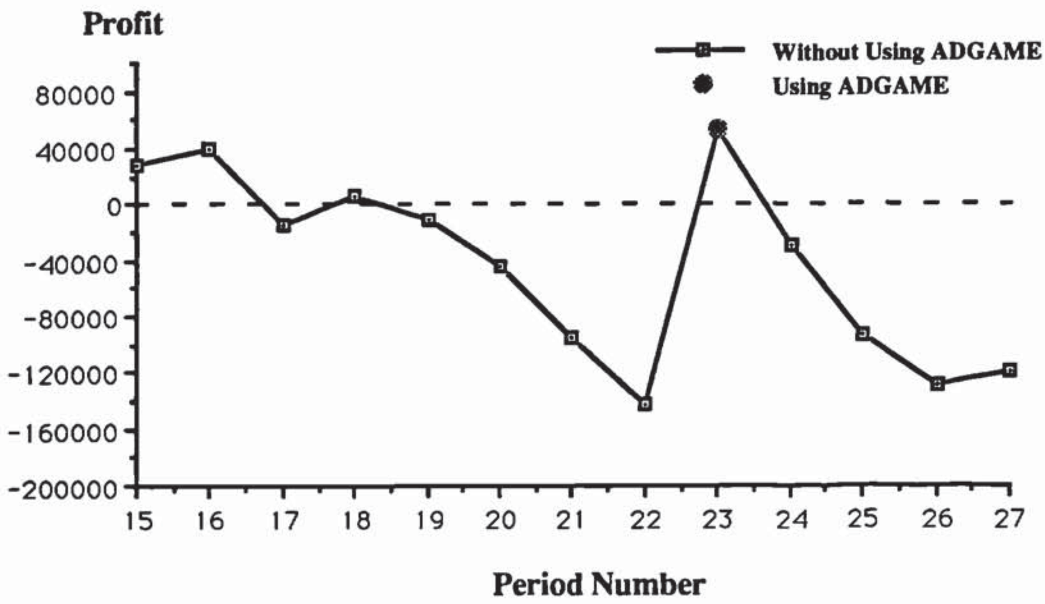


Figure 5

## Profit Changes for Team D4

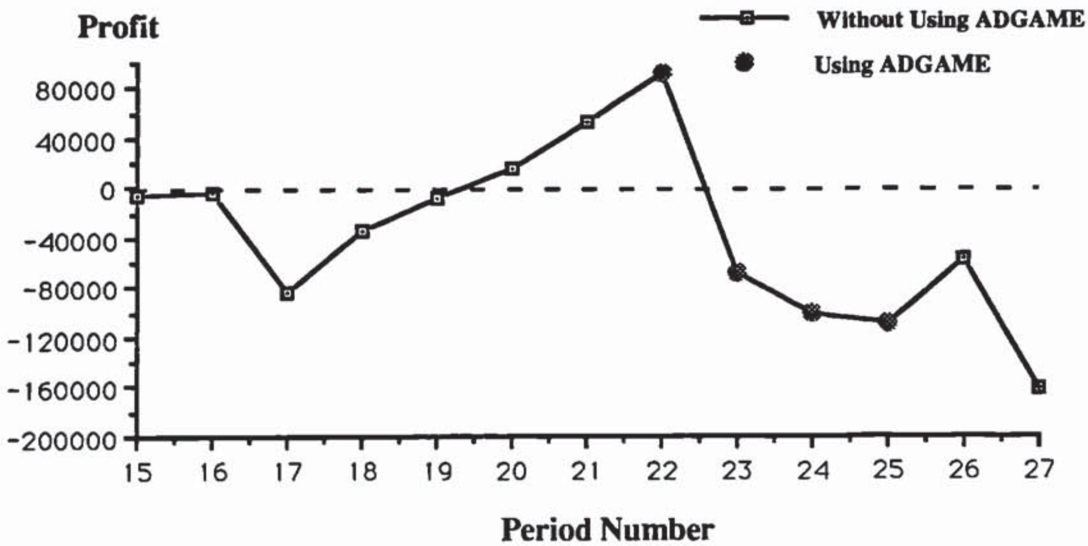


Figure 6

## Profit Changes for Team A4 (Not Using ADGAME)

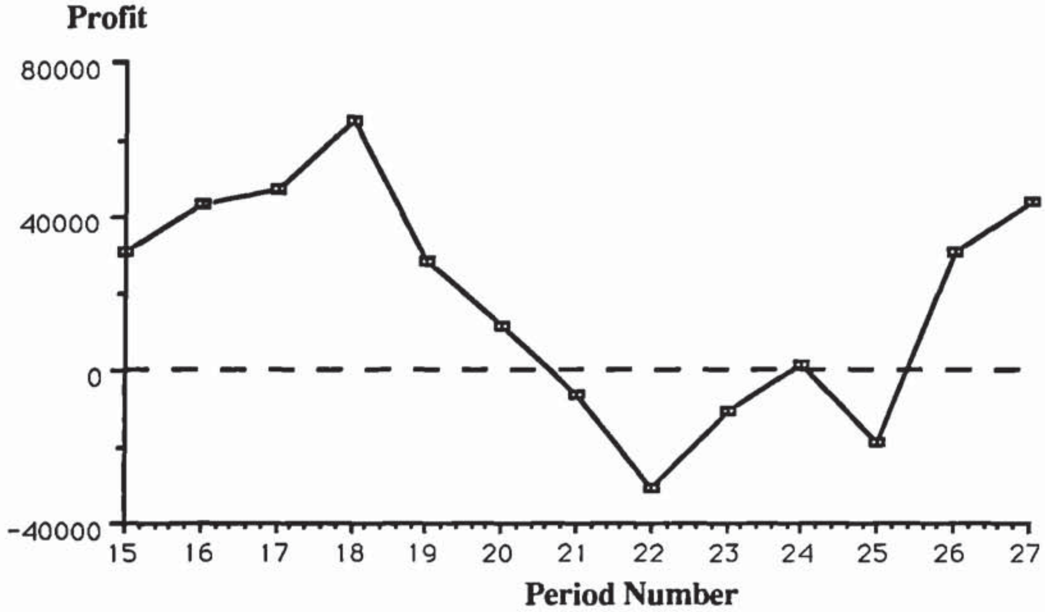


**Figure 7**

## Profit Changes for Team A5 (Not Using ADGAME)

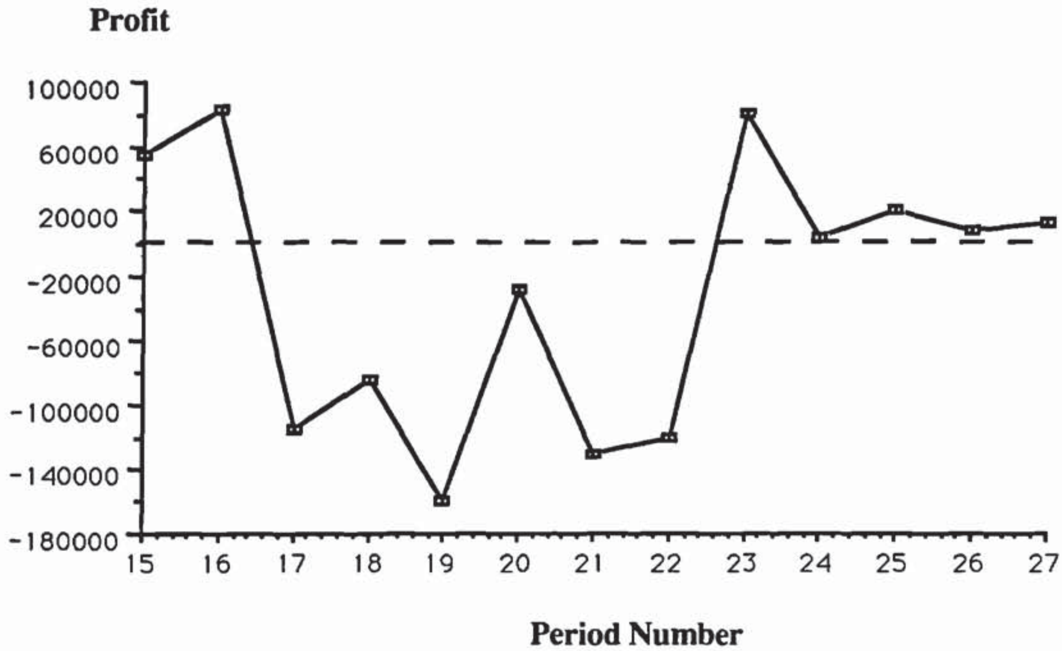


**Figure 8**

# APPENDIX 5

## MAS1 BUSINESS GAME 1991-Experiment --- SOME REVIEW QUESTIONS

These questions have two aims; the first is to provide the basis of an analysis of the knowledge and experience gained through playing the game and the second is to provide a focus for your review of it. The first aim is part of a research and development project and second should help you with the course work.

1. In which team were you involved(A3,D5 etc)? ________

2. What was your function ?

___Production Manager ___Sales Manager
___Marketing Manager ___Personnel Manager
___R & D Manager ___Financial Manager
___General Manager ___Other, Please specify
_____________________

3. Having finished the game, how do you now rate yourself as a manager?

___Very good ___Good
___Normal ___Not good
___Poor

4. Did your company set overall targets for performance?
___Yes, at the beginning.
___Yes, in the middle.
___Yes, towards the end.
___No.

If yes, do you think you achieved the target?
___NO ___ Reasonably ___Very well

How did you set the overall targets? Tick from the list below please.

___General team meeting
___Face to face individually
___written message
___Through the General Manager
___other, please specify___________________________________

5. Some questions about the way you made your decisions:

A. Your information requirements. Please rate the usefulness to your decision making of the following categories of information.(1= not at all useful to 5= very useful)

| Company summary: | Market information: |
| --- | --- |
| ___Production | ___Production |
| ___Sales | ___Sales |
| ___Marketing | ___Marketing |
| ___Personnel | ___Personnel |
| ___R & D | ___R & D |
| ___Bank statement | ___Bank statement |

Current status:
___Production
___Sales
___Marketing
___Personnel
___R & D
___Bank statement

List other information used and indicate its usefulness to you on a scale of 1 to 5:

________________________________ ____
________________________________ ____
________________________________ ____

B. How much did you discuss your decision making with other members of your company? ___(1= very little to 5= a lot)

C. How much did you discuss your decision making with your tutor? ___(1= very little to 5= a lot)

D. Which form did your discussions take? (tick as appropriate)

___General team meeting
___Face to face individually
___written message
___Through the General Manager
___Other, please specify________________________________

E. Which of these do you think was the most effective? Rank from 1=least effective to 5=most effective please.

___General team meeting
___Face to face individually
___written message
___Through the General Manager
___Other, please specify________________________

F. The interaction between decision areas. In the following list, tick the decisions that could be made without reference to other parts of the company, put a cross against those that could not be made without reference to the other parts of the company, and the leave rest blank.

PRODUCTION

___Specify shift working
___Allocate overtime
___Maintenance level
___Change the production units
___Order raw material

SALES

___Set the prices
___Allocate sales reps
___Define dispatch priorities

MARKETING

___Set home market adv.
___Set export market adv.

PERSONNEL

___Set the wage for ops
___Set the salary for reps
___Specify training hours
___Change the No. of ops
___Change the No. of reps

R & D

Allocate a sum for R&D of
___The production process
___The product and its market appeal

G. Please rank the other functions according to the frequency with which you had discussion with them.
(1=least frequent to 5=most frequent, put a "X" against your responsibility)

___Production
___Sales
___Marketing
___Personnel
___R & D
___Finance and Accounting
___General Manager

6. Were there many conflicts between your decisions and other functions? ___(rank from 1=none to 5=many)

A. What were the conflicts about: (tick the list below)

___Resources allocation
(e.g. money and labour)
___Absence of communication
___Unclear about the overall
policy of the company
___Other, please specify ____________________________

B.How did you resolve the conflicts?

___Majority vote in team meeting
___Formal discussion and find
a balance between both side
___Informal general agreement
___By the General Manager
___Other, please specify ____________________________

7. Please rank the functions listed below according to your view of their contribution to the overall company performance.
(1 = least important to 5 = most important)

___Production
___Sales
___Marketing
___Personnel
___R & D
___Finance and Accounting
___General Manager

8. Are you satisfied with the results of your company? Yes/No.
If No, Please explain the reasons here
________________________________________________
________________________________________________
________________________________________________
________________________________________________

9. Did any member(s) of your company bring special experience or expertise to your team? Yes/No

If yes, Please outline briefly:______________________

____________________________________________________

____________________________________________________

10. did you find the game (tick up to three as you feel appropriate)

___Valuable ___Enjoyable

___Helpful ___Irrelevant

___Dull ___Stressful

If you have any further comments you wish to make about the game and/or your team's approach to it, please write here.

____________________________________________________________________

____________________________________________________________________

_________________________________________________________________

Thank you for completing this. Please return it to **SW 821 or your tutor best before the end of this term.** It will be helpful if you give your name(so that we could contact you), but this is not essential. NAME_______

**MASI BUSINESS GAME 1992A-Exeriment --- SOME REVIEW QUESTIONS**

These questions have two aims; the first is to provide the basis of an analysis of the knowledge and experience gained through playing the game and the second is to provide a focus for your review of it. The first aim is part of a research and development project and the second should help you with the course work.

1. In which team were you involved (A3,D5 etc)? ________

2. What was your function ?

___Production Manager ___Sales Manager
___Marketing Manager ___Personnel Manager
___R & D Manager ___Financial Manager
___General Manager ___Other, Please specify________________________________

3. Having finished the game, how do you now rate yourself as a manager?

___Very good ___Good ___Normal ___Not good ___Poor

4. Did your company set overall targets for performance?

___Yes, at the beginning.
___Yes, in the middle.
___Yes, towards the end.
___No.

If yes, do you think you achieved the target?

___NO ___ Reasonably ___Very well

How did you set the overall targets? Tick from the list below please.

___General team meeting
___Face to face individually
___written message
___Through the General Manager
___Other, please specify____________________________

5. Some questions about the way you made your decisions:

A. Your information requirements. Please rate the usefulness to your decision making of the following categories of information.(1= not at all useful to 5= very useful)

| Company summary: | Market information: | Current status: |
|---|---|---|
| ___Production | ___Production | ___Production |
| ___Sales | ___Sales | ___Sales |
| ___Marketing | ___Marketing | ___Marketing |
| ___Personnel | ___Personnel | ___Personnel |
| ___R & D | ___R & D | ___R & D |
| ___Bank statement | ___Bank statement | ___Bank statement |

List other information used and indicate its usefulness to you on a scale of 1 to 5:

______________________________ ___
______________________________ ___
______________________________ ___

B. How much did you discuss your decision making with other members of your company? ___(1= very little to 5= a lot)

C. How much did you discuss your decision making with your tutor? ___(1= very little to 5= a lot)

D. What form did your discussions take? (tick as appropriate)

___General team meeting
___Face to face individually
___written message
___Through the General Manager
___Other, please specify________________________________

E. Which of them do you think was the most effective? Rank from 1=least effective to 5=most effective please.

___General team meeting
___Face to face individually
___Written messages
___Through the General Manager
___Other, please specify______________________

F. Please rank the other functions according to the frequency with which you had discussions with them. (1=least frequent to 5=most frequent, put a "X" against your responsibility)

___Production ___R & D
___Sales ___Finance and Accounting
___Marketing ___General Manager
___Personnel

6. Were there many conflicts between your decisions and other functions? ___(rank from 1=none to 5=many)

A. What were the conflicts about: (tick the list below)

___Resources allocation (e.g. money and labour)
___Absence of communication
___Unclear about the overall policy of the company
___Other, please specify ____________________

B.How did you resolve the conflicts?

___Majority vote in team meeting
___Formal discussion and find a balance between both sides
___Informal general agreement
___By the General Manager
___Other, please specify ____________________

7. Please rank the functions listed below according to your view of their contribution to the overall company performance. (1 = least important to 5 = most important)

___Production
___Sales
___Marketing
___Personnel
___R & D
___Finance and Accounting
___General Manager

8. Are you satisfied with the results achieved by your company? Yes/No___
If No, Please explain the reasons here

________________________________________

________________________________________

9. Did any member(s) of your company bring special experience or expertise to your team? Yes/No
If yes, Please outline briefly:

________________________________________

________________________________________

10. Did you find the game (tick up to three as you feel appropriate)

___Valuable ___Enjoyable ___Helpful ___Irrelevant ___Dull ___Stressful

If you have any further comments you wish to make about the game and/or your team's approach to it, please write them here.

_______________________________________________

_______________________________________________

_______________________________________________

## QUESTIONS ABOUT ADGAME

1. Did your team use the advisory system ADGAME when playing the business game? Yes/No ___

If "Yes" go to question 2.

If "No", could you explain the reasons please? Tick all of the following which apply.

___a. We thought the team could perform well without using ADGAME.
___b. We don't know what an expert system is.
___c. We had no time to use it.
___d. The Access to ADGAME was not convenient.
___e. We were told it was not easy to use.
___f. We didn't think it was worth the charge for it.
___g. Other, please specify

_______________________________________________

Stop here and ignore questions 2 to 13.

*******************************************

2. How did your team decide to use ADGAME?

___a. Majority vote in the team meeting
___b. By the general manager
___c. According to individual interest in the team
___d. Other, please specify_______________________________________________

3. In how many periods did your team use ADGAME to help you make decisions? ___

4. Can you describe roughly what percentage of the decisions your team made followed the suggestions of ADGAME? ___(0% --- did not take any decisions suggested by ADGAME, 100% --- took all decisions suggested by ADGAME)

5. What is your opinion about the benefit that can be gained from ADGAME? (1 = no benefit to 5 = great benefit). Tick all of the following which apply.

___a. Gain competitive advantage
___b. Make efficient use of company's resources (labour, money, etc.)
___c. Make more profit
___d. Improve users' management skill
___e. Make decisions quickly and save manager's time.
___f. Others, please specify, ________________________________________

6. How do you rate the benefit that each functional role obtained from ADGAME? (1 = no benefit to 5 = great benefit)

___a. General Manager
___b. Production Manager
___c. Sales Manager
___d. Marketing Manager
___e. Personnel Manager
___f. R & D Manager
___g. Financial Manager
___h. Other, Please specify ________________________________________

7. What is your general view about ADGAME as an aid for decision making? ___ (1 = not at all effective to 5 = very effective)

If possible, can you explain your answer briefly here please?

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________

8. Did you use ADGAME personally (i.e. "hands-on")? Yes/No ___

If "yes", then go to question 9.

If "No", tick all of the following which apply.

___a. I didn't want to use it
___b. Others had more time to use it than I did
___c. Others are better at using computers than I am
___d. Others found it easier to access ADGAME than I did
___e. ADGAME wasn't as appropriate for my job as for others
___f. Other, please specify________________________________________

Stop here and ignore questions 9 to 13.

9. Why did you decide to use ADGAME? Tick all of the following which apply.

___a. We thought it would help make better decisions
___b. We thought it would save time
___c. We thought it would resolve disagreements
___d. We thought it would be good "value for money"
___e. We wanted to try something new
___f. We like using computers
___g. We thought we were expected to
___h. We thought we needed all the help we could get
___Other, please specify________________________________________

10. How easy was it to understand the data input questions in the data input window? ___(1 = very difficult to understand to 5 = very easy to understand )

11. How easy was it to understand the other questions (apart from the data input questions) which ADGAME asked you to answer? ___(1 = very difficult to understand to 5 = very easy to understand ) ____

12. What was your opinion about the system's explanations? - were they?

___a. Clear (1 = not at all clear to 5 = very clear)
___b. Helpful (1 = not at all helpful to 5 = very helpful)
___c. The right amount (1 = too little explanation to 5 = too much explanation)

13. Please rate the helpfulness of the different ways in which advice was presented ( 1 = not at all helpful to 5 = very helpful).

___a. Precise decisions
___b. Decision ranges
___c. General advice

If you have any further comments you wish to make about ADGAME, please write them here.

________________________________________
________________________________________
________________________________________
________________________________________

Thank you for completing this questionnaire. Please return it to **your tutor at the last session of tutorial (Thursday 19 March).**

## QUESTIONS ABOUT MASI GAME IN MAY 1992
### (The 1992B-experiment)

1. In which team were you involved (A3,B5 etc)? ________

2. Did you use the expert advisory system ADGAME as decision making aid? Yes/No___

**PART ONE**

**Questions you need to answer in each period during play:**

1. The time spent.

How much time did you spend in decision making in each period?

| | | |
|---|---|---|
| ___ Minutes In Period 14 | ___ Minutes In Period 15 | ___ Minutes In Period 16 |
| ___ Minutes In Period 17 | ___ Minutes In Period 18 | ___ Minutes In Period 19 |
| ___ Minutes In Period 20 | ___ Minutes In Period 21 | ___ Minutes In Period 22 |
| ___ Minutes In Period 23 | ___ Minutes In Period 24 | ___ Minutes In Period 25 |

2. Your confidence about your decision making

A. How confident do you feel about the decisions you have made for the next period? (1 = no confidence to 5 = highly confident).

| | | |
|---|---|---|
| ___ In Period 14 | ___ In Period 15 | ___ In Period 16 |
| ___ In Period 17 | ___ In Period 18 | ___ In Period 19 |
| ___ In Period 20 | ___ In Period 21 | ___ In Period 22 |
| ___ In Period 23 | ___ In Period 24 | ___ In Period 25 |

B. How confident do you feel that you can do well in the future? (1 = no confidence to 5 = highly confident).

| | | |
|---|---|---|
| ___ In Period 14 | ___ In Period 15 | ___ In Period 16 |
| ___ In Period 17 | ___ In Period 18 | ___ In Period 19 |
| ___ In Period 20 | ___ In Period 21 | ___ In Period 22 |
| ___ In Period 23 | ___ In Period 24 | ___ In Period 25 |

**PART TWO**

**Questions you need to answer after you finish the game.**

1. Did you play the game before? Yes/No ____

2. Before playing the game, do you have enough confidence to play it well? ___(1 = no confidence to 5 = highly confident).

3. Having finished the game, how do you now rate yourself as a manager?

___Very good ___Good ___Normal ___Not good ___Poor

4. Did your company set overall targets for performance?

___Yes, at the beginning.
___Yes, in the middle.
___Yes, towards the end.
___No.

If yes, do you think you achieved the target?

___NO ___ Reasonably ___Very well

5. Some questions about the way you made your decisions:

A. Your information requirements. Please rate the usefulness to your decision making of the following categories of information.(1= not at all useful to 5= very useful)

| Company summary: | Market information: | Current status: |
|---|---|---|
| ___Production | ___Production | ___Production |
| ___Sales | ___Sales | ___Sales |
| ___Marketing | ___Marketing | ___Marketing |
| ___Personnel | ___Personnel | ___Personnel |
| ___R & D | ___R & D | ___R & D |
| ___Bank statement | ___Bank statement | ___Bank statement |

List other information used and indicate its usefulness to you on a scale of 1 to 5:

________________________________ ___

________________________________ ___

________________________________ ___

6. Are you satisfied with the results achieved by your company? Yes/No___

If No, Please explain the reasons here

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

7. Did you find the game (tick up to three as you feel appropriate)

___Valuable ___Enjoyable ___Helpful ___Irrelevant ___Dull ___Stressful

If you have any further comments you wish to make about the game, please write them here.

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

Thank you for completing this questionnaire. Please return it to **Duan in room 1118 after the game is finished.**

## QUESTIONS ABOUT ADGAME IN MAY 1992

### (The 1992B-Experiment)

1. In which team were you involved (A3,D5 etc)? ________

2. Did you play the game before? Yes/No ____

3. In how many periods did you use ADGAME to help you make decisions? ___

4. Can you describe roughly what percentage of the decisions you made followed the suggestions of ADGAME in the different stages of playing the game? (0% --- did not take any decisions suggested by ADGAME, 100% --- took all decisions suggested by ADGAME)

___a. At the first four periods
___b. At the second four periods
___c. At the last four periods

5. What is your opinion about the benefit that can be gained from ADGAME? (1 = no benefit to 5 = great benefit). Tick all of the following which apply.

___a. Gain competitive advantage
___b. Make efficient use of company's resources (labour, money, etc.)
___c. Make more profit
___d. Improve users' management skill
___e. Make decisions quickly and save manager's time.
___f. Make effecient use of company's information
___g. Help the manager to consider more factors before making decisions.
___h. Others, please specify, ______________________________________

6. How do you rate the benefit that each department manager can obtain from ADGAME? (1 = no benefit to 5 = great benefit)

___a. General Manager
___b. Production Manager
___c. Sales Manager
___d. Marketing Manager
___e. Personnel Manager
___f. R & D Manager
___g. Financial Manager
___h. Other, Please specify ______________________________

7. What is your general view about ADGAME as an aid for decision making? ___ (1 = not at all effective to 5 = very effective)

8. What is your general view about ADGAME as an aid for decision making at the different stages of playing the game? (1 = not at all effective to 5 = very effective)

___a. At the begining
___b. In the middle
___c. Towards the end

If possible, can you explain your answer briefly here please?

______________________________
______________________________
______________________________
______________________________
______________________________

8. How easy was it to understand the data input questions in the data input window? ___(1 = very difficult to understand to 5 = very easy to understand )

9. How easy was it to understand the other questions (apart from the data input questions) which ADGAME asked you to answer? ___(1 = very difficult to understand to 5 = very easy to understand ) ____

12. What was your opinion about the system's explanations? - were they?

___a. Clear (1 = not at all clear to 5 = very clear)
___b. Helpful (1 = not at all helpful to 5 = very helpful)
___c. The right amount (1 = too little explanation to 5 = too much explanation)

13. Please rate the helpfulness of the different ways in which advice was presented ( 1 = not at all helpful to 5 = very helpful).

___a. Precise decisions
___b. Decision ranges
___c. General advice

If you have any further comments you wish to make about ADGAME, please write them here.

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

# SOME SURVEY RESULTS ABOUT ADGAME

**(The 1992A-Experiment)**

*(There are twenty-five student teams in the game and six teams which is 24% had used the advisory system ADGAME.)*

1. Did your team use the advisory system ADGAME when playing the business game? **24%(Yes)/76%(No)**

If "Yes" go to question 2.

If "No", could you explain the reasons please? Tick all of the following which apply.

**73%**___a. We thought the team could perform well without using ADGAME.
**4%**___b. We don't know what an expert system is.
**15%**___c. We had no time to use it.
**5%**___d. The Access to ADGAME was not convenient.
**0%**___e. We were told it was not easy to use.
**46%**___f. We didn't think it was worth the charge for it.
**21%**___g. Other, please specify

___________________________________________

Stop here and ignore questions 2 to 13.

*******************************************

*(There are 35 students returned the questionnaire about ADGAME. The following data is the results of the survey.)*

2. How did your team decide to use ADGAME?

**55%**___a. Majority vote in the team meeting
**48%**___b. By the general manager
**12%**___c. According to individual interest in the team
**3%**___d. Other, please specify___________________

3. In how many periods did your team use ADGAME to help you make decisions? **3.46**

4. Can you describe roughly what percentage of the decisions your team made followed the suggestions of ADGAME? **73%** (0% --- did not take any decisions suggested by ADGAME, 100% --- took all decisions suggested by ADGAME)

5. What is your opinion about the benefit that can be gained from ADGAME? (1 = no benefit to 5 = great benefit). Tick all of the following which apply.

**3.58**___a. Gain competitive advantage
**3.41**___b. Make efficient use of company's resources (labour, money, etc.)
**2.96**___c. Make more profit
**2.27**___d. Improve users' management skill
**2.70**___e. Make decisions quickly and save manager's time.
**3.32**___f. Others, please specify,_________________

6. How do you rate the benefit that each functional role obtained from ADGAME? (1 = no benefit to 5 = great benefit)

**3.09**___a. General Manager
**2.79**___b. Production Manager
**2.50**___c. Sales Manager
**2.54**___d. Marketing Manager
**2.59**___e. Personnel Manager
**2.66**___f. R & D Manager
**2.14**___g. Financial Manager
**1.50**___h. Other, Please specify _________________

7. What is your general view about ADGAME as an aid for decision making? 3.18 (1 = not at all effective to 5 = very effective)

If possible, can you explain your answer briefly here please?

____________________________________________

____________________________________________

8. Did you use ADGAME personally (i.e. "hands-on")? Yes/No ___ **33%(Yes)/67%(No)**

If "yes", then go to question 9.

If "No", tick all of the following which apply.

**5%**___a. I didn't want to use it
**32%**___b. Others had more time to use it than I did
**14%**___c. Others are better at using computers than I am
**5%**___d. Others found it easier to access ADGAME than I did
**27%**___e. ADGAME wasn't as appropriate for my job as for others
**41%**___f. Other, please specify________________

Stop here and ignore questions 9 to 13.

9. Why did you decide to use ADGAME? Tick all of the following which apply.

**69%**___a. We thought it would help make better decisions
**46%**___b. We thought it would save time
**0%**___c. We thought it would resolve disagreements
**31%**___d. We thought it would be good "value for money"
**23%**___e. We wanted to try something new
**0%**___f. We like using computers
**8%**___g. We thought we were expected to
**54%**___h. We thought we needed all the help we could get
**0%**___Other, please specify________________

10. How easy was it to understand the data input questions in the data input window? 3.55 (1 = very difficult to understand to 5 = very easy to understand )

11. How easy was it to understand the other questions (apart from the data input questions) which ADGAME asked you to answer? 3.25 (1 = very difficult to understand to 5 = very easy to understand )

12. What was your opinion about the system's explanations? - were they?

**3.64**___a. Clear (1 = not at all clear to 5 = very clear)
**3.42**___b. Helpful (1 = not at all helpful to 5 = very helpful)
**3.00**___c. The right amount (1 = too little explanation to 5 = too much explanation)

13. Please rate the helpfulness of the different ways in which advice was presented ( 1 = not at all helpful to 5 = very helpful).

**3.83**___a. Precise decisions
**3.25**___b. Decision ranges
**3.00**___c. General advice

If you have any further comments you wish to make about ADGAME, please write them here.

______________________________________________
______________________________________________
______________________________________________
______________________________________________
____

Thank you for completing this questionnaire. Please return it to **your tutor at the last session of tutorial (Thursday 19 March).**

## SURVEY RESULTS ABOUT ADGAME

**(The 1992B-Experiment)**

1. In which team were you involved (A3,B5 etc)? ________

2. Did you play the game before? Yes/No ____**60%(Yes)/40%(No)**

If "Yes", do you think you performed better than you did before? Yes/No **100%(Yes)**

3. In how many periods did you use ADGAME to help you make decisions? ___**8**

4. Can you describe roughly what percentage of the decisions you made followed the suggestions of ADGAME in the different stages of playing the game? (0% --- did not use any decisions suggested by ADGAME, 100% --- took all decisions suggested by ADGAME)

**82**___a. During the first four periods
**78**___b. During the second four periods
**81**___c. During the last four periods

5. What is your opinion about the benefit that can be gained from ADGAME? (1 = no benefit to 5 = great benefit). Tick all of the following which apply.

**3.5**___a. Gain competitive advantage
**4**___b. Make efficient use of company's resources (labour, money, etc.)
**3**___c. Make more profit
**2.75**___d. Improve users' management skill
**3.75**___e. Make decisions quickly and save manager's time.
**4.25**___f. Make efficient use of the company's information
**3.6**___g. Help the manager to consider more factors before making decisions.
**3.8**___h. Provide more consistent advice for decision making
___i. Others, please specify, ______________________________

6. How do you rate the benefit that each department manager can obtain from ADGAME? (1 = no benefit to 5 = great benefit)

**4**___a. General Manager
**3.8**___b. Production Manager
**3**___c. Sales Manager
**3.8**___d. Marketing Manager
**3.6**___e. Personnel Manager
**3.8**___f. R & D Manager
**3.2**___g. Financial Manager
___h. Other, Please specify

_______________________________________________

7. What is your general view about ADGAME as an aid for decision making? ___**4.2** (1 = not at all effective to 5 = very effective)

8. What is your general view about ADGAME as an aid for decision making at the different stages of playing the game? (1 = not at all effective to 5 = very effective)

**4.2**___a. At the beginning
**4.2**___b. In the middle
**3.4**___c. Towards the end

If possible, can you explain your answer briefly here please?

_______________________________________________
_______________________________________________
_______________________________________________
_______________________________________________
_______________________________________________

8. How easy was it to understand the data input questions in the data input window? ___**4** (1 = very difficult to understand to 5 = very easy to understand )

9. How easy was it to understand the other questions (apart from the data input questions) which ADGAME asked you to answer? ___**3.6** (1 = very difficult to understand to 5 = very easy to understand ).

12. What was your opinion about the system's explanations? - were they?

**3.4**___a. Clear (1 = not at all clear to 5 = very clear)
**4.4**___b. Helpful (1 = not at all helpful to 5 = very helpful)
**3.6**___c. The right amount (1 = too little explanation to 5 = too much explanation)

13. Please rate the helpfulness of the different ways in which advice was presented ( 1 = not at all helpful to 5 = very helpful).

**4.2**___a. Precise decisions
**4.6**___b. Decision ranges
**3.2**___c. General advice

14. The time spent(in minutes)

**37**__ a. Average time of all players.
**57**__ c. Average time of players with the help of ADGAME
**27**__ d. Average time of experienced players with the help of ADGAME
**23**__ b. Average time of experienced players without help of ADGAME

## COMMENTS FROM ADGAME USERS

### The 1992A-Experiment

### Group A6

**Marketing Manager**

Why did you not get our tutors to introduce us to ADGAME and show us how to use it and to get familiar with the system.

**Managing Director**

When Analysing the decisions suggested, the financial implications may have been disastrous - however, the ADGAME highlighted the use of comparing other companies' R&D and Marketing expenditures.

### Group E4

**Sales Manager**

Suggested options we had never even considered such as 800 hours overtime.

**Managing Director**

For the one period ADGAME was used, a high profit was made, however we did not agree with the direction the system suggested.

**Marketing Manager**

The advice given by ADGAME was helpful to managers, but in order to know more about the usefulness of the decisions we would have had to use it more.

One problem I found with ADGAME is that it seems to be an easy way out. I felt that it was doing a job I should have been doing and by letting it make my decisions it was almost defeating the point of me trying to learn through my own success or errors.

**Personnel Manager**

Using ADGAME we made a profit for the first time in many periods.

**Financial Manager**

It is affective, but it stops you from making your own decisions which results in you not knowing how well you could do.

**Group C2**

**Sales Manager**

Helped us reverse some poor decisions and get us on the right track.

**Personnel Manager**

Aids decision making but overrides the real objectives of the course - to learn how to make our decisions.

**Marketing Manager**

We made such shit decisions, any help had to be an improvement.

**Group D4**

**Personnel Manager**

The ADGAME was not able to advise in view of what our aim and strategy was.

**Group A2**

**Sales Manager**

Although it was time consuming, ADGAME was particularly useful by providing support for decisions already made, i.e. we would make decisions and compare them to those offered by ADGAME.

**Managing Director**

It takes a long time to work through the information and it should be provided earlier in the game. It is useful for individual department e.g. especially Production.

**Production Manager**

Some advice conflicted e.g. It advised we produce only 1200 but that we use all

10 production units.

### Group A3

**Assistant Managing Director**

Quiet effective - added a different perspective and helped us to keep our objective - quality in mind.

**R & D Manager**

Increased competitive advantage i.e. market niches (R&D) -- all rose to above average levels.

**Sales Manager**

We had had a hiccup in our decision making and the ADGAME sorted us out in 2 periods although I feel we could have done this ourselves.

**Production Manager**

Using ADGAME's recommendations pushed us into over capacity, high stock levels etc.

**Personnel manager**

Compare to own decisions and compare tactics.

**Managing director**

Less analysis of decisions.

## The 1992B-Experiment

### Team F1

To begin with, good guide to help get started. in middle - wanted pursue other aims not covered by ADGAME which lead to problems. Hence ADGAME useful at end of game to try and put right.

ADGAME helped in method of explaining factors behind (e.g.) pricing decisions in export market(take advantage of competitors). However, advice give to me over overtime( period 23) not very helpful - massive increase in cost (about 60,000) for just an additional production of about 1000) units - perhaps a problem here?

**Team G1**

In the initial stage no one is very "adventurous", so ADGAME isn't vital, as no one is leading the market in any area yet. However, as the game progress, ADGAME helps you counter market leaders, and helps you understand and cope with the greater divergence of the companies.

**Team F5**

Beginning is very helpful since not to sure of what are doing but towards end you have your own ideas of what's going on.

**Team F4**

It is effective to understand the rule and the function of the game at the beginning. But is not very helpful to find out a new solution, once the company is facing a big problem in the middle and the end of the game.

If possible, to make more options to cope with complexity of the reality.

**Team G2**

The system helped to make sense of the mass of data on the reports early on, but once the company was running smoothly it was very much the same old thing. When I ran out of material as I tried to expand my market share, the system was very good at getting me out of trouble quickly.

It was hard to get answer to "what if" questions since it demanded data in a strict order, and adjusting a few variables to see their effect was time-consuming.

I'm sure it asked for the number of operators more than once!