An Economic Appraisal of Management Information.

by

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ABSTRACT.

The principal aim of this study is to produce a methodology for the economic appraisal of management information. It is not claimed that the methodology will work for all management information but it is considered appropriate in the majority of cases.

The first stage in the methodology is the production of a management information needs framework. This framework will have at least two level; management's present and management's potential information needs. The information needs framework is then extended into an information value and cost framework. This extension is carried out by first ordering the needs framework in order of importance to the manager of the information. One of three methods of valuation can then be used to place a value on the information which enables its economic viability to be determined.

A series of empirical studies were carried out to determine how successfully such a methodology can be operated by management. These empirical studies indicated that management can determine information needs reasonably successfully although they might need assistance to estimate potential information needs. The studies also suggested that management have problems in determining quantitative values and costs and so would need some form of training programme to carry out this part of the methodology. The thesis also contains a number of case studies relating to specific management information problems.

ACKNOWLEDGEMENTS.

I would especially like to thank my supervisor, Mr.P.W.Gay, for his help, ideas and encouragement which have contributed greatly to this thesis; also to the late Prof.P.A.Losty, *1, for help and guidance in the early stages.

I wish to thank the North Staffordshire Polytechnic for providing finance and granting time to enable the completion of the research. In particular I would like to thank Mr. A.J.H.Kitley and members of staff and students from the Department of Management Studies for their help in the studies carried out.

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Last, but not least many thanks to my wife Christine for the many hours spent typing.

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*1 Cranfield School of Management, Cranfield Institute of Technology.

*2 Joint Managing Directors of the Company used in the Company Information Study.

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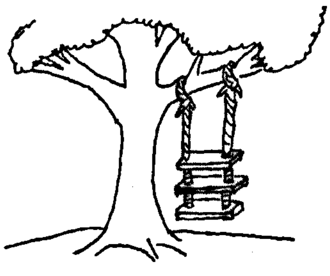

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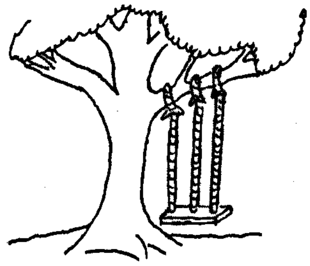

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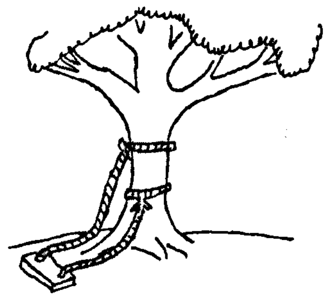

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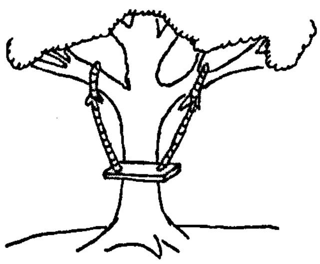

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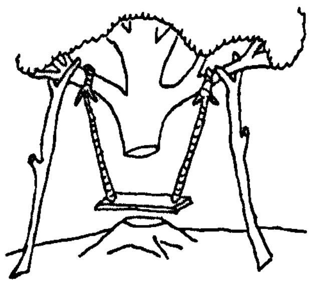

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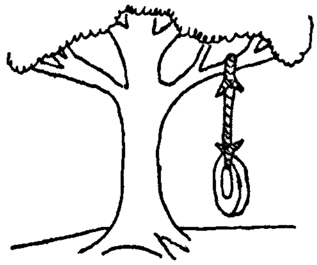

WHAT THE CUSTOMER WANTED

CHAPTER 1. INTRODUCTION.

The principal aim of this study is to produce a methodology for the economic appraisal of management information. It is not suggested that the following methodology will work for all management information but it is considered appropriate to the large majority of management information. The methodology involves the determination of managers' information needs. This information is then valued and costed to determine the information's economic viability.

The study is split into three main parts these being chapters two, three and four. Chapter two covers the analytical background of the study containing definitions of the process of management, management information and management information systems. This chapter also contains sections on the measurement of uncertainty, decision analysis and simulation. Chapter three is the central core of the study in which a methodology for the economic appraisal of management information is developed. This methodology is based on the determination of managers' information needs, then the valuation and costing of this information to determine its economic viability. Chapter four reports on the empirical studies carried out to test the effectiveness of the methodology. The work in this chapter summarises the studies the bulk of the study material being given in Appendices A to F.

The fifth and final chapter of the study summarises the conclusions.

1.1. INTRODUCTION TO CHAPTER TWO.

Chapter two provides the analytical background of the study. It establishes the basis on which the other chapters are built.

The first section of the chapter examines the processes involved within management. It is important when talking of management information to have a clear understanding of the function of management. Two definitions of the work of management are given, the first being the classical definition based around three activities: Planning, Motivating and Decision Making. The second is a definition outlined by Mintzberg (1973) who suggests that management's work is based on three roles: Interpersonal Roles, Informational Roles and Decisional Roles. If a comprehensive definition of management is to be produced then both definitions will be required. The classical definition using such activities as planning, motivating and decision making provides a good vehicle for looking at management systems. It will not work too well when talking to individual managers because the managers do not think in the terms used in the definition. When talking to individual managers the terms used by Mintzberg will have more direct meaning. The problem with Mintzberg's definition is that it is difficult to apply to management systems. Therefore to provide a comprehensive definition the classical definition is best used when describing managment systems, and Mintzberg's management roles are best used when talking to the individual manager about his job and in describing the individual manager's job.

The second section of the chapter provides a definition of management information. It draws a distinction between information and data although this distinction is seldom made by managers in practice. The ways in which managemant information can be subdivided are then examined. Information can be concerned with the internal or the external environment. It can be formal information or data ie. information or data committed to record or as part of a formal system of the organisation (this is using the term recorded in the accepted management sense ie. ledgers, files, computer tapes, and discs, etc.). It can be informal information and data that is not part of any formal system of the organisation. It can be committed to 'record' or to an individual's brain and usually it is available to a limited number of individuals and not the organisation as a whole (here the term record is used in the sense of an individual manager's record which will be available only to the manager or a limited number of individuals). There can be a third class of management information and data this being potential information and data although by definition some of this will fall outside the management information of the organisation.

The third section provides a definition of a management information system which can be briefly defined as: a series of entities which help the process of management by the provision of information and data, or in some cases hinder the process of management by the provision of misinformation, either due to poor information or data or the variable nature of the data. A management information system must by this definition be a large complex system made up of a large number of sub-systems some of which could be dynamic (especially informal systems). The Management Information System must be able to provide information and data about the internal and external environment at both a formal and informal level. It must also be able to deal with the possibility of potential information and data.

These first three sections provide definition of the process of management, management information and management information systems to be used in the sections and chapters to follow. The last three sections of this chapter fulfill a slightly different need. An important principal to remember when providing information is to provide the knowledge for the understanding of that information before the information itself. Within this thesis I shall attempt to practice what I preach. These three sections are intended to provide the background knowledge to help the reader to understand better some sections in chapter three.

Section four examines the measurement of uncertainty within the management field. It compares different ways of measuring uncertainty: words, odds, proportions and probabilities, and then gives the basic laws of probability (including Bayes' Theorom). Subjective probabilities are then considered as a basis for the setting of probabilities within certain areas of the management field and a series of heuristics are considered. Uncertainty is important when considering the value of information. The value of some information is accrued because this information reduces the amount of uncertainty, to consider this reduction methods of uncertainty measurement must be used. A knowledge of probability theory is also required to fully understand decision analysis which is used in chapter three as a method of valuation.

Section five of chapter two develops decision analysis from classical statistical decision analysis to the analysis of decision trees. Also considered is Bayesian Decision Theory, and the relationship between decision trees, simulation and other quantitative techniques.

The final section of the chapter, section six, examines simulation a technique whose use is considered a number of times in chapter three. The section starts by looking at the different types of simulation models ie. iconic, analogue and symbolic. It then considers the construction, verification and validation of simulation models. The application of simulation models in prediction is considered as a means of providing of information to management. Interactive simulations are also considered for they can be used to train managers in the setting of subjective probabilities and in the subjective setting of information value and costs. The final part of this section considers the simulation of information systems which can vary from simple analogue models showing typical information systems outputs to full scale simulated running of the system to verify and validate the system and its relationship to its environment.

1.2. INTRODUCTION TO CHAPTER THREE.

This chapter is the core of the study and outlines the production of a methodology for the economic appraisal of management information. It builds on the analytical background covered in chapter two.

The chapter starts with an examination of some of the myths surrounding management information. The ten myths of Tricker (1971) and the five myths of Ackoff (1967) are used as a base within this section.

In the summary of this first section there are listed twelve pitfalls that should be avoided when information systems are designed.

The second section of the chapter examines some basic concepts in the economic appraisal of management information. Six factors are listed which are to be taken into account when information is valued, these being: time, the speed at which the information can be obtained and is required; knowledge, the knowledge level of the recipient/s of the information; prior information, the amount and type of other information that is available to assist with the decision the piece of information is to be used for; accuracy, the accuracy of the information (this may be subjective dependent on personality); quantity, the size of the piece of information or the amount of information available for a particular decision; and finally power, information can be closely linked to power, and as a result this may enhance the value of the information to the individual but not necessarily to the organisation.

The main part of the production of methodology now starts with section three the determination of the information needs of managers. The information will have to be split into at least two levels. The first being to determine the present information needs of managers. This can be partially carried out by using systems and O & M techniques of interviews, diaries, etc., and charting the information flows that exist in the organisation at present. Although this approach can be considered a step in the right direction the existing information flows do not necessarily represent managers' present information needs. The existing information may not give all the information the manager needs and it may give some information the manager does not need or some information the manager does not understand. The existing information can only be turned into a true reflection of management's present information needs by careful discussion with managers. Care should be taken not to ask simplistic questions such as 'what information do you need' otherwise simplistic answers such as 'I do not know' or 'all the information you can give me' will be given. Managers need information to carry out their functions so any discussion of information needs must relate to this function. The second level of information needs are managers' potential information needs. Needs at this level are more difficult to determine because the managers may only have a vague notion of them due to incomplete knowledge. To get a picture of this second level of needs various specialists may need to take part in the discussions. This second level needs to be examined so as to build into the present system the flexibility to expand as managers' knowledge expands bearing in mind that knowledge should always precede information.

Having determined the information needs the next stage of methodology is to determine its value and this is considered in section four of this chapter. Having determined that the information is needed has by implication put a value on it. However, merely to say it has value is not sufficient the value needs to be quantified. In the fourth section four methods of valuing information are examined, the first being what has been called the classical approach that of statistical decision theory. This approach is that suggested by the majority of references to the valuing of information. It uses classical decision theory and/or Bayesian analysis to arrive at a value. The second method of valuation of information uses simulation models but due to the expense of producing such models they are unlikely to have any practical application. However, simulations do have an application in interactive gaming simulation used in the training of managers in some of the heuristics in method four. The third method has been called the accounting approach to information valuing. There are two approaches within this method of valuation; first to determine the cost of not having the information and then equating this cost to a value and second to determine the savings accrued due to using the information i.e. the savings from carrying out a project. The fourth method is by using a series of estimation heuristics to arrive at a value. In putting a value on all the information identified as needed then all the methods, with the exception of the second, will be required due to the differing nature of the information.

The next stage in the methodology is the determination of the cost and this is examined in section five of the chapter. This section sets out the terminology involved when costing management information and examines methods of arriving at costs. This is followed by the outline of a method for determining the cost of management information.

Section six examines the techniques of cost benefit analysis and cost effectiveness analysis and their use in the economic appraisal of management information. Both these techniques have been mainly used in the evaluation of public utilities. By combining the two techniques and modifying them slightly it is possible to arrive at a technique (cost benefit analysis of management information) for relating cost to value and determining the economic viability of the information.

Section seven of the chapter is entitled Management Information Consultation and looks at the role of the information analyst as an internal consultant within the organisation. The aim of this section is to add to the methodology some assistance to the information analyst in dealing with some of the behavioral problems that could be encountered when carrying out the other parts of the methodology. This section is a guide to the work of other people in this area and considers the problems involved in dealing with individual managers and when dealing with groups or teams of managers.

The final section of the chapter, is a summary entitled, Methodology for the Economic Appraisal of Management Information. It brings together all the other sections in the formation of a methodology concerned with information needs value and cost.

1.3. INTRODUCTION TO CHAPTER FOUR AND APPENDICES.

Chapter four is concerned with the empirical studies. The bulk of the detailed work of the studies has been included in the six appendices. Three types of study have been carried out. The first is a detailed look at the overall management information system of one company. The second type of study was carried out by observing the way in which management students, all of whom were practicing managers, solved certain problems presented as tasks and case studies. The third type of study isolates certain applications within the area of management information in case study form.

The first study was a detailed study of a company's management information system. Areas examined were the way in which it determined its information needs and decided what information to produce and not produce, the way in which it valued and costed information and whether the proposed methodology is valid and would be of value. The summary of the study and the conclusion drawn from it are given in section two of chapter four. Appropriate extracts from systems manuals and summaries and conclusions from various interviews and group discussions are given in Appendix A, A Company Information Study.

The second study examines the information needs of personnel management. This study involved students from the Institute of Personel Management Membership course. The students were asked to determine the information needs of the typical personnel department, the benefits of the information and the resources required to produce this information (because of the general nature of this study it would be unrealistic to expect the student to produce specific values for the information value and the information cost). A description of the study, the methods employed by the groups, summary of the results and the conclusions of the study are given in section three of chapter four. The full report produced by each group is given in Appendix B, Personnel Management Study.

The third study examines the marketing information system of a particular company. A case study was written describing the marketing information system of a company (the system in the case was a very poor one). Students attending a residential period as part of studies for a Diploma in Management Studies were then asked to examine the case and say how they would improve the system. A description of the study, the methods employed by the groups, summary of the results and the conclusions of the study are given in section four of chapter four. The case study and the full report produced by each group is given in Appendix C Marketing Information Study.

The fourth study is also based on a task set before and during a residential period for groups of Diploma in Management Studies Students. They were set the task of producing a blue print for starting a small business. The task was set some time before the residential to give the students time to gather background information. The study examines the information used. Extracts of the reports produced are given in Appendix D Small Business Information Study (detailed cash flows, etc., have not been included in this appendix). A description of the study, the methods employed by the groups, summary of the results and the conclusions from the study are given in section five of chapter four.

The last two studies are presented in case study form. Concord Insulators Ltd., is a case study constructed around a decision analysis problem. The full case study is given in Appendix E and a summary is given in section six of chapter four. This case has been produced to show a method of producing a value of the piece of information itself and also to show the size to which a realistic example of a decision analysis can grow. Robert Livesey and Sons Ltd. is a case study concerned with the implementation of a cost control system. The full case study is given in Appendix F and a summary is given in section seven of chapter four. This case study shows the two basic problems that can occur when a specialist system is implemented, these being a lack of understanding by managers of the information produced and the lack of credibility of the information to the managers who do understand.

CHAPTER 2. ANALYTICAL BACKGROUND.

This chapter of the Thesis is concerned with the analytical background of the research project. It starts by examining the processes involved in management and then goes on to provide a definition of management information and management information systems. Since one of the prime functions of management information is the reduction of uncertainty a section on uncertainty has been included. The last two sections of this chapter are concerned with decision analysis and simulation.

Detailed Contents of Chapter 2.

2.1. THE PROCESS OF MANAGEMENT.

Henry Fayol one of the pioneers of management in 1916 defined management in the following way:
"All activities to which industrial undertakings give rise can be divided into the following six groups

1. Technical activities (Production, manufacture, adaption).
2. Commercial activities (buying, selling, exchange).
3. Financial activities (search for the optimum use of capital).
4. Security activities (protection of property and persons).
5. Accounting activities (stocktaking, balance sheet, costs, statistics).
6. Managerial activities (planning, organisation, command, co-ordination, control).

Be the undertaking simple or complex, big or small these six groups of activities or essential functions are always present." *1

This was one of the first definitions of management and in general is still a valid one although it could be said that sections one to five are contained within section six. Section six is widely used today as a definition of management with decision making identified as a separate activity.

*1 FAYOL (1949 Page 3)

A typical modern definition which clearly owes much to Fayol would claim that management would consist of the following:

1. Planning.
2. Motivating which can be divided into
   (a) Leadership.
   (b) Organising.
   (c) Co-ordinating.
   (d) Controlling.
3. Decision Making.

As Honey and others have pointed out it is useful to recognise there are two aspects of management, management of things and the management of people, each having its own particular problems. *1

This definition of management will now be examined in detail in order to explore its implications for the information needs of management.

2.1.1. PLANNING.

Steiner defines planning and plans as:
"Planning is a basic function of management. It is a mental process of thinking through what is desired and how it will be achieved......Plans, are commitments to specific courses of action growing out of the mental process of planning." *2

*1 HONEY (1968)
*2 STEINER (1969 Page 8)

This is general in nature and for a more specific definition we can take Denning's definition of corporate planning:

"A formal, systematic managerial process, organised by responsibility, time, and information, to ensure that operational planning, project planning and strategic planning are carried out regularly to enable top management to direct and control the future of the enterprise." *1

This definition of planning indicates the range of activities that management should ideally be carrying out although in practice it is not necessarily quite so formal or systematic as suggested. Denning then goes on to suggest there are three levels of planning, Strategic, Operational and Project planning.

The distinction between strategic and operational planning levels is clear, it is difficult though to differentiate between project planning and the first two. Project planning will have to be carried out at either the strategic or operational level and so will not provide a separate level of planning. Therefore, I shall only consider two levels of planning which may be further defined as follows:

Strategic Planning:- Strategic planning is concerned with the position of the organisation in its changing external environment, i.e. the deter-

*1 DENNING. (1971 Page 2)

mination of the corporate plan and strategy. This will include such things as future market potential, management style, etc. It may also be concerned with projects and their inter-relations to the organisation. Strategic plans are usually concerned with the medium and long term periods and are broad in concept.

Operational Planning:- Operational planning is concerned with the implementation of the strategic plans. This will include the planning for all the existing operations of the organisation, e.g. plant and machinery, existing markets, etc. Operational plans are usually concerned with the short term period and are specific in nature.

Denning suggests the characteristics of the two levels of planning are as shown in Figure One. These characteristics will help in the definition and determination of the information requirements of the two levels of planning. *1

These characteristics are general in nature but they do outline some of the more important differences between the levels of planning. The separation of the levels of planning is also used by Ansoff although with slightly different terminology. *2 He suggests that the difference between the levels of planning is in the width of the decisions taken i.e. Policy decisions are

*1 DENNING. (1971 Page 6)
*2 ANSOFF. (1965)

Figure One: The Characteristics of the Two Levels of Planning.

TYPE OF PLANNING	AMOUNT OF UNCERTAINTY INVOLVED	RELEVANCE OF THE EFFECTIVENESS OF JUDGEMENT	PROBLEMS ARISING OUT OF ERROR
STRATEGIC PLANNING	Large	Large	Very grave could endanger life of organisation
OPERATIONAL PLANNING	Small with the short term plans but will increase with the length of time involved	Small	Tends to be only a short term loss in profit

NOTE: Denning included a third type of planning in his original diagram.

wider than strategic decisions which in turn are wider than tactical decisions. The difference between the two classifications is that Ansoff has separated the policy plans from the strategic plans and called the operational plans tactical plans. It can also be seen that Ansoff has firmly introduced decision taking into Planning.

Within each level of planning there will clearly be various types of plan, Murdick suggests the following five categories:
single use, repeat, standing, standby and reject plans.
*1

1) Single use plan is the type of plan used to achieve one particular goal and is never used again, e.g. the operational plan for the installation of a particular computer system.

2) Repeat plan is the type of plan for use in stable situations to provide for a given set of conditions which may or will repeat themselves in the future, e.g. the strategic plan for introduction or replacement of computers under stable conditions would possibly remain the same and so become a repeat plan.

3) Standing is a refinement of the repeat plan but one that automatically goes into operation

*1 MURDICK. (1971 Page 49)

at a given trigger or time interval, e.g. a stock control policy, stock levels are set and action is taken when these levels reach a certain value.

4) Standby plan is a plan that has been drawn up to cope with a given set of conditions should they occur, e.g. The Government's plan with regard to petrol rationing in 1973 is an example of a standby plan.

5) Rejected plan is a plan that has been drawn up but has been rejected although the rejection may be due to condition changes and not a fault in the plan, e.g. a plan to open a new factory which has been rejected due to a downward trend in demand although this may of course become a standby plan for the time demand begins to rise again.

The category into which a plan falls may change over time due to changing conditions, etc. Also any plan may be modified in its life, this modification may or may not change the plans category.

The processes involved within planning must now be considered. Denning has produced a chart to show the long range or corporate planning process. *1
This has been modified in figure two to include the operational planning process.

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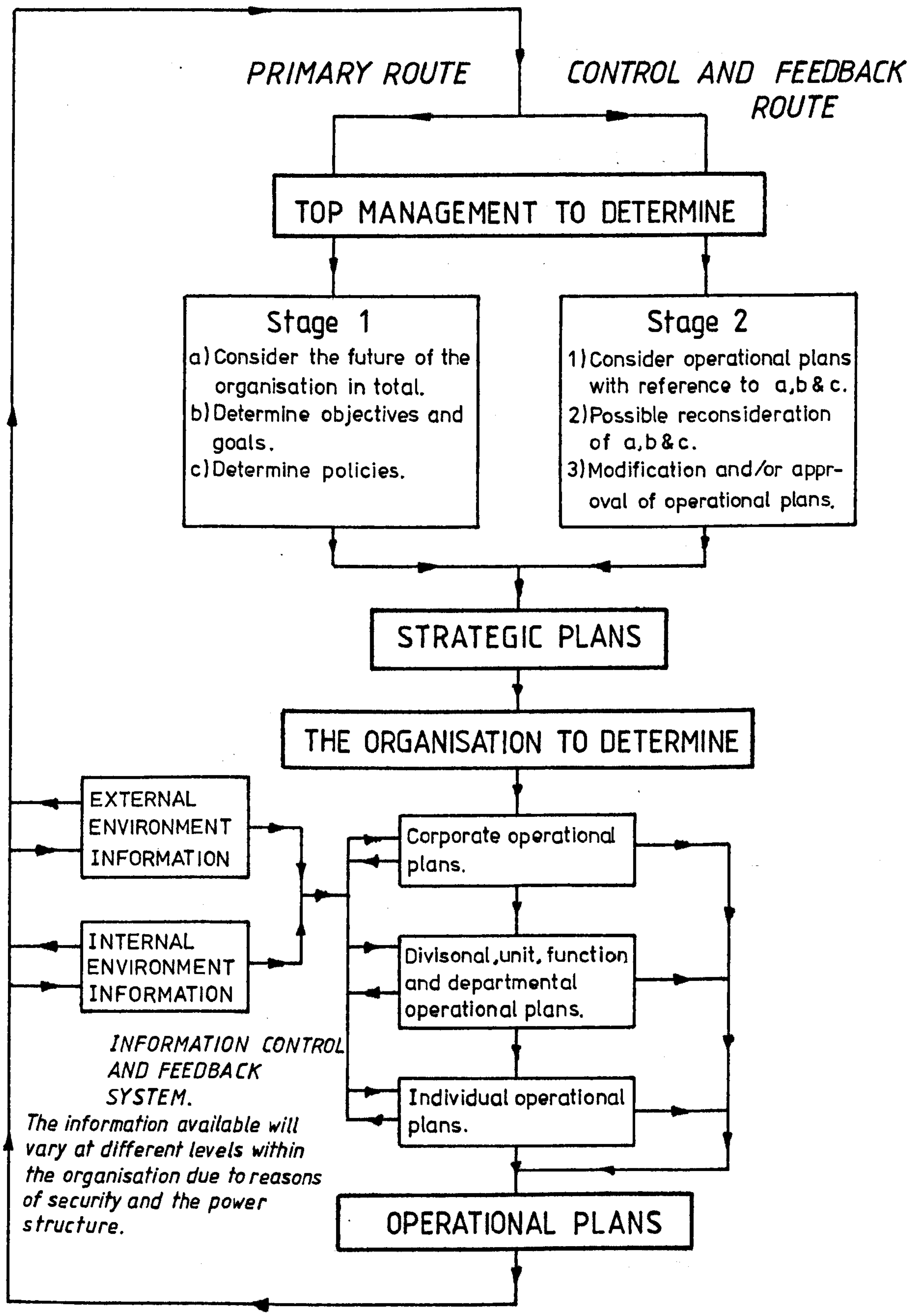
*1 DENNING. (1971 Page 55)

Figure Two: Outline Process Involved in Planning.



This diagram outlines the different levels at which plans are produced. Using information concerned with the external and internal environment top management set the strategic plans, which may be refined later when the feasibility of operational plans is considered. The whole organisation then expands these strategic plans into operational plans which are produced at varying levels throughout the organisation.

Johnson, Kast and Rosenzweig suggest that a comprehensive systems approach to planning would include the following steps. *1

1. Appraising the future political, economic competitive and technological environment.

2. Assessing the long run value, interests and aspirations of managers and other participants.

3. Visualising the desired socioeconomic role of the organisation in its future environment.

4. Analysing the organisation's resources and capabilities for fulfilling the desired role.

5. Designing a corporate strategy which matches the future environment, values and aspirations, desired socioeconomic role, and organisational resources.

*1 JOHNSON, KAST AND ROSENZWEIG. (1967 Page 55)

6. Developing specific objectives and strategic plans which will direct the efforts of the total organisation.

7. Translating this broad planning into functional efforts on a more detailed basis: research, design and development, production,distribution and services.

8. Developing more detailed planning and control of resource utilisation within each of these functional areas, always related to the overall planning effort.

9. Providing a system of communications and information flow whereby organisational members can participate in planning processes.

10. Designing an information feedback and control system to determine the progress and problems in the implementation of plans.

The process of planning defined so far provides a good model of how planning should be carried out within organisations. Organisations carrying out good planning will be following procedures similar to the model. The effectiveness of planning will vary considerably across all organisations depending on the management development of the organisation.

The setting of objectives is an important part of planning, but this should not be confused with the technique of Management by Objectives put forward by Humble, which is merely a method of setting performance objectives for management control and will be considered in more detail in section 2.1.2.

The classification of objectives has been considered over a period of time by management theorists. A variety of classifications have been suggested but the most widely accepted view is the one proposed by Ackoff. *1, and supported by others. He suggests a divisions into stylistic and performance objectives.

Stylistic objectives are involved with the management style of the company and they tend to be non-quantifiable in nature; an example of this form of objective would be to improve labour relations or to improve management style by management education.

Performance objectives are objectives which can be quantified and are the type that individual managers tend to be trying to achieve although they can of course apply to the company as a whole. There is however, a tendency within some organisations not to quantify these objectives with the result that they then lose all meaning and cease to be objectives, e.g. a general reduction in waste rates is not an adequate performance objective it would be better to aim for a reduction of

*1 ACKOFF (1970 Chapter 2)

10% in waste rates assuming that the level is a realistic one.

It is possible to get complex objectives which could be a mixture of the two containing stylistic objectives and going through to performance objectives. Such a complex objective could be split into its component parts but makes more sense when kept together.

In addition to classifying objectives into two types it is useful to consider in relation to the two levels at which planning is carried out. *1 It will be recalled that the two levels are strategic and operational (tactical). Strategic objectives relate to the strategic plans of the organisation and are therefore concerned with large long term changes of state. Operational objectives relate to the operational plans of the organisation and are therefore concerned more with the short term and may be localised in nature. Strategic objectives tend to be a mixture of stylistic and performance objectives where as Operational objectives tend to be predominantly performance objectives.

2.1.1. MOTIVATING.

The motivating aspect of management can be split into four categories, leadership, organising, co-ordinating and controlling.

Leadership: This is the process by which an individual exerts an influence on the behaviour of others within

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*1 LOSTY. (1970 (1))

the organisation. McGivering *1 with reference to McGregor *2 states:

> "The current view, therefore, is that the leader cannot usefully be considered apart from the situation in which he exercises his leadership and that his personal characteristics and abilities are seen as only one variable amongst others.
>
> 1) the personality of the leader.
> 2) the expectations and needs of the followers.
> 3) the structure of the group and the immediate situation which confronts it.
> 4) the wider cultural environment within which the group is located."

Although leadership is an important part of motivating there are many other factors which will affect the motivation of an individual. The amount of motivation an individual can create in others will depend upon his personality or "Charisma" (coined by Max Weber) which tends to be fixed and only marginally subject to development. The more charisma an individual has the more he will be able to motivate others.

Organising, Co-ordinating and Control: Leadership is an important part of organising and co-ordinating the plans and decisions of management, although the other factors which involve motivation must now be considered. Vroom and Deci in a review of work in the field of

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*1 MCGIVERING (1976)
*2 MCGREGOR (1960)

motivation *1 put forward three approaches to the motivation of individuals to complete a task.

The first of these a paternalistic approach, is based on the assumption that individuals will be motivated to complete given tasks if they are satisfied by these tasks i.e. the more one rewards and satisfies the needs of the individual the more is achieved. Within this approach rewards are given unconditionally to the members of the organisation to increase motivation, i.e. pension plans, group insurance, comfortable working conditions, etc. However, work reviewed by Brayfield and Crockett *2 shows there is little relationship between job satisfaction and motivation. However, there is a relationship between job satisfaction and staff turnover, i.e. individuals who are satisfied with their job are more reluctant to leave than people who are not satisfied with their job.

The second approach to motivation is based on the scientific management methods of Taylor *3. This is also based on rewards but these are not unconditional and the system also makes use of penalties. The rewards and penalties are directly linked to the performance of the individual, e.g. promotion or lack of, the apportionment of pay rises, etc. A considerable amount of work has been carried out in this field of reward and penalty and the psychologists have termed it the Law of Effect, which suggests that rewards and

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* 1 VROOM AND DECI (1970 Page 9 - 19)
* 2 BRAYFIELD AND CROCKETT. (1955)
* 3 TAYLOR. (1947)

penalties will motivate the individual to a degree. There is, however, a problem in determining what rewards to offer. As Maslow *1 suggests, individuals have a large number of needs of varying degree from individual to individual. Therefore, any reward will have a differing effect from individual to individual dependent on that individual's needs. There must with this system be an effective method of measurement of performance and an assessment of an individual's needs to ensure appropriate rewards.

The third approach to Motivation has been suggested by McGregor *2 and Likert *3 and Maier and Hayes *4 and has often been called participative management. It is a development of the first two approaches in that it has the paternalistic approach and uses the rewards and penalties but in addition as its name suggests it allows the individual to participate in the management of the organisation. These ideas have been used by Humble *5 in the development of his motivating technique '<u>Management by Objectives</u>'.

Humble defined M.B.O. as
"A dynamic system which seeks to integrate the company's need to clarify and achieve its profit and growth goals, with the managers need to contribute and develop himself." *5

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*1 MASLOW. (1943)
*2 MCGREGOR. (1957)
*3 LIKERT. (1961)
*4 MAIER & HAYES. (1962)
*5 HUMBLE. (1968)

M.B.O. involves the setting of company objectives from which each division, department and section has to develop its own detailed objectives. In addition planning implementation and control of these objectives is carried out. The main stages in the M.B.O. process as put forward by Humble are as follows.

1. Analyse Opportunities and Plan:- Indentification by top management of areas requiring improvement remembering that all levels of management should be allowed to contribute to the identification of problems and constraints and the setting of target levels of achievement. This analysis must be extended to form strategic and operational plans.

2. Company Objectives:- Prepare short and long term objectives to enable the operational plans of the organisation to be carried out by management.

3. Unit, Function and Department Objectives:- To analyse the company objectives and the actions that need to be carried out to achieve them. Determine what part in these actions each unit, functions and department must take. The majority of these objectives at this level will tend to be of the performance type.

4. Key Results Analysis:- Each manager with his superior must now be involved in using the objectives set in stage 2 and 3 to determine the key results which

the manager must achieve. The manager and his superior must agree performance standards based on these key results which are compatible with the company and department objectives.

5. Improvement Plans:- This stage is an extension of the key result analysis and it is usual for it to be carried out during the key result stage. During this stage the problems to be overcome are identified and discussed. Group and individual plans are drawn up by the manager and his superior, with the aim of achieving the objectives decided upon.

6. Control and Review:- The agreement of appropriate control information for the performance objectives agreed in the key results analysis. The frequency of the control information agreed will also be agreed by the manager and his superior. The Manager and superior have to periodically review the progress and results achieved against the key analysis and improvement plans. This control and review stage however, does not end at the individual level, as the results are also reviewed against the company, function and department objectives in the preparation of the next set of short term objectives.

The whole M.B.O. process is cyclic and continuous. M.B.O. becomes effective only when it becomes the style of management of the organisation and this must include all levels of management and all managers. Care must be taken in the setting of the objectives for they should be realistic. They should not be too difficult or too easy to meet, this realistic level being difficult to find. There is a danger when the formalised system of M.B.O. is used within the larger organisation for it to become institutionalised thus tending to reduce or damage the natural flair and spontaneity of management.

Stages one to four in the M.B.O. process could in fact perform a valuable role in the planning process shown in figure two. However, in most organisations M.B.O. is used purely to set performance objectives and not as an integrated part of planning.

2.1.3. DECISION MAKING.

Although decision making is an integral part of the planning and motivating process it is best considered in its own right. Forrester suggests:-

> "Decisions are made at multiple points throughout the system. Each resulting action generates information that may be used at several but not all decision points. This structure of cascaded and interconnected information-feedback loops, when taken together, describes the industrial system. Within a company, the decision points extended from the shipping room and the stock-clerks to the board of directors." *1

*1 FORRESTER (1961)

Decisions are taken at all levels of management and are the basis of management itself. Many attempts have been made to classify the types of decision taken by management. Simon *1, suggests that decisions can be of two types "Programmed" and "Non-Programmed" and others agree with this basic division but use slightly different terminology. Forrester *2 calls them "implicit" and "overt" and Blumenthal *3 calls them "analytic" and "synthetic". Simon's category titles seem to be more explicit than the others therefore these are the ones I shall use. The word programmed should not be taken to mean that this type of decision is carried out by computers. Simon defines his two categories as follows:

> "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 will not have to be treated de nova each time they occur....
>
> Decisions are non-programmed to the extent that they are novel, unstructured and consequential. There is no cut and dried method for handling the problem because it has not arisen before, or because its precise nature and structure are elusive and complex or because it is so important that it deserves a custom-tailored treatment." *4

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*1 SIMON. (1960)
*2 FORRESTER. (1961)
*3 BLUMENTHAL. (1965)
*4 SIMON. (1964)

Although Forrester *1 classifies decisions into two groups he feels that there is no distinct border between the two which would appear to be more realistic. Decisions can also be multiple and within this multiplicity they can be of the two types. For example the suite of decisions concerned with stock control. The first decision is that taken to introduce stock control and the type of control to be used. To an organisation that has not used stock control previously this type of decision will be new and novel and will, therefore, be non-programmed, but to an organisation which has used stock control previously the application of stock control in another unit could well be a programmed decision (i.e. working to a previous procedure). The actual setting of stock levels and the application of these stock levels will be a series of programmed decisions. A decision may change categories dependent on the organisation in which it is being applied.

The classification of decisions having been considered the processes involved within decision taking can now be explained. A part of decision taking is problem solving. Indeed it could be said that almost all decision taking should be preceded by some problem solving. The two should not be confused and in any management application the two will not necessarily be carried out by the same people, for example

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*1 FORRESTER. (1961 Page 99)

specialists may use problem solving techniques but the manager actually takes the decision. Looking at the processes involved in decision making Simon has put forward the following general problem solving model.*1

The problem solving model is organised around aims of three types.

i) Transformation Aims:- to transform object one into object two.

ii) Difference Reduction Aims:- to eliminate or reduce differences between objects one and two.

iii) Operator Application Aims:- to apply an operator to object one to reduce differences between object one and two.

For each of these aims is a method of achievement associated with it, these being:-

1) Methods for transformation aims; to transform object one to two.
   - (i) Notice a difference between object one and two.
   - (ii) Establish the aim of reducing difference between object one and two.
   - (iii) Try to obtain the new aim.
   - (iv) If successful, find a new difference and repeat.

2) Method for difference reduction aims, to reduce difference between object one and two.
   - (i) Recall an operator that is relevant to differences of the type already defined.

*1 SIMON. (1964)

(ii) Establish the aim of applying the operator to object one.

(iii) Try to obtain this new aim.

(iv) If successful, return to the previous transform aim.

3) Method for operator application aims, to apply operator to one object.

(i) Compare conditions for application of operator to object one.

(ii) If these are not satisfied, establish and try to attain the aim of transformation of object one into an object that meets these conditions.

(iii) When the conditions are satisfied, apply operator to object one and return to the previous differences reduction aim with the modified object one.

These methods give a simplified description of problem solving. The Problem Solving Model is a model which reasons about ends and means. It is capable of defining ends, seeking means to attain them and in the process of so doing, defining new subsiduary ends, or sub-goals to the original end.

Simon's model gives a general problem solving model to extend this to describe the decision making process requires some further work.

Operational Research by definition is an aid to management decision making. Churchman, Ackoff and Arnoff *1 suggest the following stages for the application of O.R.

" 1) Formulating the problem.
2) Constructing a mathematical model to represent the system under study.
3) Deriving a solution from the model.
4) Testing the model and the solution derived from it.
5) Establishing controls over the solution.
6) Putting the solution to work 'implementation'. "

Moore *2 defines the phases of O.R. as:-

" a) Definition of the problem and objective.
b) Representation (or model) of situation.
c) Test of model against actual conditions.
d) Analysis of model to select optimum conditions to meet objective.
e) Pilot implementation test.
f) Implementation. "

By using the above two descriptions of the O.R. approach and the general problem solving model it is possible to construct a model of the decision taking process this being given in figure three.

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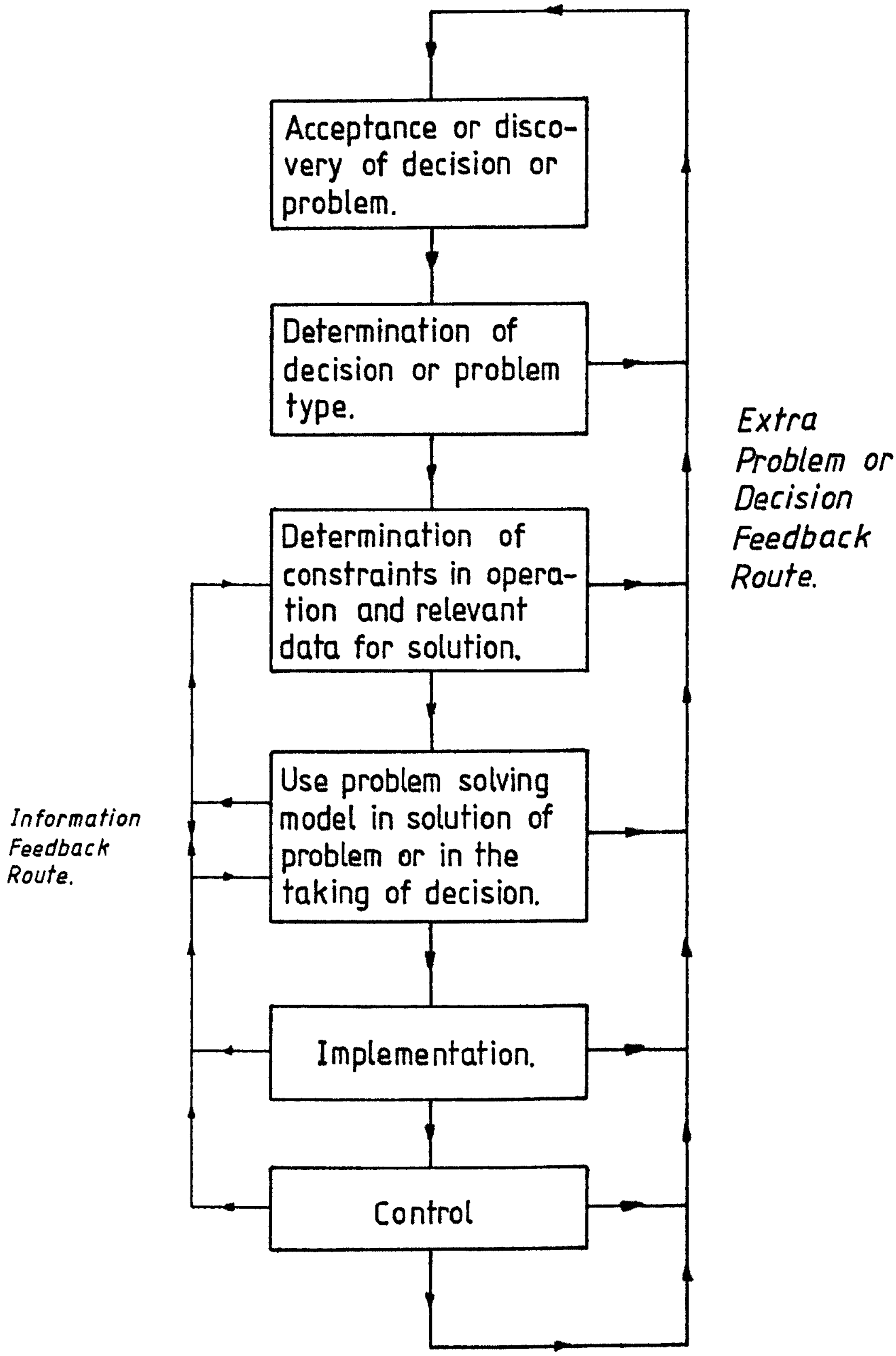
*1 CHURCHMAN, ACKOFF & ARNOFF (1966 Page 13)
*2 MOORE. (1976 Page 11)

Figure Three: The Decision Process.



The model consists of the following six stages:-

1) Acceptance or discovery of the decision or problem. This is the stage when decisions or problems are sought or where decisions or problems are accepted.
2) Determination of decision or problem type. This stage is where the decision is put into broad categories to determine the area of responsibility or the area of solution.
3) Determination of constraints in operation and relevant data for solution. This is a stage where initial constraints are identified and initial data and information on the situation is sought out. There will be a feedback to the start of the process at this stage because of the possibility of discovering further decisions or problems.
4) Use problem solving models in solution or in the taking of decisions. This is the stage where decisions are taken and/or problems solved. Within this stage will be used the techniques or decision taking aids developed in recent years, e.g. statistical analysis, decision analysis, simulation and many other O.R. techniques. There will be an information feed-back route to stage three for the collection of further information or data and the further clarification of the constraint in operation on

the system. Also at this stage there will be a feedback to the start of the process because of the possibility of discovering further decisions or problems.

5) Implementation. This is the stage that is concerned with the implementation of the decisions or the solution of the problem. It is here where motivation becomes of great importance for here it is necessary to motivate people to follow the decisions or solutions to the problems. There will be a feedback route from this stage to stage 4 to allow problems of implementation to be built into the decision or solution to the problem. Also at this stage there will be a feedback to the start of the process because of the possibility of discovering further decisions or problems.

6) Control. The implementation of decisions require a control to be kept on them so as to determine:-

   (i) Assessment of decisions:- to determine the degree of success of the decision to be used when taking decisions of a similar nature in the future so as to attain more successful results.

   (ii) Change of Conditions:- to monitor the implementation to ensure that it is being carried out to plan (especially important when new and complicated systems are being introduced).

Also at this stage there will be a feedback to the start of the process because of the possibility of discovering further decisions or problems.

The process will basically be the same for both programmed and unprogrammed decisions. However, for the programmed decision stage three and four will be replaced by the looking for the standard pattern to use which will have its standard implementation and control system.

2.1.4. THE WORK OF HENRY MINTZBERG.

The definition of management so far produced is very useful when describing management systems but it tends to break down when talking to the individual manager. A large proportion of managers find it difficult to talk in terms of this classification. Few managers think in terms of 'now I shall plan' or 'now I shall motivate'. Mintzberg *1 has taken a different approach from the classical management theorists. He starts from a series of studies of what managers actually do (both his and the work of others) and has arrived at ten roles that managers carry out.

Mintzberg has not identified any new aspects of managerial work his contribution has been to reclassify the work in line with the way managers think. Mintzberg does not suggest that his classification is definitive, it is only a start in classifying management in a way that is meaningful to managers.

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*1 MINTZBERG. (3 papers, a thesis and a book)

Mintzberg places managerial roles in three groups. Group one the interpersonal roles of which there are three, Group two the informational roles of which there are three and Group three the decisional roles of which there are four.

2.1.4.1. INTERPERSONAL ROLES.

(i) Figurehead Role:- In this role the manager is required to carry out a number of social, inspirational, legal and ceremonial duties. The manager must also be available to people who require to deal with him because of his status and authority.

(ii) Leader Role:- This role is where the manager must try to co-ordinate the needs and aims of the individuals with the needs and aims of the organisation and to motivate his subordinates to these ends.

(iii) Liaison Role:- This role is concerned with the manager's dealings with other organisational units. These may be with other organisational units within his own organisation or may be with other units from the external environment. For example a sales manager will deal with more units from the external environment and production manager will deal with units mainly from the internal environment.

The manager spends a considerable amount of time performing this role developing a network of contacts in which information and favours are traded for mutual benefit.

Through the leader and liaison roles, the manager gains access to privileged information and he emerges as the 'nerve centre' of his organisation. He alone has formal access to every subordinate in his own organisation, and he has unique access to a variety of outsiders, many of whom are nerve centres of their own organisations. This leads onto the next set of roles.

2.1.4.2. INFORMATIONAL ROLES.

(i) Monitor Role:- "As monitor the manager continually seeks and receives internal and external information from a variety of sources to develop thorough knowledge of milieu. Because a good part of this information is current and non-documented , the manager must take prime responsibility for the design of his own information system, which is necessarily informal. Managers in new jobs, particularly, spend considerable time on the monitor and liaison roles in order to build up their information systems and bring themselves up to the level of knowledge needed for effective strategy making." *1

(ii) Disseminator Role:- "As disseminator the manager transmits some of his internal and external information to subordinates. In this way, he maintains their only access to certain priveleged information (and to an extent his position of power). Some of this information is of a factual nature; some relates to the values of the organisation's influencers." *2

(iii) Spokesman Role:- "As spokesman the manager transmits information to individuals outside his organisational unit. He acts in a public relations capacity, lobbies for his organisation, informs key influences, tells the public about the organisation's performance, and sends useful information to his liaison contacts. Furthermore, the manager must serve outsiders as an expert in the industry or function in which his organisation operates. Managers of staff groups, because their sub-units are highly specialised and oriented to analysis, spending considerable time in this expert capacity as well as giving relatively more attention to the other informational roles." *3

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*1 MINTZBERG. (1973 Page 167)
*2 MINTZBERG. (1973 Page 168)
*3 MINTZBERG. (1973 Page 168)

2.1.4.3. DECISIONAL ROLES.

(i) Entrepreneur Role:- In the role of entrepreneur the manager is responsible for much of the 'controlled' change in the organisation. It may be a direct control or may be some form of delegated control.

(ii) Disturbance Handler Role:- In the role of disturbance handler the manager takes charge when his organisation is threatened. The threat can be internal or external. This role will increase when the organisation is in a period of innovation.

(iii) Resource Allocator Role:- In the role of resource allocator the manager decides on the allocation of his organisational unit's resources and thereby maintains control of its strategy-making process. This role is carried out in three ways. Firstly the manager by scheduling his own activities sets the priorities for the rest of his organisation unit. Secondly the manager determines the work schedule of his unit, he decides what will be done and by whom (the further up the organisation the more general the 'by whom' becomes). Finally the manager authorises the actions required.

(iv) Negotiator Role:- "Finally as negotiator the manager takes charge when his organisation must have important negotiations with another organisation. As figurehead he represents his organisation, as spokesman he speaks for it, and as liaison and resources allocator he trades resources in real-time with the opposite party." * 1

Another important aspect of Mintzberg's work in connection with management information systems and in particular management information needs is the analysis of the characteristics of managerial work.

To identify these characteristics he uses his own studies and the studies of a large number of other workers in this field, the full list of whom can be found in Mintzberg's book 'The Nature of Managerial Work'. *2

Mintzberg suggests that the work of management can be characterised by its brevity, variety and fragmentation, these factors being ones which the managers grow to like. Managers appear to prefer the more active elements of the job carrying these elements out in preference to the others. This is reflected in the way in which the manager deals with his mail (documented information). Little of his mail is concerned with live action, consequently dealing with mail often becomes a chore for managers, much of the mail only getting a superficial inspection.

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*1 MINTZBERG. (1973 Page 169).
*2 MINTZBERG. (1973 Appendix A, Page 199).

Some ineffective managers may like routine work as they can hide behind such work. Such routine work is then likely to give them little time to carry out the other aspects of the managers work which they perform badly.

The Manager has five media through which he can carry out his function:-

1) Mail (documented).
2) Telephone (partly verbal).
3) Unscheduled meetings (informal face to face).
4) Scheduled meetings (formal face to face).
5) Tours (observational).

The evidence from the studies shows the manager clearly favours the three verbal media, spending most of his time in verbal contact.

On the basis of these characteristics of management Mintzberg suggests that there is a need to reprogram the information system of managers. This is best considered with reference to the three basic areas of the managers information system, monitoring, storing and disseminating.

2.1.4.4. THE MONITORING SYSTEM.

The manager needs to monitor and to carry this out he needs information. A large portion of this information is of the following three types.

1. Current Information. The manager requires information to be current, and studies have shown

he appears to be not so concerned with the accuracy but with the speed that he receives it. For example "Rumour takes time to become substantial fact, and it takes even longer for that fact to find its way into a quantitative report." *1 This would appear a valid point. It would seem that from Mintzberg's work senior management at least reject Myths number five, (that accuracy is of vital importance). There is, however, a danger that the manager falls into the trap of the fourth myth (for information to be available instantly increases its usefulness). *2

2) Trigger Information. The manager prefers his information to contain triggers which link it to specific objectives,he wishes to hear of specific events, ideas and problems.

3) Verbal Information. Due to the preference of the manager for the more verbal media a large portion of the information a manager seeks and receives is in a verbal form.

By their nature these forms of information put the manager in conflict with the formal information system of the organisation. The manager seeks information of a current, speculative or trigger kind, but the formal information system provides him with largely historical, precise,aggregated information. The formal system deals mainly with control and regulation information (budgets,

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*1 MINTZBERG. (1973 Page 171).
*2 SEE SECTION 3.1.4. and 3.1.5.

costs, production, programs, etc.), essential to the specialist for carrying out his specialist function (although not necessarily his management function). It does not include the intelligence information required by senior management for their strategic decisions (these usually being of the unprogrammed type) or the information which is also needed concerning the external environment.

2.1.4.5. THE MANAGER AS A DATA BANK.

This conflict usually makes it necessary for the manager to design his own system (usually mainly verbal) to collect the information he requires. Although most of the manager's extra information can be provided this way such a system is usually crude, inconsistent and incomplete. It can only be an incomplete system because the manager does not have verbal contact on a regular basis with all members of his organisation who could provide him with information of value. Another problem with manager's personal information systems is summarised by the following quote from Mintzberg.

"Today the manager is the real data bank for an important class of organisational information. Unfortunately he is a walking and talking data bank, but not a writing one. Herein lies the problem. When he is busy, information ceases to flow. When he departs, so does the data bank." *1

This conflict between the manager's system and the formal system stems from a lack of consultation and

*1 MINTZBERG. (1973 Page 150)

understanding between the manager and systems designer/ information analyst. Managers must take and be allowed to take a much more active role in the design of information systems. This does not mean to say that the manager's information system requires to be formalised, which could in fact destroy the effectiveness of it. An attempt to semi-formalise, but not to automate the system could succeed to make it more consistent and complete, although not more accurate as the base data and information remains partly speculative. To carry out effectively the semi-formalisation of the information system there has to be a greater degree of trust and a better relationship between the manager and systems designer/information analyst. The semi-formalisation means that the manager must pass on information he obtains personally to the system along with information arriving from different sources. Such information needs to be stored in some type of data bank and because of its vital and strategic nature various types of security problems are likely to arise.

2.1.4.6. THE DISSEMINATING SYSTEM.

An important role of the manager is the disseminating of information to his subordinates. This tends to be carried out verbally and is dependent on the availability of the manager's time. These difficulties could be overcome by semi-formalising the manager's information system but the manager may not wish all the information to be available to all subordinates.

Some systems designers/information analysts live in a utopian world of data bases with total access by all members of the organisation. This availability problem will probably be a major difficulty in the setting up of such systems. Most managers manage from a power base, this power base being maintained by the manager's control of the availability of information to others. For a manager to commit such information to a free system would probably mean his committing organisational suicide. When devising such a semi-formalised system the analyst must realise that no manager will commit all his information to such a system and some of the information released will be for restricted circulation only. A manager's confidence will grow with such a system as it proves to be secure to his requirements.

2.1.5. SUMMARY.

The classical definition works well when talking in terms of management systems. Management can be said to consist of the following:-

1. Planning.
2. Motivating which can be divided into
   (a) Leadership.
   (b) Organising.
   (c) Co-ordinating.
   (d) Controlling.
3. Decision Making.

1) Planning.

Plans can be at two levels; strategic or operational. Within these two levels, plans can be of five types: single use, repeat, standing, standby or reject plans although any particular plan may change its type. over time or due to a change in conditions.

2) Motivating.

This is concerned with the implementation of the plans or decisions and the most effective way to motivate people in the implementation of plans or decisions would appear to be that of participative management. This style of management has the paternalistic approach and uses rewards and penalties but as its name suggests it allows the individual to participate in the management of the organisation. It is here the the technique of Management by Objectives may be used.

3) Decision Making.

Decisions can be categorised into two types, programmed and unprogrammed, although this categorisation does not have a clear border.

When talking of the behavioral aspects of managers the classical definition tends to break down because the terms used in it are not the ones readily used by managers. Mintzberg reorganises the classical definition into a series of ten roles which better fit the behavioral aspects of the manager's function. These ten roles are divided into three groups as follows.

(1) Interpersonal Roles.

(i) Figurehead Role.

(ii) Leader Role.

(iii) Liaison Role.

(2) Information Role.

(i) Monitor Role.

(ii) Disseminator Role.

(iii) Spokesman Role.

(3) Decisional Roles.

(i) Entrepreneur Role.

(ii) Disturbance Handler Role.

(iii) Resource Allocator Role.

(iv) Negotiator Role.

It is vital that any person operating in the field of management information understands what management is about and is able to converse with managers in their own terms both at the management systems level and the behavioral aspects level.

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PATERSON (1967)
PORTER & ROBERTS (1977)
ROSE (1978)
STEWART (1963 & 1967)

2.2. DEFINITION OF MANAGEMENT INFORMATION.

The Oxford Dictionary defines information to be:-

> "Telling; what is told, knowledge, items of knowledge, news", and Management to be:-
> "Conducting the working of, have effective control of, bend to ones will, cajole."

Management has also been defined in great detail in section 2.1. Therefore, Management Information can be described as knowledge, items of knowledge and news required to ensure the effective working and control of an organisation. A distinction must be drawn here between data and information. Data are facts and figures which become information after analysis and interpretation have set them into context of particular needs. Managers are usually aware of the distinction between data and information although in practice they rarely use it and call all inputs information.

Losty has suggested that Management Information can be subdivided in the following way. The various types of management information are concerned with two areas. The Internal Environment, involves information about the state of the company, its strength, weaknessess and all its operating characteristics. The External Environment involves information about the type of environment within which the organisation is operating. *1

There are two types of management information and data,

*1 LOSTY. (1970 (2)) and NAUGHTON (1974 Page 23) these being formal and informal. These may be defined in the context of the business organisation as follows:-

Formal Information and Data, is the information and data that is committed to record or is part of a formal system of that organisation, e.g. balance sheets, accounts, computer files, production schedules, etc.

Informal Information and Data, is the information and data that is not part of any formal system of the organisation. It can be committed to 'record' or to an individuals brain and usually it is available to a limited number of individuals and not the organisation as a whole, e.g. the internal political situation, the 'black books' made by people just in case! *1

It could be argued that a third possible class of management will exist, this being potential information and data although some of this by definition will fall outside the management information of the organisation.

External Potential Information and Data, is information and data that exists outside the organisation and of which the organisation is unaware. This information may be of value to the organisation and could be collected or assimilated by them, e.g. Government Statistics, information about the market which could be obtained by market reserach, etc.

Internal Potential Information and Data, is information and data which is within the organisation but its whereabouts or existence is unknown by a member of the organisation to whom such information and data would be

*1 LOSTY. (1970 (1) & (2))

of use.

The relevance of information must also be considered, this will vary for different pieces of information and can also vary for any single piece of information, dependent upon the application it is being used for. Information Theorists define the amount or degree of relevance of a piece of information as the effect that piece of information has on reducing the uncertainty associated with particular event or set of events. *1 This concept will be further explored in the latter sections on value.

SUMMARY.

There is a difference between data and information, data (raw facts and figures) becoming information when some meaning or value has been given to them,although most managers do not draw such a distinction in practice. Management Information and data within the organisation can be concerned with two areas the internal and external environment of the organisation and can be of two types either formal or informal. We must also recognise potential information and data as a third category. Some of this by definition falls outside the management information of the organisation although it may be of value. Any piece of information will have a 'degree of Relevance' for any application it is being used in.

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*1 NAUGHTON (1974 Page 4) and KEMPNER (1976 'Information Theory').

2.3. DEFINITION OF MANAGEMENT INFORMATION SYSTEMS.

System is a word used today within modern management theory and in other fields. The following list of definitions put forward by various authors in the field of management and information shows the spectrum of the use of the term 'system'.

> "An assemblage or combination of things or parts forming a complex or unitary whole." *1

> "A set of objects with a given set of relationships between the objects and their attributes." *2

> "A set of objects together with the relationships between the objects and between their attributes." *3

> "The basic notion of a system is simply that it is a set of inter-related parts." *4

> "A system is a set of objects with relationships between the objects and between their attributes." *5

> "An array of components designed to accomplish a particular object according to plan." *6

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*1 STEIN. (Page 1230)
*2 OPTNER. (1965 Page 26)
*3 YEAR BOOK FOR THE ADVANCEMENT OF GENERAL SYSTEMS THEORY. (1956)
*4 TILLES. (1963)
*5 HALL. (1962 Page 60)
*6 JOHNSON, KAST & ROSENZWEIG. (1976 Page 113)

"A system is a device, procedure, or scheme which behaves according to some description its function being to operate on information and/or energy and/or matter in a time reference to yield information and/or energy and/or matter." *1

"A system is a network of related procedures developed according to an integrated scheme for performing a major activity of the business." *2

"A system is a complex of inter-related entities." *3

The following is an attempt to synthesise the important features of the above definitions.

A system is a series of entities either physical or non-physical that exhibits a set of inter-relations among themselves and interact towards one or more goals, objectives or ends. These goals, objectives, or ends may or may not be achieved and the end could be intentional or accidental. The entities can be physical entities such as men, machines, etc., or they may be non-physical such as management activities (planning and motivating) or they may be ideas, concepts, etc. The entities could also be other systems, (i.e. sub-systems making a large complex system).

A Management Information System may be defined as a series of entities which help the process of management

*1 ELLIS & LUDWIG. (1962 Page 3)
*2 NEUSCELL. (1960 Page 10)
*3 ACKOFF. (1962 Page 121)

by the provision of information and data, or in some cases hinder the process of management by the provision of misinformation, either due to poor information or data or the variable nature of the data. A Management Information System must by this definition be a large complex system. It must be able to provide information and data about the internal and external environment at both a formal and informal level. It must also be able to deal with the possibility of potential information and data.

The large complex Management Information Systems will be made up of a large number of sub-systems some of which could be dynamic (especially informal systems). The sub-system can be either formal or informal or they could be a combination of the two. They may be concerned with the internal or the external environment or a combination of the two. There may also be sub-systems for the analysis or the provision of potential information or data. The sub-systems produced as part of the formal system of the organisation will as a whole be far easier to identify and record than informal sub-systems, this being due to the dynamic nature of informal sub-systems.

2.4. THE MEASUREMENT OF UNCERTAINTY.

In the measuring of uncertainty managers talk of uncertainty in such phrases as:-

probable	hoped	expected
quite certain	possible	doubtful
unlikely	not certain	
likely	not unreasonable that	

Moore and Thomas *1 took these ten phrases and asked 250 executives, on middle and senior general management programmes at the London Business School and elsewhere to rank them in order of certainty.

The following results were obtained:-

Phrase	Average rank	Range of Ranks.
Quite certain	1·10	1 - 3
Expected	2·95	1 - 6
Likely	3·85	2 - 7
Probable	4·25	2 - 9
Not unreasonable that	4·65	3 - 7
Possible	6·10	3 - 9
Hoped	7·15	3 -10
Not certain	7·80	3 -10
Doubtful	8·60	7 -10
Unlikely	8·75	3 -10

As can be seen from the above table each phrase can be taken to imply a different degree of uncertainty by different managers and only two of the 250 executives arrived at the same ranking. There are of course far more phrases that managers use in practice to describe uncertainty, thus compounding the problem. Further investigations by Moore and Thomas also show that managers

*1 MOORE AND THOMAS. (1975)

were not consistent with their ranking over time. Thus it would seem that phrases and words are not a suitable vehicle for measuring uncertainty because of the varying interpretation managers can place on them.

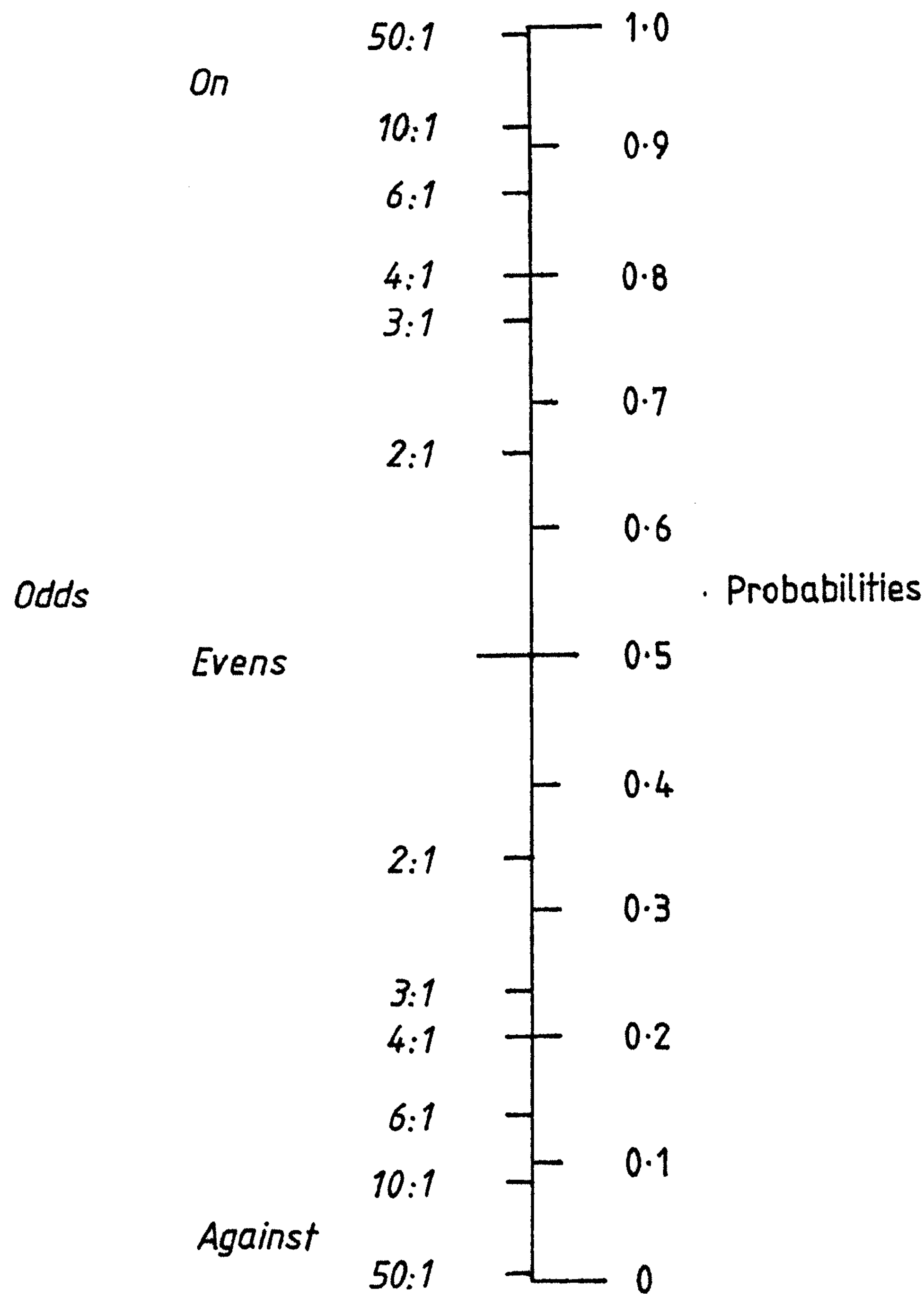
It would appear that a better approach would be to use a numeric measure. There are a number of measures that could be used for example:odds, proportions or probabilities. Odds are commonly used in the world of racing and are referred to in the form 2 to 1 against, 10 to 1 against, 2 to 1 on, etc. Ehrenberg *1 defines probability in the following manner.

> "The probability of a particular event occuring can be any number from 0 to 1. If the event is part of a steady series, then the probability of the given outcome should equal the proportion of times that event occurs in the series. That is how the numerical value of the probability is often arrived at in the first place."

A probability of 0 represents absolute certainty an event will not occur 1 represents absolute certainty an event will occur. Probabilities are closely linked to proportions, e.g. a probability of 0•5 corresponds to a proportion of 50%. Probabilities are preferable to proportions for two major reasons; firstly probabilities are easier to work in a mathematical sense and secondly probabilities can be used to refer to individual events whereas proportions can only refer to groups of events.

*1 EHRENBERG. (1975 Page 214)

Figure Four: The Relationship Between Odds and Probabilities.



Odds can be used to refer to uncertainty. Figure four, taken from Moore and Thomas *1 relates odds to probabilities.

Odds can be of advantage in referring to uncertainty when the manager has a good working knowledge of them. However, when both odds and probability are unknown to the manager then odds are probably less comprehensible than probability. Odds also suffer two other major drawbacks; 1) odds are not easily worked mathematically, 2) odds are thought of only in integer steps, the scale is of a non linear form and so there are parts of the scale relatively devoid of points unless odds such as 11:4 are resorted to.

It would therefore seem that the best measure of uncertainty is by the use of probabilities. The concept of probability must now be examined in more detail.

2.4.1. <u>BASIC LAWS OF PROBABILITY</u>.

Murdoch and Barnes * 2 give the following three important laws of probability.

"1. <u>Addition Law of Probability</u>:- This law states that if A and B are mutually exclusive events, then the probability that either A or B occurs in a given trial is equal to the sum of the separate probabilities of A and B occuring.

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*1 MOORE & THOMAS. (1975)
*2 MURDOCH & BARNES. (1973 Page 2 -4)

In symbolic terms this law can be shown as

$$P(A \text{ or } B) = P(A) + P(B)$$

This law can be extended by repeated application to cover the case of more than two mutually exclusive events.

Thus $P(A \text{ or } B \text{ or } C\ldots) = P(A) + P(B) + P(C) + \ldots$

These events of this law are mutually exclusive events, which simply means that the occurrence of one of the events excludes the possibility of the occurrence of any of the others on the same trial.

2. <u>Multiplication Law of Probability</u>:- This law states that the probability of the combined occurrence of two events A and B is the product of the probability of A and the conditional probability of B on the assumption that A has occurred.

Thus $P(A \text{ and } B) = P(AB) = P(A) \times P(B/A)$ where $P(B/A)$ is the conditional probability of event B on the assumption that A occurs at the same time (or prior).

While this law is usually defined as above for two events, it can be extended to any number of events.

3. Independent Events:- Events are defined as independent if the probability of the occurrence of either is not affected by the occurence or not of the other. Thus if A and B are independent events, then the law states that the probability of the combined occurrence of the events A and B is the product of their individual probabilities. That is:-

$P(AB) = P(A) \times P(B)$."

Given these three laws of probability this makes it possible to mathematically relate multiple events.

It is important when considering the measurement of uncertainty that the type of data being considered should be known. There are two basic types of data, continuous and discrete. Continuous data as its name suggests can take any value (although in practice the range of possible values may be limited) for example sales figures. Discrete data can take only a given set of values, usually a set of positive integers for example the number of strikes in an organisation per year, i.e. 0, 1, 2, 3, 4,........ etc., there can never be 1·5 strikes per year. The probability calculation will vary depending on the type of data being considered.

In recent years the Bayesian Approach to conditional probability has become popular. The 'Bayesian Approach' *1 is basically to take prior information and convert it to 'prior probabilities' and then by using Bayes' Therom these are converted into 'posterior probabilities.'

Bayes Therom is as follows:- Given that the event A can occur only if one of the mutually exclusive events B_1, B_2 ,.......B_n has occurred before it. The B's may precede A in time or may occur simultaneously B_1......B_n

$$P(B_i/A) = \frac{P(B_i) \times P(A/B_i)}{\sum_{j=1}^{n} P(B_j) \times P(A/B_j)}$$

Bayes Therom is best considered in terms of an example. Three urns contain the following proportion of coloured balls.

	Urn 1 (U_1)	Urn 2 (U_2)	Urn 3 (U_3)
White	1	1	4
Black	2	1	5
Red	3	1	3

If a sample of two balls of which one is white and the other is red, is taken from one urn without knowing

*1 WHITTLE. (1976 Page 86-87) & RAFFA (1968) which urn is being sampled, what is the probability that the urn sampled is:-

(a) Urn 1 (U_1)

(b) Urn 2 (U_2)

(c) Urn 3 (U_3)

It would seem reasonable to assume that each of the urns are equally likely to occur.

$$P(U_i) = \tfrac{1}{3} \qquad i = 1,2,3.$$

Conditional probability for the event that has occurred (A i.e. One white and one red ball drawn).

$P(A/U_1)$ = Probability of event A given it was from urn 1.

= P(white) and P(red) or P(red) and P(white)

= $1/6 \times 3/5 + 3/6 \times 1/5$

= $1/10 + 1/10 = 2/10 = 1/5$

Similarly

$$P(A/U_2) = 1/3$$
$$P(A/U_3) = 2/11$$

Substitute in Bayes Therom

$P(U_1/A)$ = Probability that Urn 1 was used given that event A has occurred.

$$P(U_1/A) = \frac{1/3 \times 1/5}{(1/3 \times 1/5) + (1/3 \times 1/3) + (1/3 \times 2/11)}$$

$$= \frac{33}{118} = 0{\cdot}28$$

Similarly

$$P(U_2/A) = \frac{55}{118} = 0{\cdot}42$$

$$P(U_3/A) = \frac{30}{118} = 0{\cdot}25$$

It could be argued that so far the cart has been put before the horse; all that has been considered is the use and further calculations of probability with no mention of how probabilities are arrived at.

The classical statistical approach to the calculation of probabilities given in the statistical texts is that probability of a particular event occurring is given by the number of occurrences of the event divided by the total number of all occurrences, i.e.

$$\text{Probability of event A} = \frac{\text{Number of occurrences of event A}}{\text{total number of all occurrences.}}$$

This method of determination of probability is effective providing the data required is available. Although this is the case for calculations involving decks of cards, dice, etc., this is not true in connection with the majority of business situations. Consider a typical business problem that of forecasting future sales.

Past sales information can be used to determine the probabilities of different sales figures by using various mathematical techniques from moving averages to the more mathematically sophisticated Box-Jenkins Technique. These methods of forecasting the probabilities of different events are passive in nature. They assume that like the pack of cards the sales will react along fixed lines based purely on past information. Most business situations do not depend completely on the past but on changing conditions in the present. The oil crisis of the early nineteen seventies is a good example of this. This crisis had a dramatic effect on the sales of a new motor vehicle, which were less than expected. This was just one factor which could have had an effect on car sales, others could have been Government legislation, social changes, environmental issues, etc. An alternative approach to producing a single component forecast is to carry out a multivariate analysis. With multivariate analysis the effect of each factor is estimated individually. This has the advantage that when a forecast is produced each factor can be varied individually. This makes the forecast sensitive to changes in individual factors.

The effects of some factors are not predictable from the past sales figures but must be estimated in some other way. One possible way is by determining the effect of these factors on the probabilities of sales in a subjective manner. Some probabilities can only be set subjectively as there is no past data from which to work. One other method for the determination of the effects of various factors on probabilities and the generation of probabilities when there is little past information is that of simulation modelling, this technique will be dealt with more fully in a later section, however, there can be required within simulation subjective probabilities.

A subjective probability may be defined as a probability that has been set by an individual or a group of individuals using his/her or their collective experience and knowledge due to the fact that there is insufficient data to allow the probability to be calculated in the classical manner (the situation may be changeable which could not allow the probability to be calculated in a classical manner either).

There are many problems which can arise when subjective probabilities are being determined. Tversky and Kahneman *1 put forward the idea that there are three basic Heuristics people use when setting probabilities, 1) Representativeness, 2) Availability and 3) Anchoring and Adjustment.

*1 TVERSKY & KAHNEMAN (1974)

2.4.2. THE HEURISTIC OF REPRESENTATIVENESS.

Suppose one is asked one of the following questions. What is the probability that object A belongs to class B ? What is the probability that event A originates from Process B ? What is the probability that process B will generate event A ? In the determination of such probabilities the heuristic of Representativeness is likely to be used. To think how representative object A is of class B or how representative event A is of events produced by process B is a way of approaching this question. This approach can lead to certain major problems.

Kahneman and Tversky *1 carried out some work with occupations and descriptions of peoples characters. For example given the following description of an individuals character "Steve is very shy and withdrawn, invariably helpful but with little interest in people, or in the world of reality. A meek and tidy soul, he has a need for order and structure and a passion for detail" and the following list of occupations farmer, salesman, airline pilot, librarian or physician, then rank these from the most likely to the least likely occupations that Steve follows.

They found that people solving the problem used the representativeness of their stereotypes of the different occupations in determining the relative chances of the different occupations.

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*1 KAHNEMAN & TVERSKY. (1973)

This method for determining probabilities needs to take account of other factors. If these factors are ignored then the basic laws of conditional probabilities have not been taken into account and the following mistakes could be made.

a) Not allowing for prior probabilities.

Prior probabilities are not usually used in the process of representativeness. Take for example the problem of Steve and determining his occupation. The fact there are more farmers in the population than there are librarians should have affected the relative probabilities of the different occupations. The exact effect of the prior probability is debatable but this is to be expected as we are talking in terms of subjective probabilities. Kahneman and Tversky *1 have carried out some experimental work which suggests that the majority of people ignore Prior Probabilities when setting subjective probabilities.

The subjects were given a series of character profiles 'chosen at random' from a group of 100 professionals. 30 engineers and 70 lawyers. The character profiles were carefully worded so as to give no information as to the profession of the individual for example 'Dick is a thirty-year-old man. He is married with no children. A man of high ability and high motivation, he promises to be quite successful in his field. He is well liked by his colleagues.'

Given this type of description (which is completely

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*1 KAHNEMAN & TVERSKY. (1973)

useless providing no information) the subjects ignored the useful prior probabilities and considered the probability of an engineer 0·5 and the probability of a lawyer 0·5. When the subjects were given no character profile at all and just asked for the probability of an individual chosen at random from the group then they used the prior probabilities and came out with the probability for Engineers 0·3 and Lawyers 0·7.

b) Insensitivity to sample size.

Another problem of the technique of representativeness is that of insensitivity to sample size. Kahneman and Tversky *1 showed that when people were presented with a problem that involved sample size this sample size was ignored. One of the problems they used was concerned with the sampling from a large group of men (average height 5' 10") samples of 1000, 100 and 10 men and then using these to obtain average height figures. The subjects were asked to estimate the probability of obtaining samples with average heights in excess of six feet. The majority of subjects arrived at the same figure for all three samples sizes which showed a lack of understanding of the fact that the greater the sample size the smaller the variation in means and therefore the probability of such an event should reduce as sample size increases. The subjects fared no better even when the sample size was emphasised in the formulation of the problem, for example 'A certain town is served by two hospitals. In the larger hospitals about 45 babies are born each day,

*1 KAHNEMAN & TVERSKY. (1972)

and in the smaller hospital about 15 babies are born each day. As you know, about 50% of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50%, sometimes lower.

For a period of one year each hospital recorded the days on which more than 60% of the babies born were boys. Which hospital do you think recorded more such days ?'

When this problem was used the majority of subjects still thought the probabilities would be the same in all cases.

c) Lack of understanding of the element of chance. This problem falls into two main parts the lack of understanding of randomness and the non-appreciation of independence. Kahneman and Tversky *1 showed that the concept of randomness was not fully understood by the majority of their subjects. When they asked their subjects which was more likely when tossing a coin six times H-T-H-T-T-H or H-H-H-T-T-T the majority of their subjects said that the first was more likely than the second and only a few came up with the correct answer that they are in fact both equally likely. This shows that people are likely to think that ordered sequenced groups cannot be random whereas this is not necessarily so.

The other problem concerning chance is the lack of understanding of independence. For example if a coin

*1 KAHNEMAN & TVERSKY (1972)

has been thrown six times and six heads have been recorded what is the chance of obtaining a head on the next throw. It is an understandable mistake to assume that the chance of a head must be less than that of a tail, i.e. to assume that one throw is related to the next, when in fact each throw is independant (a coin cannot have a memory and remember the prior results) Tversky and Kahneman *1 showed that this was a common failing in their subjects.

d) Misconception of validity.

A further problem arising from the use of the heuristic of representativeness can be the attribution of too high a validity to subjective probabilities obtained in this way. Most people take insufficient account of the problems caused by lack of information or inaccuracies within such information or misinterpretation of the information available.

e) Misconception of regression.

Applying incorrect causal relationships can lead to bias and error in the representative heuristic. The following example of Kahneman and Tversky *2 illustrates an incorrectly assumed relationship.

"In a discussion of flight training, experienced instructors noted that praise for an exceptionally smooth landing is typically followed by a poorer landing on the next try, while harsh criticism after a rough landing is usually followed by an improvement on the next try. The

*1 TVERSKY & KAHNEMAN. (1971)
*2 KAHNEMAN & TVERSKY. (1973)

instructor concluded that verbal rewards are detrimental to learning while verbal punishments are beneficial, contrary to accepted psychological doctrine."

This in fact is a spurious relationship. Whatever comments are made to the trainee, the results are likely to be the same due to the fact that performances are distributed about a mean for each trainee and will vary about that mean, some better some worse. The acceptance of spurious relationships can lead to inaccuracies in the setting of subjective probabilities. This type of mistake is not only made by people with no statistical training but is all too common among people with statistical training.

2.4.3. THE HEURISTIC OF AVAILABILITY.

This technique is used in situations where people assess the frequency of occurrence of a class or the probability of a given event by the number of times and the ease that such occurrences or events can be brought to mind. For example if one was asked to assess the risk of fatality due to motor vehicle accidents one way would be to bring to mind the fatalities encountered and use this to assess the risk.

This like the first method of assessing subjective probabilities can be reasonable, however, it can lead to certain problems which can introduce bias and error.

a) <u>The retrievability of instances</u>.

Tversky and Kahneman *1 suggest:

"When the size of class is judged by the availability of its instances, a class whose instances are easily retrieved will appear more numerous than a class of equal frequency whose instances are less retrievable."

They showed this effect by presenting their subjects with lists of men and women and asking them which of the lists were the larger. Errors were frequently made when smaller lists of famous men or women were used. The subjects thought these lists were the larger.

Other problems of retrievability are the way by which the events arrived at the brain and the recentness of such events. If one actually experiences an event oneself the impact and therefore the retrievability is usually much greater than if one records or is told of such an event. Also the source of ones information (whether read or told) can effect the impact of the information, the more 'reliable' the information the more the impact. How recently the event occurred could possibly effect the retrievability of such an event. Retrievability can be affected by many things and will of course vary considerably from individual to individual.

b) <u>Biases due to the effectiveness of a search set</u>.

Biases may be due to the ineffectiveness of certain sets

*1 TVERSKY & KAHNEMAN. (1974)

of events stored by people. Due to social, economic, business or other reasons people form different sets of events due to their different experiences and this could form an element of bias. The search set of managers (i.e. their experience) will vary from manager to manager depending upon such factors as, the length of time the person has been a manager, the types of management roles carried out, the management ability of the person, etc.

c) Biases of imaginability.

"Imaginability plays an important role in the evaluation of probabilities in real life situations. The risk involved in an adventurous expedition, for example, is evaluated by imagining contingencies with which the expedition is not equipped to cope. If many such difficulties are vividly portrayed the expedition can be made to appear exceedingly dangerous, although the ease with which disasters are imagined need not reflect their actual likelihood. Conversely, the risk involved in an undertaking may be grossly under-estimated if some possible dangers are either difficult to conceive of, or simply do not come to mind."

Tversky and Kahneman *1.

Although this is in terms of expeditions the same applies to a large number of business decisions. There can be a great difficulty in imagining and conceiving the factors involved and the possible outcomes of events.

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*1 TVERSKY & KAHNEMAN. (1974)

Imaginability is not only important in terms of different factors it can also be important in mathematical concepts. For example if you were to ask a production manager the number of possible schedules it is possible to draw up by putting 50 different jobs through a six machine sequence he is most likely to grossly under-estimate the possible number. This lack of imaginability of certain mathematical concepts can cause problems in the setting of some subjectives probabilities.

2.4.4. THE HEURISTIC OF ADJUSTMENT AND ANCHORING.

A possible technique when setting subjective probabilities is to start from an initial value and then adjust this value in the light of experience or knowledge. An example of this type of heuristic could be found in the forecasting field. The initial forecast will be set by using mathematical forecasting, this being the anchoring stage. This initial value could then be adjusted by managers to take account of such factors as, increased amount of advertising by either own company or competitors, the present economic climate etc., this being the adjustment stage.

There are two main problems with this technique the first the initialisation value and second insufficient adjustment from this value. Slovic and Lichtenstein *1 carried out a series of studies concerned with asking people certain quantities stated in percentages (for example the percentage of African countries in the

*1 SLOVIC & LICHTENSTEIN. (1971)

United Nations). They started the process at random for the initialisation value and asked the subjects whether it was too high or too low and to adjust the values. They found that due to reluctance of the subjects to move far away from the initialisation value this value had quite an effect on the final estimates even though this value had been set at random. This particular effect is likely to be felt in the business situation when initial values have been set by the Managing Director or a technical expert, whom other personnel would be reluctant to challenge.

2.4.5. SUBJECTIVE PROBABILITY IN PRACTICE.

Where an individual is setting subjective probabilities it is unlikely that just one of three heuristics will be used. It is far more likely that some combination of the three will be used. These techniques can give quite acceptable results providing that the problems discussed in sections 2.4.2.,3 & 4 are overcome. An important contribution to the solving of these problems is to ensure that the manager has a knowledge of the statistical concepts involved.

A concept that can be used successfully to supplement the three heuristics is the cumulative density function (CDF). This has the advantage that a range of values can be created instead of individual values. To create a CDF five percentiles have to be estimated the 1st, 25th, 50th, 75th and 99th percentiles. Training may need to be given as to what percentiles are and most people will need some experience at setting them which can be obtained by using a gameing simulation. There will in most people be a tendency to set the percentiles too close together and to give a CDF with too little range as the majority of people fail to appreciate the uncertainty associated with situations. Raiffa and Alpert *1 and Wallace *2 have carried out experiements which seem to suggest that this conservatism is general. With training this natural conservatism can be overcome.

The percentiles required may be defined as follows:-

1st Percentile is a value such in the assessors opinion there is a 1% chance that the quantity being assessed will be below it and a 99% chance it will be above it (this value could almost be considered the lower limit of the quantity.)

25th Percentile is a value such in the assessors opinion there is a 25% chance that the quantity being assessed will be below it and a 75% chance it will be above it.

50th Percentile is a value such in the assessors opinion there is a 50% chance that the quantity being assessed will be below it and a 50% chance it will be above it.

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*1 RAIFFA & ALPERT. (1969)
*2 WALLACE. (1975)

75th Percentile is a value such in the assessors opinion there is a 75% chance that the quantity being assessed will be below it and a 25% chance it will be above it.

99th Percentile is a value such in the assessors opinion there is a 99% chance that the quantity being assessed will be below it and a 1% chance it will be above it. (this value could almost be considered the upper limit of the quantity.)

A possible procedure for the setting of these Percentiles is as follows:-

1. Select a value for the 50th Percentile.
2. Select the values for the 1st and 99th Percentile. (i.e. the upper and lower limit).
3. The values for the 25th and 75th percentiles now need to be set. These can be arrived at by dividing the halves of the distribution already obtained. This division must be carried out by dividing probabilities by two and not the distance along the distribution. The value arrived at by this division will be approximately one third of the way along the scale from the 50th percentile (one standard deviation). An alternative approach to the setting of these two percentiles is to produce a range within a range. When the 1st and 99th percentile are set the range of all values is set. The second range could be set

within the first range but containing 50% of values. Individual managers may have a preference for either of the methods depending on their statistical knowledge and training.

Such a procedure is quite useful when used in conjunction with the heuristics and a basic training in statistics.

Gameing simulation can be very useful in the training of assessors of subjective probabilities. It allows individuals to gain experience and allows them to get over some of the problems outlined without any dangers to the organisation of incorrect or biased results. Also it allows the organisation the chance to assess the subjective probability setting of different individuals. The techniques of simulation modeling will be dealt with in section 2.6.

Computers will obviously be of value for gameing simulation. Schlaifer *1 takes the use of the computer into an interactive role. He designed a series of on-line packages. Initially they provide a tutorial system for the assessor to gain experience and knowledge in the assessing of subjective probabilities. When this has been gained they then go on to assist the assessor in the assessing of actual subjective probabilities and provide him with built in consistency checks. The Post Office Corporation have found that individuals setting subjective probabilities have prefered the computer interaction

*1 SCHLAIFER. (1971)

rather than having a statistician or decision analyst providing the consistency checks.

The use of groups in the setting of subjective probabilities will only be dealt with briefly here. The methods of using groups will be dealt with in a separate section as they are also important in a number of different areas including the determination of information needs and design of information systems. One major problem with the use of groups is the bandwagon effect, that is to say the group will tend to follow the individual or sub-group of individuals with the stronger personality and/or most power. This would be fine if these were the people who were best at setting these subjective probabilities but this unfortunately is not necessarily the case. A way round this effect is to use techniques like Delphi. Within this technique individuals are asked to fill in questionnaires, the results of which are used to produce the next questionnaire and this procedure is continued until a consensus opinion is reached. By this approach it is usual to eliminate a certain amount of the band wagon effect although some individuals views will bound to be stronger than others. Winkler *1 has suggested that the final concensus should be a weighted average of the individuals estimates. He suggests four methods of weighting such values.

1. Equal weights to each individual.
2. Self-weighting.
3. Subjective weighting by a third party

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*1 WINKLER. (1970)

(possibly by members of the group or by an 'expert unbiased individual').

4. A weighting based on past experience.

The first method is of no value and the latter three could introduce considerable bias. It should be possible to introduce a combination of the last three that if used carefully could reduce bias. Indeed if it is to be considered a realistic method then some method other than the first must be used, although this will not preclude the possibility of equality being arrived at.

2.4.6. SUMMARY.

The only effective way to measure uncertainty is to use a numeric measure such as probability. The phrases used by some managers such as possible, doubtful, etc., are of little value as they mean different levels of uncertainty to different people. Probabilities being numeric in nature can be used to extend the knowledge of the situation by using the various rules of probabilities including the more complex theromes such as Bayes' (these can be of great use in such things as decision analysis, decision trees, etc.).

There does occur one major problem with probabilities; that of actually determining a value. The majority of business situation unlike most situations talked of in classical probability are dynamic. Consider the probability of drawing an ace from a pack of cards, an easy situation. To determine a large number of business situations would be like finding the probability of an ace from a randomly changing pack of cards (not only changing in terms of the number of cards but also in terms of contents with a few jokers for good measure). It is not easy to calculate probabilities under these conditions it is better to use subjective probabilities i.e. probabilities assessed by individuals or groups of individuals based on experience, knowledge and information. There are three heuristic methods available which can be used individually or in a combination these being:-

1. The heuristic of Representativeness.
2. The heuristic of Availability.
3. The heuristic of Adjustment and Anchoring.

There can be problems in using these methods and assessors will need a certain amount of statistical training and assistance in setting of probabilities. This can be provided effectively by using simulation gameing in the form of an interactive computer package. It sometimes can be advantageous to use groups of assessors to arrive at a more broadly based subjective probability although this again can lead to problems.

2.5. DECISION ANALYSIS.

The process of decision making by management has been discussed in detail within the section on the 'Management Process'. Decision Analysis as being discussed here could be said to consist of a group of analytical techniques which assist managers to make decisions. These techniques carry out much of the problem solving then allowing management to make the decisions.

The taking of decisions in uncertain conditions involves the following sequences of stages. The range of actions available to the manager must be specified. The outcomes for each action should then be listed, these outcomes could be different for each action and variable in nature. Using these possible outcomes monetary values may be placed upon the different actions open to the managers, these may be in terms of returns and costs. The manager then uses this information, his decision criterion and any non-quantifiable information to try and make the best decision.

Decision analysis as proposed by some writers in the field of O.R. is concerned only with statistical decision theory. Although this is an important part of decision theory, there is in fact a great deal more to be considered.

2.5.1. STATISTICAL DECISION THEORY.

Statistical decision theory applies the concepts of probability and expectation to provide a decision aid for managers. The concepts of probability have been developed in section 2.4.

Expectation is concerned with the establishment of the Expected Return (or in some cases Expected Cost) associated with a series of outcomes resulting from a given action. Providing that the probability and the Monetary Returns (or cost) are known for each outcome and that the set of outcomes contains all possible outcomes for that action, the expected Monetary Return (E(M)) can be calculated as a weighted average by multiplying the probability by the return of an outcome and then summing over all possible outcomes.

Suppose a person receives an amount of money M_1 if event Z_1 occurs, M_2 if Z_2 occurs and so on to M_n if Z_n occurs. Expected monetary return = E(M) = (probability of $Z_1 \times M_1$) + (probability of $Z_2 \times M_2$) +..........+ (probability of $Z_n \times M_n$), given that the sum of all probabilities equals one.

Consider the following example from the field of life insurance. The probability that a man aged 55 will live for another year is 0·99. How large a premium should he pay for a £2,000 life insurance policy for one year? The amount of premium the man should pay for such insurance must be equal to his expected return from the policy. There are two possible outcomes. Outcome one, that the man lives, has a probability of 0·99 and a monetary return of £0. Outcome two, that the man dies, has a probability of 0·01 and a monetary return to the man's estate of £2,000.

$$\begin{aligned} \text{therefore } E(M) &= (0{\cdot}99 \times 0) + (0{\cdot}01 \times 2000) \\ &= 0+20 \\ &= £20 \end{aligned}$$

therefore the premium = £20 + (charges for the insurance companies administration, profit, etc.).

This technique can be applied in situations where a decision needs to be taken. The following example requires a decision. A person wishes to sell his car and has two alternatives. Alternative one, to go to a dealer with complete certainty of selling for £1,550. Alternative two, to advertise in a local paper at a cost of £10 in order to sell the car for £1,700 but he only expects a 0·6 probability of a sale. The Monetary Returns from the actions can be evaluated as follows:-

Alternative one:- not to advertise

Outcome	Probability	Monetary Returns.
Sell to dealer	1	£1,550

$$\begin{aligned} \text{therefore } E(M_1) &= 1 \times 1550 \\ &= £1,550 \end{aligned}$$

Alternative two:- to advertise in local paper

(cost £10)

Outcome	Probability	Monetary Return.
sell through ad.	0·6	£1,700
sell to dealer	0·4	£1,550

therefore $E(M_2) = (0 \cdot 6 \times 1700) + (0 \cdot 4 \times 1550)$

$= 1020 + 620$

$= £1640$ this value is a gross return.

the cost of the action must be deducted

$E(M_2) = 1640 - 10$

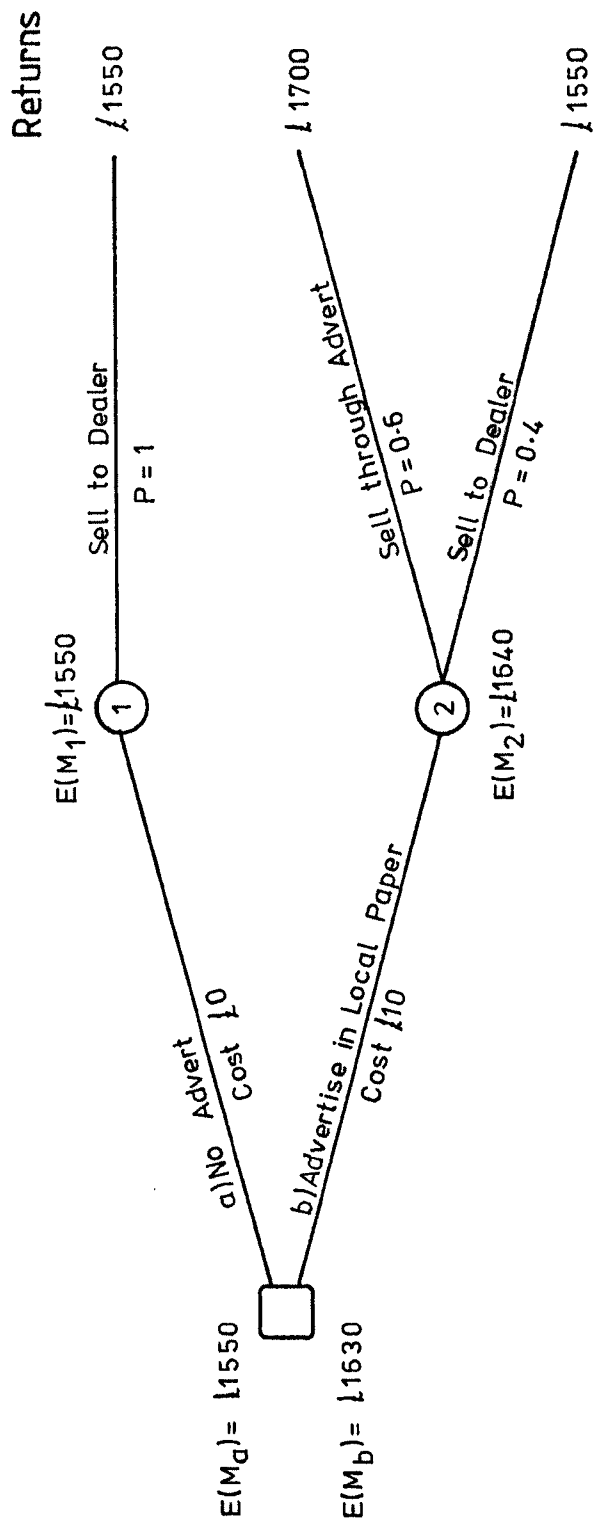
$= £1,630$ this value is a net return.

From these figures it would appear that the action giving the greatest return would be to advertise the car in the local paper. This information can be presented in a different form which gives a greatly improved visual impact. This method of presentation is called a Decision Tree. The example of selling the car can be produced in a decision tree form and is shown in figure five. It can be seen from this decision tree that the calculations stay the same but the tree has a greater visual impact than the table. This visual impact becomes greater the more complicated the tree.

Decision trees are constructed with four basic steps:-

1) Construct the tree to represent the logic of the situation; squares to show a decision point with the actions coming from the square; circles to show points of alternative outcome with the alternative

Figure Five: Decision Tree for Car Selling Problem.



$E(M_1) = 1 \times 1550$
$= £1550$

$E(M_2) = (0{\cdot}6 \times 1700) + (0{\cdot}4 \times 1550)$
$= 1020 + 620$
$= £1640$

The best decision would appear to be to advertise in the local paper.

outcomes coming from the circle.

2) Write on the trees the return from different alternatives and their probability of occurrance, ensuring that the probabilities on any branch of the tree add to one. Also place on the tree the costs of the various actions open to the decision maker.

3) Calculate the Expected Monetary Returns starting from the right hand side of the tree and working to the left.

4) Determine the best decision from the tree. Classical decision theory suggest that the best route through the tree and hence the best decision is the one with the largest monetary return or if expected costs are being considered the one with the smallest Expected Cost.

The use of decision trees can be further examined by use of an example closer to the problems facing management. The following example although still a simplification of reality has been used by both Moore *1 and Magee *2 to demonstrate how to produce decision trees.

The following information is available to the manager from three sources.

---

*1 MOORE. (1976)
*2 MAGEE. (1964)

a) Marketing Information.

The Marketing Manager suggests a 60 per cent chance of a larger market in the long run and 40 per cent chance of a low demand developing as follows:-

Initially high, sustained high	60%	
Initially high, long term low	10%)	Low 40%
Initially low, continuing low	30%)	
Initially low, subsequently high	0%	

2 years → 8 years →

10 years →

b) Annual Income.

The Management accounting section have put forward the following financial estimates:

(i) A large plant operating under high market demand conditions would yeild £1 million annually in cash flow.

(ii) A large plant operating under low market demand conditions would only yield £0·1 million annually in cash flow because of high fixed costs and inefficiencies.

(iii) A small plant operating under low market demand conditions would be economical and would yield £0·4 million annually in cash flow.

(iv) A small plant operating under high market demand conditions initially (i.e. the first two years) would yield £0·45 million annually in cash flow, but this would drop to £0·25 million annually in cash flow if the high demand market conditions were sustained for the last eight years of operating.

(v) If an initial small plant was expanded after two years and was operating under high market demand conditions it would yield £0·7 million annually in cash flows for the remaining eight years and so would be less efficient than a large plant built initially.

(vi) If an initial small plant was expanded after two years and was operating under low market demand conditions it would yield £0·05 million annually in cash flows for the remaining eight years and so would be less efficient than a large plant built initially.

c) Capital Costs.

Estimates from construction companies indicate that a large plant would cost £3 million to build and put into operation. A small plant would cost £1·3 million initially and an additional £2·2 million if expanded after two years.

Management has two possible actions it can take either to build a large plant or a small plant. If the small plant is constructed there is an option to extend it after two years. A series of outcomes of high and low market demands will follow these actions. Given this knowledge and the three sets of information a decision tree can be constructed. The decision tree being shown in figure six.

The probabilities after outcome one and two need to be adjusted because from the information the probability of an initial high and then a sustained high is 0•6 and the probability of an initial high and then a long term low is 0•1. This gives a branch on the tree with a set of probabilities that do not add to one, this then needs to be rectified to ensure they do add to one. This is carried out with a simple weighting process by dividing each probability by the sum of the probabilities on that branch so ending with probabilities which add to one.

therefore Probability of initial high,

$$\text{then sustained high} = \frac{0{\cdot}6}{0{\cdot}6+0{\cdot}1} = \frac{0{\cdot}6}{0{\cdot}7} = 0{\cdot}86$$

therefore Probability of initial high,

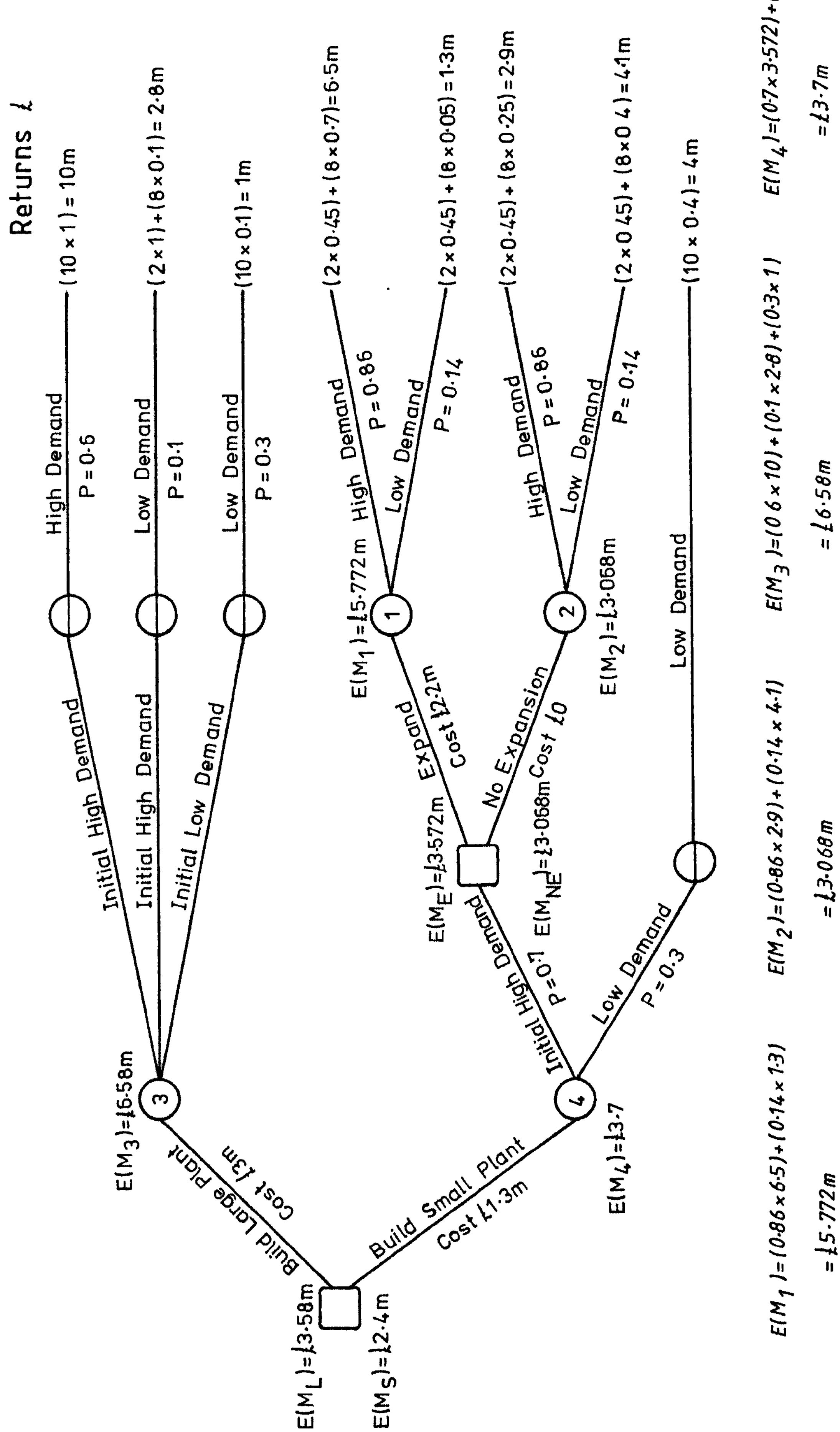
$$\text{then long term low} = \frac{0{\cdot}1}{0{\cdot}6+0{\cdot}1} = \frac{0{\cdot}1}{0{\cdot}7} = 0{\cdot}14$$

Using Classical Statistical Decision Theory the decision giving the greatest return is that of building a large plant.

2.5.2. THE EFFECT OF DISCOUNTING ON DECISION TREES.

The discounted cash flow method of appraisal attempts to value projects in terms of the future value of the money

Figure Six: Decision Tree to Plant Size Problem.



returned. The basic philosophy behind D.C.F. techniques is that a pound invested in a project now could as time progresses be earning interest and so increasing its total value so this amount of interest that could have been earned must be taken off the money returned from the project.

The present value (Discounted Cash Flow) can be calculated by the following formula.

$$\text{Present Value} = \frac{M}{(1+I)^n}$$

where M = amount of money to be discounted

n = number of periods or times at which interest is calculated.

I = the interest rate used for calculation of interest in any one of the n periods mentioned above.

A discounting factor for any given time period will be given by the following formula.

$$\begin{array}{l}\text{Discounting Factor} \\ \text{(for time period n)}\end{array} = \frac{1}{(1+I)^n}$$

The principle argument against the use of discounting is that as this discounting rate can only be an estimate then the results cannot be considered reliable. In this particular application all the other information tends to be estimated and, therefore, one more estimate can be of little consequence as the solutions are only correct within certain limits. It must be remembered that discounting rates could be expected to change during the project life span, this will then require the use of several discounting rates. Discounting can be carried out by multiplying the return by the appropriate discounting factor. The factor can be obtained from tables (Murdoch & Barnes *1) or from the following accounting approach. The actual choice of a discount rate is difficult and can only be made by managers in conjunction with the accountants looking at economic forecasts to estimate what the rate is likely to be in the future. In the case of this example suppose 10% was thought appropriate and factors for ten years will be needed.

DISCOUNTING RATE 10%

YEAR	FACTOR	YEAR	FACTOR
1	0•91	6	0•56
2	0•83	7	0•51
3	0•75	8	0•47
4	0•68	9	0•42
5	0•62	10	0•39

These discounting factors can then be applied to the returns in the manner shown in the table given in figure seven A,B & C. Having now discounted the returns they can now be added to the tree as shown in figure eight. All costs have now been taken from these returns so the costs now added to the tree are only added as points of information.

*1 MURDOCH & BARNES. (1970 Table 33)

Figure Seven A: Table Discounting Returns to Plant Size Problem.

Demand		Build Large Plant					
Initial		High		High		Low	
Long Term		High		Low		Low	
Year	Factor	Return £m	DCF	Return £m	DCF	Return £m	DCF
1	0·91	1	0·91	1	0·91	0·1	0·091
2	0·83	1	0·83	1	0·83	0·1	0·083
3	0·75	1	0·75	0·1	0·075	0·1	0·075
4	0·68	1	0·68	0·1	0·068	0·1	0·068
5	0·62	1	0·62	0·1	0·062	0·1	0·062
6	0·56	1	0·56	0·1	0·056	0·1	0·056
7	0·51	1	0·51	0·1	0·051	0·1	0·051
8	0·47	1	0·47	0·1	0·047	0·1	0·047
9	0·42	1	0·42	0·1	0·042	0·1	0·042
10	0·39	1	0·39	0·1	0·039	0·1	0·039
Total DCF £m			6·14		2·18		0·614
Less Cost £m		3		3		3	
Nett Present Value £m		3·14		(0·82)		(2·386)	
Return on Capital Invested (per £)		1·05		(0·27)		(0·08)	

(0·82) *indicates negative values*

Figure Seven B: Table Discounting Returns to Plant Size Problem.

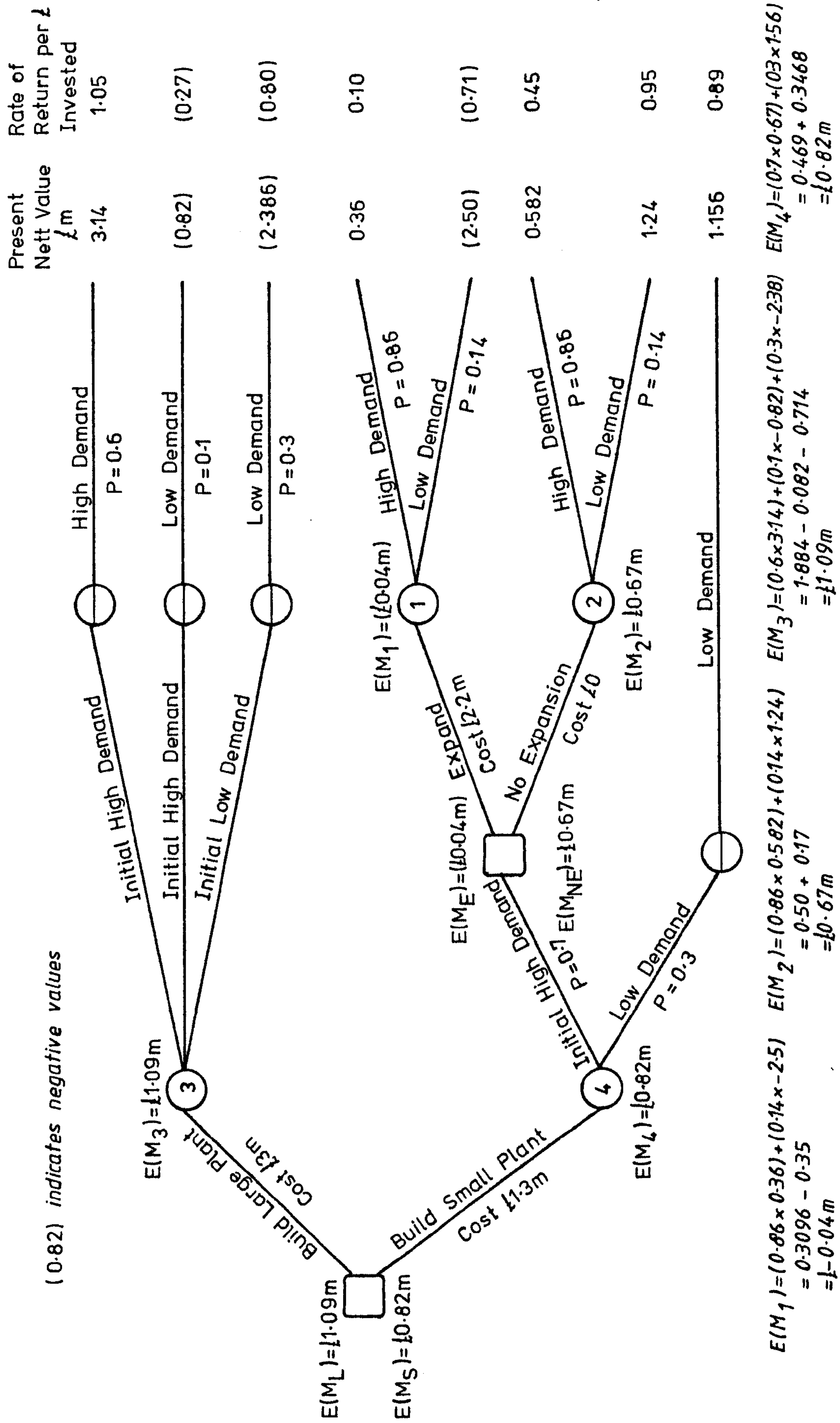
Demand		Small Plant (Not Extended)					
Initial Long Term		High High		High Low		Low Low	
Year	Factor	Return £m	DCF	Return £m	DCF	Return	DCF
1	0·91	0·45	0·41	0·45	0·41	0·4	0·364
2	0·83	0·45	0·37	0·45	0·37	0·4	0·332
3	0·75	0·25	0·188	0·4	0·30	0·4	0·300
4	0·68	0·25	0·170	0·4	0·272	0·4	0·272
5	0·62	0·25	0·155	0·4	0·248	0·4	0·248
6	0·56	0·25	0·140	0·4	0·224	0·4	0·224
7	0·51	0·25	0·128	0·4	0·204	0·4	0·204
8	0·47	0·25	0·118	0·4	0·188	0·4	0·188
9	0·42	0·25	0·105	0·4	0·168	0·4	0·168
10	0·39	0·25	0·098	0·4	0·156	0·4	0·156
Total DCF £m		1·882		2·54		2·456	
Less Cost £m		1·3		1·3		1·3	
Nett Present Value £m		0·582		1·24		1·156	
Return on Capital Invested (per £)		0·45		0·95		0·89	

Figure Seven C: Table Discounting Returns to Plant Size Problem.

Demand		Small Plant Extended			
Initial / Long Term		High / High		High / Low	
Year	Factor	Return £m	DCF	Return £m	DCF
1	0·91	0·45	0·41	0·45	0·41
2	0·83	0·45	0·37	0·45	0·37
3	0·75	0·7	0·525	0·05	0·036
4	0·68	0·7	0·476	0·05	0·034
5	0·62	0·7	0·434	0·05	0·031
6	0·56	0·7	0·392	0·05	0·028
7	0·51	0·7	0·357	0·05	0·026
8	0·47	0·7	0·329	0·05	0·024
9	0·42	0·7	0·294	0·05	0·021
10	0·39	0·7	0·273	0·05	0·020
Total DCF £m		3·86		1·00	
Less Cost £m		3·5 (1·3+2·2)		3·5 (1·3+2·2)	
Nett Present Value		0·36		(2·5)	
Return on Capital Invested (per £)		0·10		(0·71)	

(0·71) *indicates negative values*

Figure Eight: Decision Tree of Plant Size Problem showing Discounted Returns and a Simple Rate of Return.



2.5.3. THE ANALYSIS OF DECISION TREES.

Using a classical decision theory approach the best decision would appear to be to build a large plant with an expected return at present nett value of £1·09 million.

For a manager to use a decision tree to assist him in the decision process the whole of the tree must be used. A decision tree is a powerful method of visually presenting the actions which can be taken by the manager and the possible outcomes that can occur when these actions are taken along with the expected results. The manager must then use all of this information to make the decision. The classical decision theory approach to choose the decision with the largest expected return is only one criterion of choice and is in fact not a very good criterion.

Company policy could well affect the decision. Although building the large plant brings in the greatest return it does have a large risk element to it. With this route there is a 0·6 chance of getting a large return, with a 0·4 chance of some amount of loss; With the small plant route providing that it is not expanded whatever outcome ensues some form of profit will be made. A large company may well be able to stand the possibility of loss for the greater return but for the small company the only option may be to adopt the safe route as any loss could mean their complete closure.

The financial terms are better considered in the amount of money being returned not purely as an amount but as a rate per pound invested to obtain the return. The best possible return on capital invested is £1·05 per £1 invested from the large plant operating with high market demand. Taking into account the probabilities to obtain the expected returns at present nett value and then using these values to calculate the return on capital invested, the action to build the large plant gives a rate of return of £0·36 per £1 invested and with the action to build a small plant the rate of return is £0·63 per £1 invested. It would then seem a better decision to invest £1·3 million in the small plant and try to find a project with a higher rate of return from the remaining £1·7 million that may have been invested in the large plant.

It must be remembered that there will be other projects within the organisation all competing for limited resources. Therefore, this project cannot be considered in isolation and the returns should be considered along with the returns from the other projects to find the project or the group of projects best suited to the firms requirements.

The decision maker must add into the decision making process the effects of factors which may be difficult to quantify. Factors such as availability of capital, the effect of various actions on the employment of the organisation, the effect of various actions on the 'image' of the organisation the availability of labour to staff the plants, the availability of equipment for the different plants, etc., all may need to be taken into consideration by the decision maker and could well affect the final action to be taken.

Finally it must be recognised that most of the figures used in a decision tree of this nature are estimated and the rate at which the returns are discounted can only be an estimated rate. Given that the financial estimates and the probabilities are estimated they can only be correct within given limits. These limits need to be considered by the decision maker. They could be written on the tree and then used by the decision maker to apply a sensitivity analysis with the use of statistical techniques. It is likely however, that the average decision maker could have considerable difficulty with the concepts involved in confidence limits. One way around this problem is to produce three trees:-

1) An optimistic tree showing all the values at their best possible i.e. costs at the lowest returns at the highest, etc.

2) A pessimistic tree showing all the values at their worst possible, i.e. cost at the highest, returns at the lowest, etc.

3) An expected tree showing all the values at their expected or average value.

This method has a number of advantages to recommend it. It is useful at the stage where subjective values are being set, it allows the manager to produce a series of values instead of just one value and therefore it is likely to improve the manager's ability to set such subjective probabilities (see section 2.4.). The three trees can then be used by the manager to allow for effect of inaccuracies in the estimates. Given the average value (expected value) it is possible to estimate the standard deviation from the following formula

$$\text{Standard Deviation} = \frac{\text{Optimistic Value} - \text{Pessimistic Value}}{6}$$

This formula can be used to determine standard deviations for sales or for expected values. The formula is based on the fact that the optimistic value minus the pessimistic value will give the range of values and that the 99% Confidence Limits contain six standard deviations. Therefore, an approximate value for the standard deviation will be given by dividing the range by six. This approximation will become less accurate the more skewed the distribution becomes. The following simplified example shows how this technique can be applied.

A manufacturer has the choice of three different types of machine to replace his existing plant.

Any money outlaid on machines must be returned in 3 years which is the expected life of the machines.

The Company Accountant has produced the following cost per unit estimates for the three types of machines.

M/C TYPE	A	B	C
Pessimistic Cost/Unit (£)	3.80	2·80	2·20
Expected Cost/Unit (£)	3·00	2·00	1·50
Optimistic Cost/Unit (£)	2·60	1·80	1·30

These costs include all costs associated with the production, administration and selling of the product e.g. the cost of manufacturing, distributing, etc., but excluding the initial purchase cost of the machine.

The Sales Manager has produced the following estimates of sales over the three year period. These sales estimates are independent of machine type and are in unit sales.

PESSIMISTIC ESTIMATES.

Sales over three year period	8000	15000	25000
Probability of occurrance	0·2	0·5	0·3

EXPECTED ESTIMATES

Sales over three year period	10000	20000	30000
Probability of occurrance	0·2	0·4	0·4

OPTIMISTIC ESTIMATES

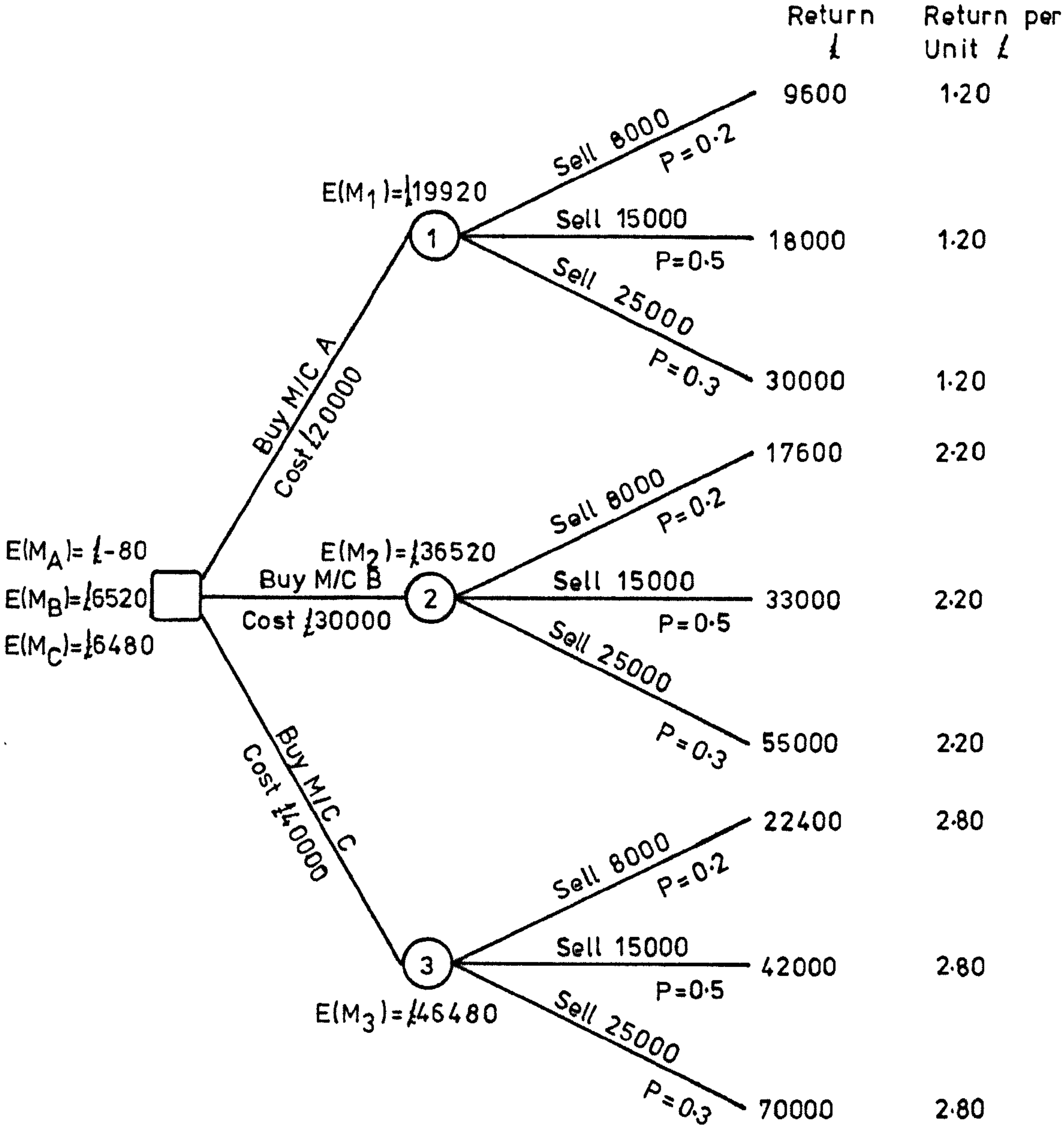
Sales over three year period	12000	25000	35000
Probability of occurrance	0·1	0·5	0·4

The cost of the machines are considered fixed and the price at which the machines can be purchased is as follows: Machine A at £20,000, Machine B at £30,000 and Machine C at £40,000. The selling price of the units is £5 per unit. Splitting the information into three groups pessimistic, expected and optimistic then three decision trees can be produced. The figures have not been discounted for ease of calculation but would be in practice. The pessimistic tree is shown in figure nine, the expected is shown in figure ten and the optimistic tree is shown in figure eleven.

The results from the tree can be brought together for any point on the tree,working on the point of the greatest interest the final box decision, although it is important in any practical case to consider other points on the tree. These final decision box figures can be summarised.

MACHINE A	Pessimistic Return	=	(£80)
	Expected Return	=	£24,000 Standard Deviation = £7,760
	Optimistic Return	=	£46,480
MACHINE B	Pessimistic Return	=	£6520
	Expected Return	=	£36,000 Standard Deviation = £8687.
	Optimistic Return	=	£58,640

Figure Nine: Pessimistic Decision Tree to Machine Choice Problem.

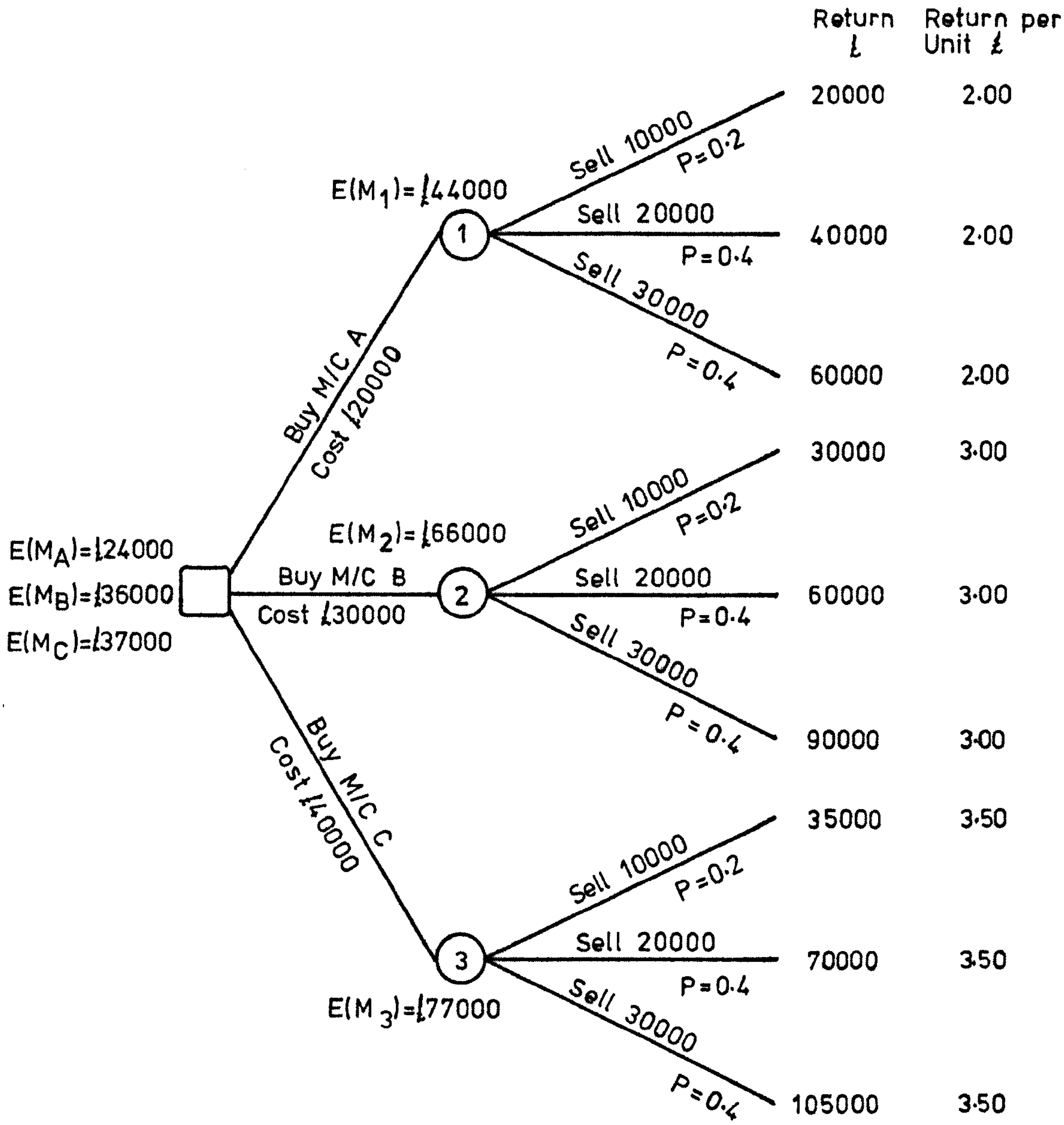


$$E(M_1) = (0{\cdot}2 \times 9600) + (0{\cdot}5 \times 18000) + (0{\cdot}3 \times 30000)$$
$$= 1920 + 9000 + 9000$$
$$= £19920$$

$$E(M_2) = (0{\cdot}2 \times 17600) + (0{\cdot}5 \times 33000) + (0{\cdot}3 \times 55000)$$
$$= 3520 + 16500 + 16500$$
$$= £36520$$

$$E(M_3) = (0{\cdot}2 \times 22400) + (0{\cdot}5 \times 42000) + (0{\cdot}3 \times 70000)$$
$$= 4480 + 21000 + 21000$$
$$= £46480$$

Figure Ten: Expected Decision Tree to Machine Choice Problem.

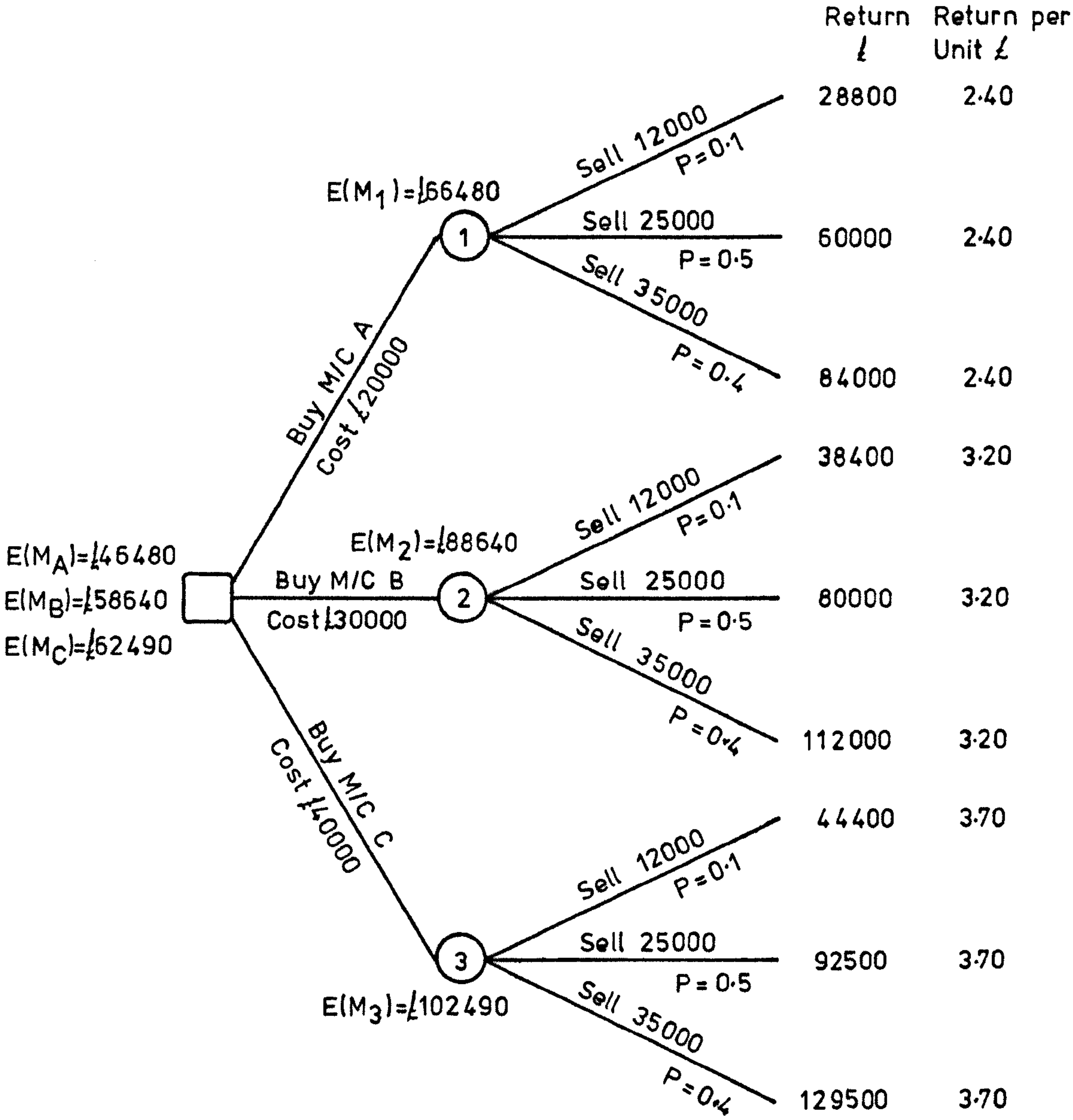


$$
\begin{aligned}
E(M_1) &= (0{\cdot}2 \times 20000) + (0{\cdot}4 \times 40000) + (0{\cdot}4 \times 60000) \\
&= 4000 + 16000 + 24000 \\
&= £44000
\end{aligned}
$$

$$
\begin{aligned}
E(M_2) &= (0{\cdot}2 \times 30000) + (0{\cdot}4 \times 60000) + (0{\cdot}4 \times 90000) \\
&= 6000 + 24000 + 36000 \\
&= £66000
\end{aligned}
$$

$$
\begin{aligned}
E(M_3) &= (0{\cdot}2 \times 35000) + (0{\cdot}4 \times 70000) + (0{\cdot}4 \times 105000) \\
&= 7000 + 28000 + 42000 \\
&= £77000
\end{aligned}
$$

Figure Eleven: Optimistic Decision Tree to Machine Choice Problem.



$$E(M_1) = (0{\cdot}1 \times 28800) + (0{\cdot}5 \times 60000) + (0{\cdot}4 \times 84000)$$
$$= 2880 + 30000 + 33600$$
$$= £66480$$

$$E(M_2) = (0{\cdot}1 \times 38400) + (0{\cdot}5 \times 80000) + (0{\cdot}4 \times 112000)$$
$$= 3840 + 40000 + 44800$$
$$= £88640$$

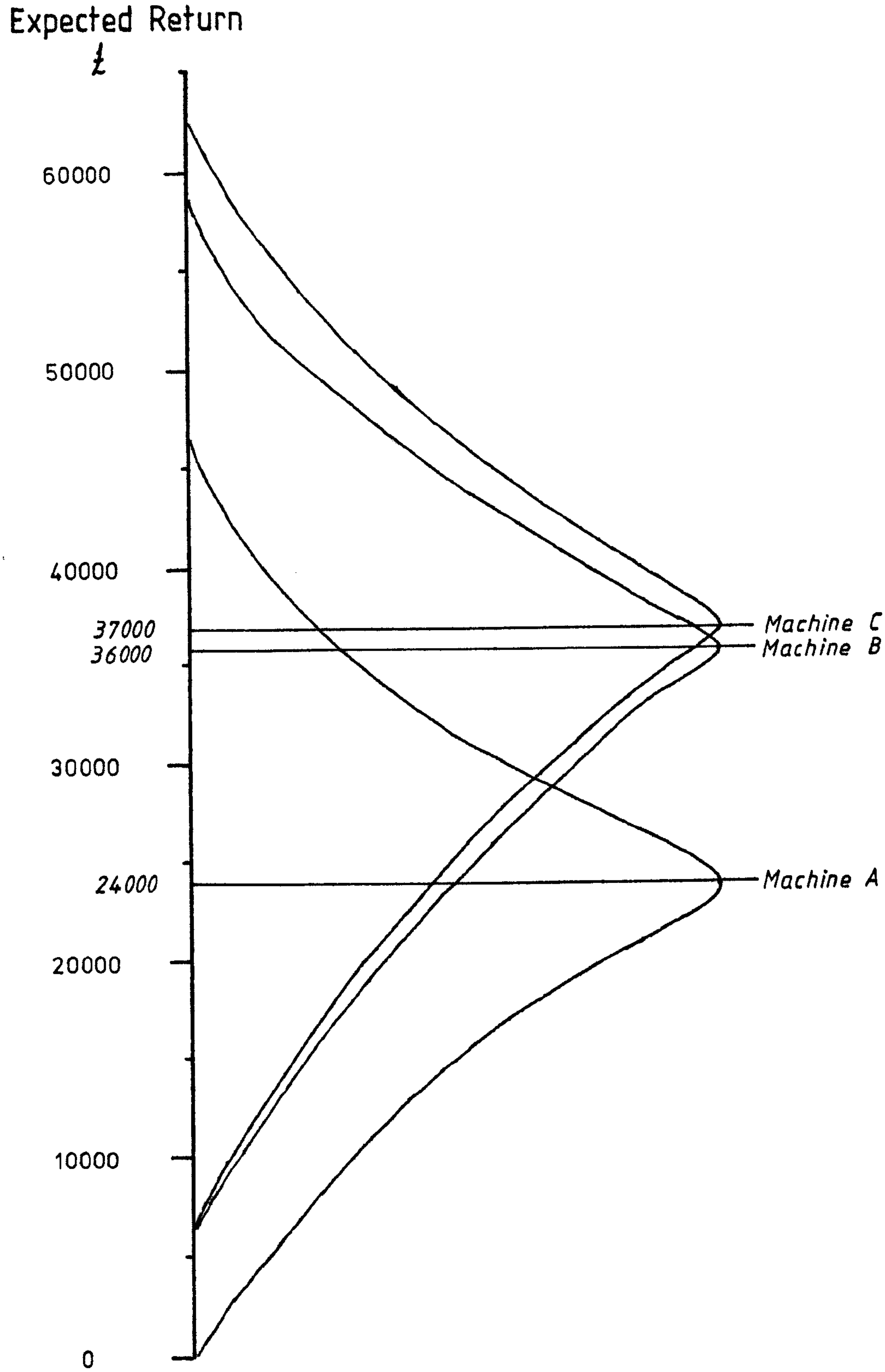
$$E(M_3) = (0{\cdot}1 \times 44400) + (0{\cdot}5 \times 92500) + (0{\cdot}4 \times 129500)$$
$$= 4440 + 46250 + 51800$$
$$= £102490$$

MACHINE C	Pessimistic Return	=	£6,480
	Expected Return	=	£37,000 Standard Deviation = £9,335
	Optimistic Return	=	£62,490

These results are best presented in a visual form so as to have maximum impact on managers this is shown in figure twelve. Such a presentation can be valuable even to managers with little statistical knowledge. The greater the manager's statistical knowledge the more probablistic the analysis can become. Normal distribution theory can be used to determine the probability of achieving given returns or given expected (average) returns.

The disadvantage of this method is that all the tree is say optimistic whereas the manager may only want part of the tree or some of the values of the tree to be optimistic. This problem could be possibly overcome with the use of an interactive computer simulation package to enable the manager to monitor the effects of various changes in the tree. There is also a problem of the amount of work involved. Such an analysis increases the work in collecting estimates, etc., but the time spent gaining a range of value should greatly improve the quality of such estimates. The work in the production of the trees will be increased two fold and the work in analysis will also be increased. Extra benefits gained from the extension of decision trees in this manner, i.e. better estimates, a greater awareness of the variability of decision trees

Figure Twelve: Graph Showing Relationship Between Expected Returns of the Three Machine Types in the Machine Choice Problem.



and a measure of this variability, should outweigh this extra work.

2.5.4. BAYESIAN DECISION THEORY AND DECISION TREES.

Bayesian ideas are important for decision theory. Consider the following example used by Emery *1 in determination of value of information.

Suppose the introduction of a new product is being considered and to simplify the analysis we assume a given profit if the product is a success and a given loss if the product is a failure.

		Actual Outcomes (£000)	
		Success	Failure
ACTION	INTRODUCE	100	-50
	DO NOT INTRODUCE	0	0

From past information marketing management determine that 60 per cent of the time new products have been successful and therefore 40 per cent of the time failure. This in Bayesian terms give the prior probabilities.

The problem is whether or not to produce a Market Research Study and again we find that from past records the predictions of such surveys are correct 80 per cent of the time.

*1 EMERY. (1971)

We now require the probabilities of predicting success and actually getting success, predicting success and actually getting failure, etc. By using Bayes Therom we can arrive at the following mathematical form for the probability of a failure given a prediction of a failure ($Prob(F/P_F)$) (See section 2.4.)

$$Prob(F/P_F) = \frac{Prob(P_F/F \cdot Prob(F)}{Prob(P_F)}$$

$$= \frac{Prob(P_F/F) \cdot Prob(F)}{Prob(P_F/F) \cdot Prob(F) + (P_F/S) \cdot Prob(S)}$$

where $Prob(F/P_F)$ = probability of failure given a prediction of failure.

$Prob(P_F/F)$ = probaility of predicting failure if it actually would occur.

$Prob(F)$ = probability of failure.

$Prob(P_F/S)$ = probability of predicting failure if success actually would occur.

$Prob(S)$ = probability of success.

Thus giving in this example:-

$$P(F/P_F) = \frac{0{\cdot}8 \times 0{\cdot}4}{0{\cdot}8 \times 0{\cdot}4 + (1-0{\cdot}8) \times 0{\cdot}6}$$

$$= \frac{0{\cdot}8 \times 0{\cdot}4}{0{\cdot}8 \times 0{\cdot}4 + 0{\cdot}2 \times 0{\cdot}6}$$

$$= \frac{0{\cdot}32}{0{\cdot}32 + 0{\cdot}12} = \frac{0{\cdot}32}{0{\cdot}44} = {\cdot}7273$$

Similarly the other posterior probabilities can be calculated to give the following table of posterior probabilities.

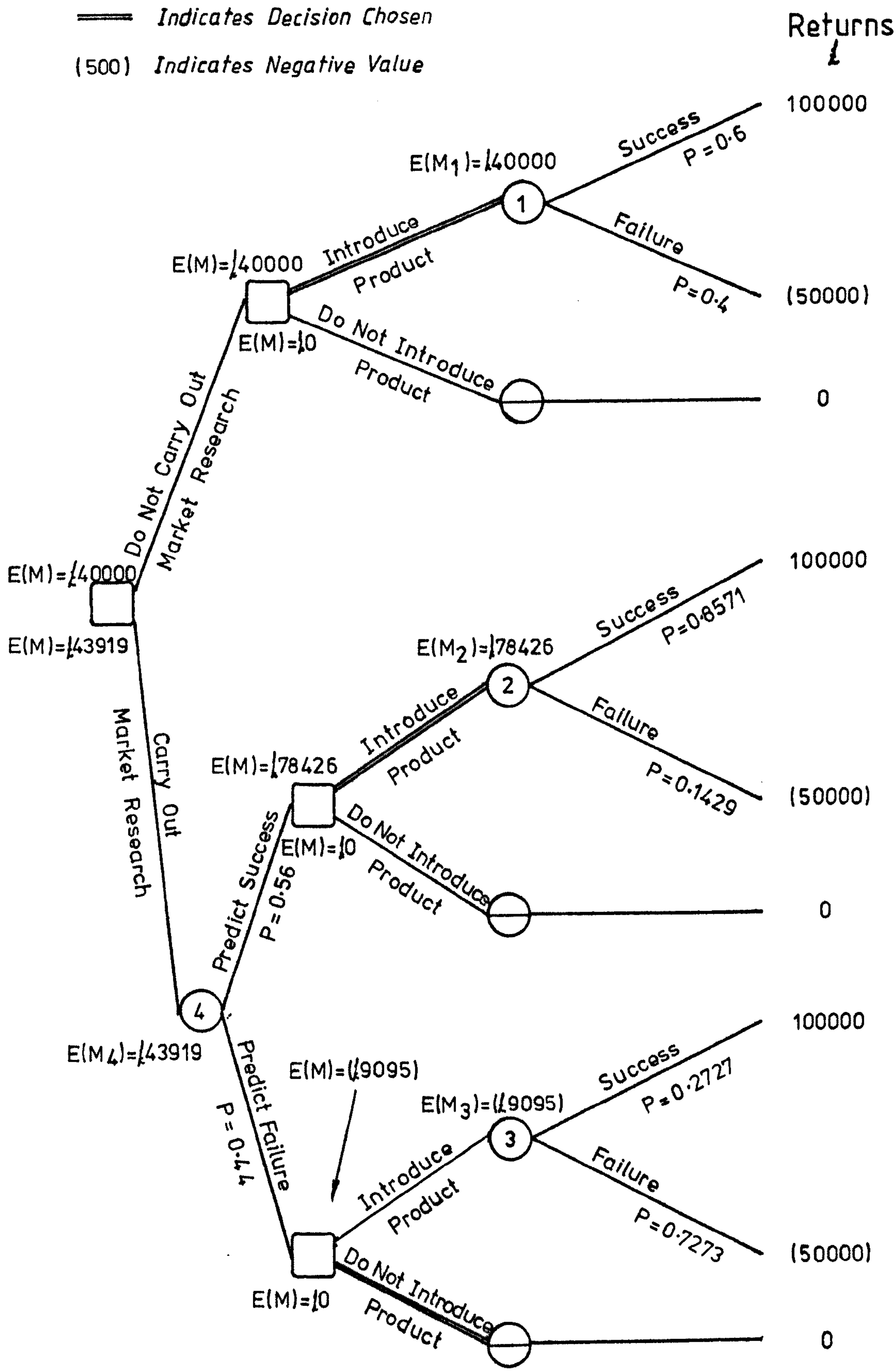
		ACTUAL OUTCOME	
		SUCCESS	FAILURE
PREDICTED OUTCOME	SUCCESS	0•8571	0•1429
	FAILURE	0•2727	0•7273

All this information can now be used to produce a decision tree of this situation. The cost of the market research has not been placed on the tree as the value of this piece of information is being determined. The cost must then be at most equal to the value of the information before it can be considered economic to carry out the market research. If the cost is less than the value of the information then it could be said that there is an 'Information Profit'. The returns on the tree have not been discounted so as not to complicate the example although in practice some form of discounting may be considered necessary. The decision tree for this problem is shown in figure thirteen.

$$
\begin{aligned}
E(M_1) &= (0{\cdot}6 \times 100{,}000) + (0{\cdot}4 \times -50{,}000) \\
&= 60{,}000 - 20{,}000 \\
&= £40{,}000
\end{aligned}
$$

$$
\begin{aligned}
E(M_2) &= (0{\cdot}8571 \times 100{,}000) + ({\cdot}1429 \times -50{,}000) \\
&= 85{,}571 - 7{,}145 \\
&= £78{,}426
\end{aligned}
$$

Figure Thirteen: Decision Tree to Market Research Problem.



$$E(M_3) = (0{\cdot}2727 \times 100{,}000) + (0{\cdot}7273 \times -50{,}000)$$
$$= 27{,}270 - 36{,}365$$
$$= £-9{,}095$$

$$E(M_4) = ({\cdot}56 \times 78426) + (0{\cdot}44 \times 0)$$
$$= £43{,}919$$

NOTE:- The probability of 0·44 for the prediction of a failure comes from the underside of the Bayesian expression to obtain the probability of a failure given a prediction of a failure.

From the tree the value of the Market Research information could be taken as £3,919 and providing that it could be carried out for this value it would be economic. If it could be carried out for less then it could be said that an 'Information Profit' is being made. The full interpretation of the tree will need to be carried out as for the previous example of a decision tree. For example we may have our own Market Research Section who are at the present moment going through a slack period (only of a temporary nature). In such cases even though the survey may cost £6,000 it may still be considered necessary to carry out the survey to keep the Market Research Section in full employment. It must be remembered though that such a value of the information is based upon an 80% success rate of predictions. If this falls its value will be reduced but if it can be increased then the value will increase, but will level towards the 100% success rate.

In this case the prediction rate of success and failure have been taken to have the same value, in practice this is not necessarily the case and different rates may need to be used.

The use of Bayesian decision theory within decision trees allows for the use of prior and posterior probabilities which takes account of the fact that predictions and outcomes are not necessarily the same thing. Providing that the success rate of predictions is known it can be taken into account and can be used as one method of setting value to information. The use of Bayesian decision theory bypasses the need for confidence limits on the conventional decision tree and eliminates some of the difficulties associated with decision trees.

2.5.5. SIMULATION AND OTHER QUANTITATIVE TECHNIQUES AND DECISION TREES.

Simulation can have two major impacts on decision trees. First it can provide information relating to business decisions. By the use of simulation models with many parameters predictions can be made of future events. Models can provide probability elements, costs, returns, etc., to place on the tree. This predictive mode of simulation will be discussed at length in section 2.6.

The other major impact of simulation is in the provision of an interactive simulation package, almost certainly computerised. The first part of the package would provide, with the use of programmed learning, the manager's introduction to decision analysis. This would then be followed up with a further part providing support for the manager's decision making. This would carry out all the calculation work for the manager although from the first part of the package he would have an understanding of the calculations involved. There would need to be a question-answer procedure to construct the detail of the decision tree and then to enable the manager to ask such questions, as "what happens if I take the following action" etc. It would have advantages to provide such a package on an on-line computing facility in that managers appear to prefer to work with a computer than a decision analyst in person. The manager would not have as many consultative problems with the computer, he would not have to admit lack of knowledge or ask the help of another member of the organisation.

It must be remembered that many quantitative techniques may be used in the determination of the various actions and associated returns on the decision tree. Stock Control, Mathematical Programming, Replacement and Reliability Theory, etc., might all be used. Decision Analysis could be said to involve many quantitative techniques and must also take account of non-quantifiable factors.

2.5.6. SUMMARY

Decision Analysis can be of great value to management.

Decision trees provide a clear pictorial presentation of any particular decision whatever quantitative techniques have been used to determine results and outcomes of the different actions which can be taken. It must be remembered though that decision analysis is only an aid to managers and such an analysis should be considered by the manager along with all the non-quantifiable aspects of the decision.

It is possible to use decision analysis as one method of setting a value for a particular set of information.

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2.6. SIMULATION.

The technique of simulation modelling was developed for three major reasons. First the basic approach of people in the solution of problems is that of experimentation. If one wants to change the layout of a room in a house the basic approach by most people would be to experiment with different layouts, until the best is found. The penalty cost involved with disruption, relayout costs, etc., are probably small and only limited to a little extra backache. If this approach of direct experimentation was to be applied in the redesign layout of a production area within an organisation then the disruption and relayout costs, etc., would be considerable so making the approach uneconomic. Simulation modelling though allows a form of experimentation to be carried out economically. To build a model of the actual system provides a vehicle which can be used at relatively little cost to carry out experiments.

The second major reason could be said to be mathematical in origin. Simulation modelling can provide solutions to problems that may require complicated, if not intractable mathematics to solve. Queueing Theory is a good example of this. The mathematics involved in the production of equations for a simple queue are quite reasonable but unfortunately simple queues are not found in many practical examples. When queues are complicated by limits to their size, varying arrival rates, complicated service rules, etc., then the mathematics becomes very complex so making simulation the easiest and the most economical approach.

The third reason is in the development of O.R. itself. Practitioners in the field of O.R. found that the techniques frequently used were basically experimental in nature which naturally led to the development of simulation. An important part of O.R. is the implementation of results, i.e. the 'selling' of the results to management. Sophisticated mathematical solutions and concepts are all very well between O.R. workers, but are unlikely to carry a great deal of weight with the average manager. The old proverb is very true: "People would rather live with a problem they cannot solve than accept a solution they cannot understand".

The average manager will be familiar with the methods of simulation although not necessarily the jargon. Providing that the methods are not obscured by massive computer programs and fancy jargon he should be able to understand clearly the processes used to obtain solutions.

Simulation models can be divided into three basic types.

2.6.1. ICONIC MODELS.

An iconic model represents certain aspects of a system pictorially or visually. A model aircraft used in a wind tunnel is an iconic model. Iconic models are frequently used to display to customers a company's product range and to help them visualise products which are either too large or too small. They can be of great value when used to provide visual information of this sort. They can also in a limited sense be of value in prediction i.e. in the case of the aircraft it is far cheaper to make design changes at the model stage of development than at the prototype stage.

2.6.2. ANALOGUE MODELS.

An analogue model employs one set of properties to represent some other set of properties which the system being studied possesses, e.g. for certain purposes the flow of water through pipes may be taken as an analogue of the flow of electricity in cables or visa-versa. Maps, graphs, and flow charts are further examples of analogue models, where colours lines and positions are used to show physical or other characteristics of the entity being studied. These types of model have a considerable value in the provision of information but like the Iconic model this is principally in the provision of visual information and only to a small degree in prediction and control.

2.6.3. SYMBOLIC MODELS.

A symbolic model is one which employs symbols to represent properties of the system under study by means of a mathematical equation or set of such equations and mathematical rules. The symbolic system is of the three the most difficult to conceive and the most general and abstract. This problem can be overcome in part by using a corresponding iconic or analogue model, whose function is more often explanatory than predictive. Symbolic models are well suited to the prediction or determination of effects of changes on the actual systems. Symbolic modelling is the type frequently used in Operational Research where effects of change, etc., need to be discovered. This type of modelling can be either carried out manually or on a computer. In practice the majority of O.R. applications of simulations are carried out with a digital computer, which has a very much greater speed of operation and is usually more accurate. The type of problems to which solutions have been found by simulation include queuing problems, stock control, production balancing, production planning and scheduling, market and corporate planning, etc.

Any particular simulation application may use more than one type of model.

2.6.4. CONSTRUCTION OF A SIMULATION MODEL.

The best way to describe the construction of a simulation model is with the aid of an example. Consider the following example: A large building company has four sets of a certain piece of specialised equipment (a cement spraying machine). The company keeps the sets of equipment at a central depot and they are sent out to the company's different sites when required.

The first stage in the construction of a simulation is that of determining the problem to be solved. This is extremely important as it will affect the construction of the model. It is also useful at this stage to try to consider possible future uses of the simulation to try and make the work more economically viable. In this particular case the problem is that the company have found that four sets of the equipment are not sufficient and require to know the effect of different methods of operation of the existing equipment and the effects of purchasing more sets of the equipment. Given this statement of the problem the model can now be constructed.

The next stage is to define the system. Within simulation a simplistic definition of system can be used. The system can be defined by the boundary drawn around it. Everything inside the boundary is 'the system' everything outside the system is 'the environment'. The drawing of this boundary can be difficult. Too wide a boundary and the simulation is large, difficult to construct and possibly uneconomic, too small a boundary and the simulation is easy to construct but is unlikely to represent the situation correctly. The boundary should then be drawn as small as possible for economic reasons but wide enough to allow an accurate representation of the factors affecting the problem. This definition of the system could well change as the situation is analysed in more detail. In the case of the example being considered a reasonable definition of the system would appear to be the sets of the equipment and the jobs on which they are used.

Having now defined the system the next step is to analyse the system and to decide how detailed the simulation needs to be. How detailed the simulation is to be is a similar problem to that of defining the systems. The more highly detailed the model the more it will reproduce the real system, it will however be large, cumbersome and expensive. A model with little detail will be general in nature and it will be relatively inexpensive but the results obtained from it will have a wider margin of error. Within the example do we need to create a separate entity for the operator? This will depend upon the relationship between the operator and equipment. If the operator comes with the equipment or if anybody can operate the equipment then no, but if there are only a limited number of operators within the organisation all operating any of the sets of the equipment then it may be possible that they could affect the utilisation of the machine. If so then it would be necessary to create separate entities for the operators and machines. In the case of the example it will be assumed that the equipment can be operated by any individual, so such a model will require two sets of entities, one to represent the sets of equipment (four initially but will need to be increased when model is used for prediction), and the other set to represent the jobs requiring the equipment, (number unknown). Continuing the analysis of the system the entities need to be described further. The best way to describe a real system is by describing the states of the entities and the rules affecting the transition between states. Within this example the states of the two entities and the relationship between the states can be produced.

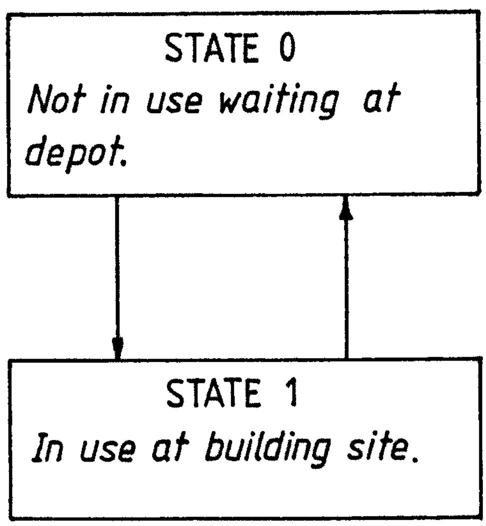
ENTITY:- Set of Equipment (4 such entities).

LIST OF STATES: STATE 0 Not in use waiting at depot

STATE 1 In use at building site

NOTE:- in an actual example there would be far more states for example; brokendown, waiting transport, etc. These have not been included so as not to over complicate the example.

RELATIONSHIP BETWEEN STATES: Such relationships are better shown in diagramatical form as below.



ENTITY:- Job (number dependent on length of simulation run)

LIST OF STATES. STATE 0 Job Arises.

STATE 1 Waiting for piece of equipment to become vacant.

STATE 2 Job being carried out by equipment.

STATE 3 Job completed.

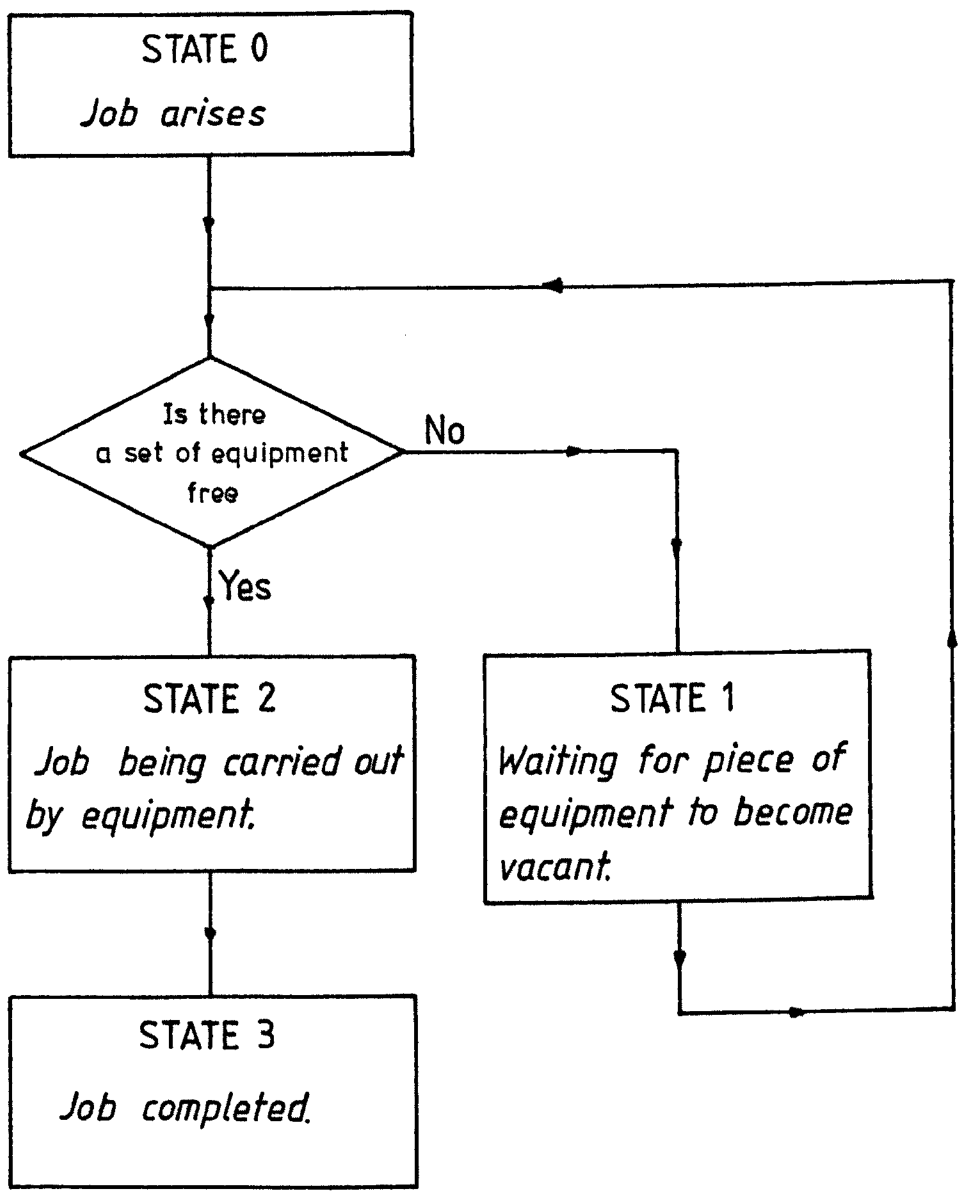
RELATIONSHIP BETWEEN STATES: This relationship for job entity is shown in figure fourteen.

The next process in the production of a simulation model is to determine the rules of transition between the states. Some transitions are due to logic, the majority though occur because of the progression of time. For example for the entity job to move from state 2 to state 3 the time taken to complete the job must have elapsed. For the example being considered the following distribution of times taken to complete jobs has been determined.

TIME TAKEN TO COMPLETE JOB IN DAYS.	PROBABILITY OF OCCURRENCE.
1	0·35
2	0·30
3	0·20
4	0·08
5	0·05
6	0·02

The time taken to complete a job is not fixed but is variable and this variability can be built into the model with Random Numbers. If a random number stream of two digits is taken (00 to 99) and 35 of those numbers associated with 1 day, 30 of them with 2 days and so on, then such a table with the use of a random stream can create

Figure Fourteen: Diagram Showing Relationship Between the States of the Job Entity for the Simulation Example.



job times randomly, but following the same pattern as would be expected in the real situation.

LOOK UP CHART ONE TO CREATE JOB TIMES.

RANDOM NUMBER	DAYS.
00 - 34	1
35 - 64	2
65 - 84	3
85 - 92	4
93 - 97	5
98 - 99	6

Also needed to complete the model will be the number of new jobs arising in any time period. For this example the number of new jobs arising in any day is given. New jobs arising at the beginning of the day.

NUMBER OF NEW JOBS ARISING IN ANY DAY	PROBABILITY OF OCCURRENCE
0	0•40
2	0•35
4	0•18
6	0•05
8	0•02

Converting this to a look up chart gives

LOOK UP CHART TWO: TO CREATE NUMBER OF JOBS/DAY.

RANDOM NUMBER	NUMBER OF JOBS/DAY.
00 - 39	0
40 - 74	2
75 - 92	4
93 - 97	6
98 - 99	8

The mechanics of the simulation can now be constructed in the form of a flow chart and operational tables. The flow chart for this example is shown in figure fifteen A,B and C.

Before a table/s to operate these instructions can be determined a method for determining time needs to be introduced. The simulation needs a clock, this usually being a simple counter. The 'tick' of the clock being determined for each simulation as large as possible and yet small enough to allow for the detail of the simulation. In this case things occur daily so it would seem that a day would be an appropriate 'tick'.

Now the time scale has been determined the tables to carry out these rules can be constructed, in this case one to record the M/Cs and one to record the jobs. These tables are shown with the simulation being run for 15 days. Figure sixteen shows table one the record of machines and figure seventeen shows table two which records the job

Figure Fifteen A: Flowchart for Simulation Example.

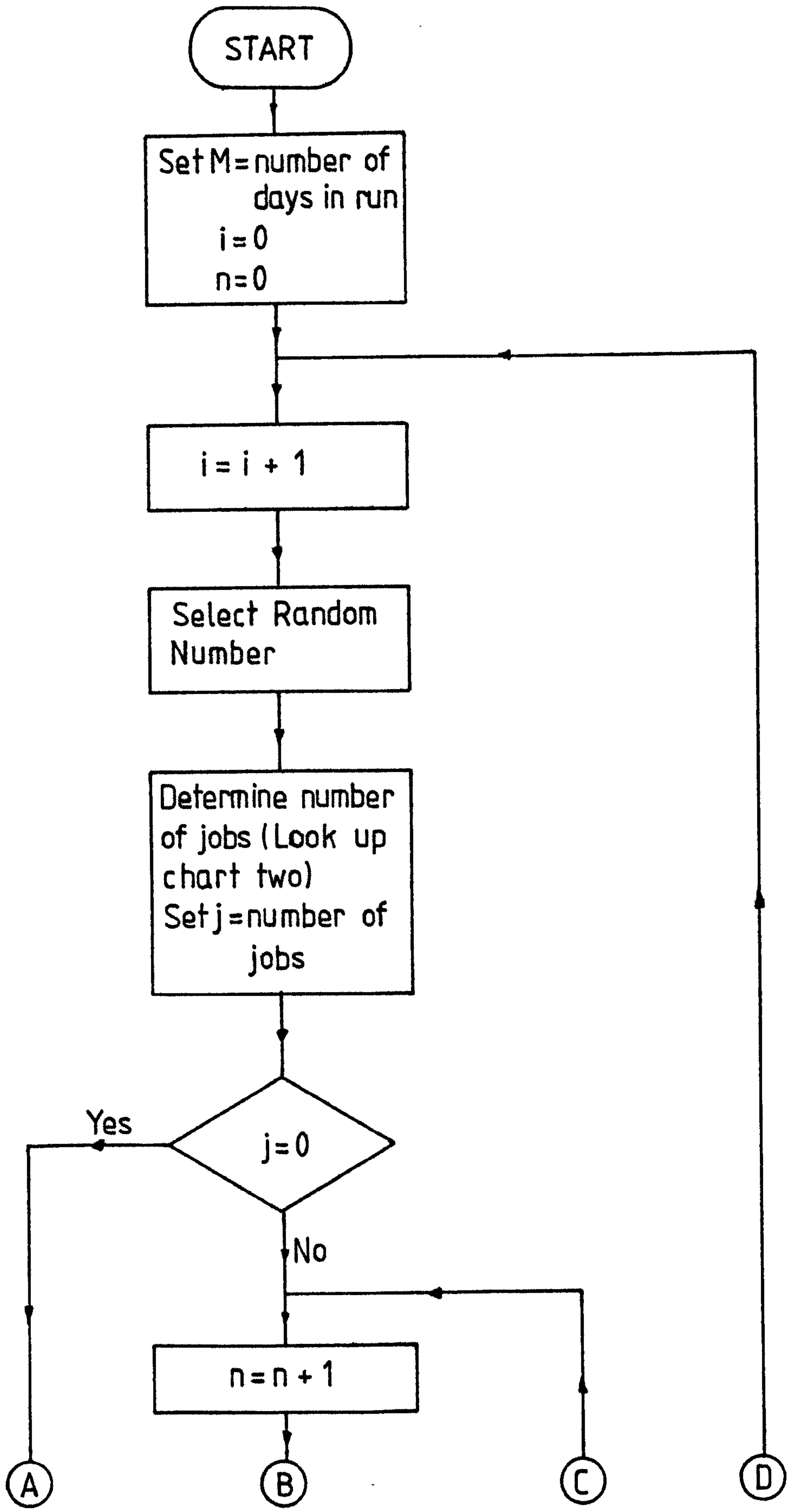


Figure Fifteen B: Flowchart continued.

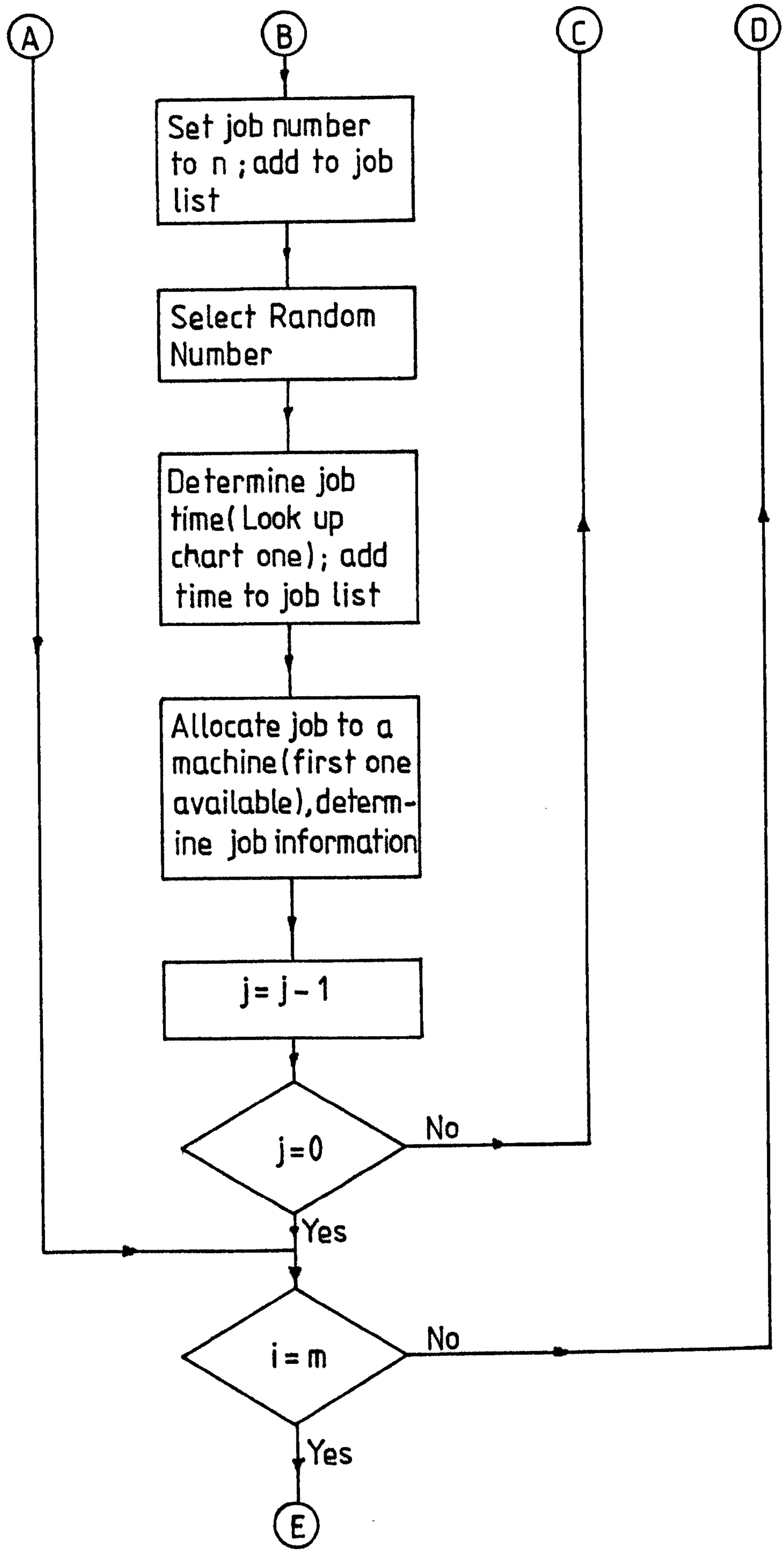
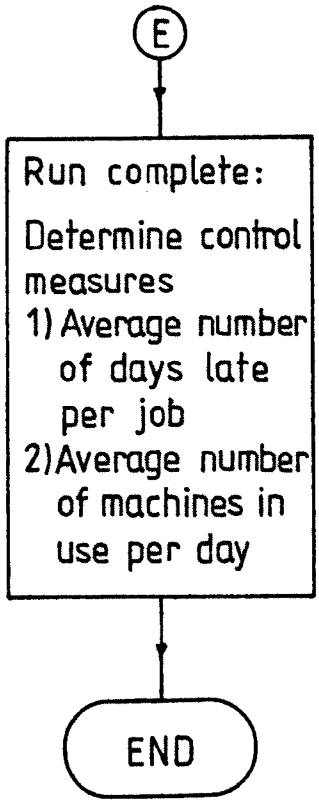


Figure Fifteen C: Flowchart continued.



Note: Job information comprises the following:

1) Start day
2) Required completion
3) Actual completion
4) Days late

Figure Sixteen: Simulation Operating Table One the Record of Machine Operations.

Run No 1 Sheet No 1 No of Days 15 TABLE ONE

TIME Days	Number of Jobs R.N.	Number of Jobs Jobs	M/C 1	M/C 2	M/C 3	M/C 4	No M/Cs In Use
1	09	0					0
2	54	2 1 2	1	2			2
3	80	4 3 4 5 6		3	4	5	4
4	79	4 7 8 9 10	6	7		9	4
5	59	2 11 12			8		4
6	35	0		11		12	4
7	91	4 13 14 15 16	10			14	4
8	55	2 17 18		15	13		4
9	47	2 19 20	16	17		18	4
10	52	2 21 22	19			20	4
11	96	6 23 24 25 26 27 28		21	22		4
12	86	4 29 30 31 32				24	4
13	20	0	23	25	26	27	4
14	26	0		28	29		4
15	90	4 33 34 35 36	30				4
16			34		32	33	
17				31			
18			35				
19							
20					36		
21							
22							

Figure Seventeen: Simulation Operating Table Two the Record of Job Information.

Run No 1 Sheet No 1 No of Days 15 TABLE TWO

Job Number	Number of Days		Start Day	Req Compltn (End of Day)	Actual Compltn (End of Day)	Days Late
	R N	Days				
1	42	2	2	3	3	
2	01	1	2	2	2	
3	06	1	3	3	3	
4	06	1	3	3	3	
5	26	1	3	3	3	
6	57	2	4	4	5	1
7	52	2	4	5	5	
8	80	3	4	6	6	
9	45	2	4	5	5	
10	68	3	6	6	8	2
11	48	2	6	6	7	1
12	12	1	6	5	6	1
13	89	4	7	10	10	
14	49	2	7	8	8	
15	33	1	8	7	8	1
16	10	1	9	7	9	2
17	60	2	9	9	10	1
18	19	1	9	8	9	1
19	55	2	10	10	11	1
20	48	2	10	10	11	1
21	49	2	11	11	12	1
22	54	2	11	11	12	1
23	80	3	12	13	14	1
24	05	1	12	11	12	1
25	17	1	13	11	13	2
26	23	1	13	11	13	2
27	56	2	13	12	14	2
28	15	1	14	11	14	3
29	08	1	14	12	14	2
30	18	1	15	12	15	3
31	95	5	15	16	19	3
32	73	3	15	14	17	3
33	79	3	15	17	17	
34	57	2	16	16	17	1
35	01	1	18	15	18	3
36	97	5	18	19	22	3

Figure Eighteen: Random Numbers.

09 49 09 99	52 98 05 19	45 89 27 98
54 54 62 47	02 49 03 36	27 75 35 38
42 96 32 08	14 42 14 45	89 76 42 81
01 80 91 76	14 29 39 41	34 85 93 93
80 05 69 21	49 46 06 96	20 70 07 68
06 17 48 57	19 66 86 53	24 27 61 22
06 23 07 77	48 73 87 89	05 22 68 52
26 56 64 54	62 13 17 64	89 56 24 52
57 15 69 96	04 17 17 37	42 92 56 53
79 86 44 02	33 94 77 15	89 03 70 72
52 08 72 73	05 54 66 07	37 74 47 08
80 18 11 76	53 07 14 57	11 00 86 84
45 95 37 56	29 91 68 05	75 53 77 09
68 73 35 98	70 36 26 32	47 74 80 07
59 20 99 68	17 97 85 52	16 07 84 86
48 26 31 05	05 06 11 90	24 75 49 96
12 90 80 45	02 30 16 80	94 40 09 03
35 79 88 45	35 38 26 28	38 88 80 15
91 57 90 19	53 94 95 50	01 63 72 47
89 01 46 37	67 26 67 51	47 18 91 50
49 97 54 93	31 32 97 46	50 80 85 06
33 33 51 04	34 06 73 72	67 72 76 92
10 64 43 52	00 76 75 40	73 09 68 48
55 01 62 85	48 64 64 25	27 92 79 78
60 50 51 62	74 19 26 22	18 74 20 07
19 29 10 83	35 09 45 47	16 87 44 32
47 34 25 24	17 80 01 94	54 60 77 83
55 46 48 76	03 34 87 15	96 81 99 01
48 11 89 53	05 45 20 10	56 02 43 69
52 43 25 83	23 02 01 50	82 15 87 50

Figure eighteen gives the random numbers used in the simulation.

NOTE:- Days shown are only working days, non-working days need not be shown as jobs will not arrive or be worked on during them.

Over this 15 day period

Average number of days late per job $= \frac{43}{36} = 1{\cdot}2$ days

Average number of M/Cs in use per day $= \frac{54}{15} = 3{\cdot}6$ M/Cs.

Before this model can be used in prediction it is necessary to determine that it is modelling the real situation within the limits of accuracy acceptable. There is need for the verification and validation of the simulation models, a step not always carried out in practice.

2.6.5. VERIFICATION AND VALIDATION OF SIMULATION MODELS.

The verification of the simulation model is to ensure that the model is behaving in the manner intended by the modeller, testing the machanics of the simulation. Testing things like the random number generator or the random numbers to ensure they are random. In the majority of simulations pseudo-random number generators are in fact used. They produce random numbers but after a few million they tend to repeat themselves. This stage is like a program test ensuring that all the sub-systems operate as intended. In the example being considered this is a relatively easy stage. The simulation uses a set of standard random tables *1 and the rules of operation are relatively simple. Within a large complex simulation carried out on a computer this can be a difficult and time consuming stage. The programs as well as the systems need to be debugged.

Having now verified the simulation and decided it is following the rules set down by the modeller it must now be validated. Validation is the process where the similarity between the model and the real system is tested. The model is run with parameters for which there are known results from the real system and then checked to ensure there is no significant difference between the model and the real system. Not only should various means be tested but also the variance of the measures to ensure similarity between the model and the real system. To carry this out there are various statistical tests. In the case of the example measure such as average number of days late per job, average number of machines in use and their variability could be compared from the model and compared with the real system. This stage of verification and validation can be likened to the calibration and testing of a scientific instrument. It can be very important when it comes to the implementation stage of the simulation results. It can be used to convince managers that the simulation replicated the real situation faithfully.

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*1 SEE FIGURE EIGHTEEN. (for more random numbers MURDOCH & BARNES. 1970 Table 24).

Models will usually have two modes of operation an initialisation phase and then a steady state. The initialisation phase of the example is when all the sets of equipment are in the depot and there are no jobs waiting to be processed i.e. the start up. The steady state will be reached in a few days operation, with the possibility of machines being out and jobs waiting. Depending upon the application it may not be desirable to have the initialisation stage. This should be taken into account at the verification and validation stages and also when the model is used for prediction.

2.6.6. USE OF SIMULATION MODELS IN PREDICTION.

Once the model has been tested it can be used to predict by running with different parameters to obtain the information required. This information used with further data such as cost information can then be used in the decision process. Care should be taken to ensure that the relationships used within the simulation are valid over the range of the parameters used in the predictions. If this is not known this should be taken into account when working out the confidence limits of the predictions.

In the example being considered runs (the length of the run being determined by standard sampling procedures) could be carried out to predict the effect of working rest days, operating 5, 6 or 7 sets of the equipment, etc. The results of these runs would then be used with such costs as, costs of set of equipment, cost of days late, cost of working days, etc., alongside company strategies and policies to assist management in determining a solution to the problem of waiting time.

The more complex the simulation and or the more runs required of the model the more likely it will be economic to computerise it. Computer models have the advantage of speed and accuracy, but are difficult to conceptulise and understand to the non-specialist. Therefore, when it comes to presenting the results of the simulations to management it may be necessary to employ an analogue model to assist their understanding and the operation of the simulation.

Simulations are of considerable value in the provision of prediction information and data to management both at the operational and strategic level.

2.6.7. USE OF INTERACTIVE SIMULATION MODELS.

Interactive simulation models can be used in the field of Management Information. By combining simulation models with programmed learning a package can be put together possibly with the use of real time computing, to assist managers to assess such things as uncertainty, value of information, etc. Such a package could provide initial training and practice for managers. Such a package could also provide consistancy checks, etc., when actually setting such values. The Post Office Corporation have found that individuals setting subjective probabilities have preferred the computer interaction rather than having a statistician or decision analyst providing the consistency checks. Sometimes the impersonality of the computer can have advantages.

2.6.8. THE SIMULATION OF INFORMATION SYSTEMS.

Models can be used in the design stage of information systems. The models can be simple analogue models to show the manager the proposed layout of a computer system's output. They can be much more complex for example a dry run of a new system. Before a system goes into operation it can be run giving typical outputs to ensure there are no bugs in the system and to ensure that managers are getting the outputs they require. Simulation models can also be used in predictive and interactive modes in the design stage of information systems.

2.6.9. SUMMARY

Simulation provides for managers a method of experimenting with processes which it would be impossible or very uneconomical to experiment with in real life. Models can be used in demonstration or can be used to make predictions which can then be used by managers in decision making and planning. By combining simulation with programmed learning such a package can be used by managers to develop skills in areas such as assessing uncertainty, setting value to information and many other subjective assessments. Models can also be useful when information systems are being designed.

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CHAPTER 3. ECONOMIC APPRAISAL OF MANAGEMENT INFORMATION : THE PRODUCTION OF A METHODOLOGY.

This chapter is the core of the thesis: the production of a methodology for the economic appraisal of management information. It builds on the work already covered in Chapter 2 the analytical background. The first section of the chapter examines some of the myths surrounding management information. This is then developed into a section covering the basic concepts in the economic appraisal of management information. The next three sections cover the determination of management information needs, value and cost. The next section in the chapter is entitled Cost Benefit Analysis of Management Information and looks at the relationship between the value and cost of information. There is then a section that looks at the role of the information analyst as a consultant within the organisation. The final section summarises the chapter and outlines the methodology for the economic appraisal of management information.

Detailed Contents of Chapter 3

3.1. THE MYTHS OF MANAGEMENT INFORMATION.

People who have concerned themselves with Management Information appear to fall into two groups: individuals who are optimistic, some almost to the point of euphoria, and individuals who are pessimistic, some almost to the point of cynicism. A number of people have put forward, with a degree of pessimism, various 'myths' of management information. Tricker *1 identified the following ten myths which encompass the majority of myths suggested by other people.

1. The study of management information systems is about the use of computers.
2. More data in reports means more information for managers.
3. The accountant aims to keep the cost of information to a minimum.
4. For information to be available instantly increases its usefulness.
5. Accuracy in reporting is of vital importance.
6. More frequent reporting means more useful information.
7. Total integration is the ultimate goal in information system design.
8. One corporate data base will ultimately provide common data for all application programmes and produce the data for management information.
9. Managers' information needs can be determined by professional systems study.
10. We understand what management information is.

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*1 TRICKER. (1971)

The last one Tricker refers to as the supreme myth of management information. These myths will now be considered in detail.

3.1.1. THE STUDY OF MANAGEMENT INFORMATION SYSTEMS IS ABOUT THE USE OF COMPUTERS.

"In a bibliography published in 1969 there were more than 500 references to books and papers which were to some extent, concerned with the subject. Since then the interest and the number of papers have multiplied. There must be as many definitions of information systems as there are writers: indeed more, since some of us change our views over time.

Yet the predominant focus has been on harnessing the computer's potential in business and other systems. Glib claims have been made about the possibility of providing "better management information". The major applications,however, have had little to do with management information. Almost exclusively they have involved work at the operating level." *1

Tricker appears to be justified in his statement as far as the sixties, early seventies are concerned. M.I.S. was taken to be computer systems and even then purely at an operational level. Recent work has moved away from this to a more realistic view of M.I.S. to include Informal Information Systems and the non-computer formal information

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*1 TRICKER. (1971)

of the organisation. More thought is also being given to the information needs of management. Also work is being carried out in the O.R. field for the provision of information from corporate models to assist management in strategic decision making, (most of these being computer based due to the complexity of the computations). The use of modelling for the provision of information to management has been dealt with in section 2.6. Although it is now generally agreed that the study of M.I.S. is not just the study of computers, whenever a computer is used in an organisation it can, provided it is used correctly, become a powerful tool for the provision of some of the information required by management. The use of computers within management information systems will be considered later.

3.1.2. MORE DATA IN REPORTS MEANS MORE INFORMATION FOR MANAGERS.

> "This is a classical misapprehension. The hoary tales of massive computer printouts which are ignored by managers are legion. The accountant frequently fails to recognise that there is a difference between data in which he deals and information which involves the use made of data by managers". *1

Tricker's paper was aimed at accountants but his criticisms could equally be levelled at other members of organisations. The myth that Tricker talks of is that more data means more information and is based on

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*1 TRICKER. (1971)

the difference between data and information. Grindlay *1 takes this further and suggests that it is wrong to assume that a manager needs more information although he does not really follow this through to say why. At this stage the relevance of the information (see section 2.2.) must be considered. Information will be of greater value the greater the relevance. Management therefore will need the information with the greatest degree of relevance, but it may be possible to take several pieces of low relevance information and collate them to produce information of a higher relevance. So it may be said that the amount of information a manager needs will depend upon its relevance.

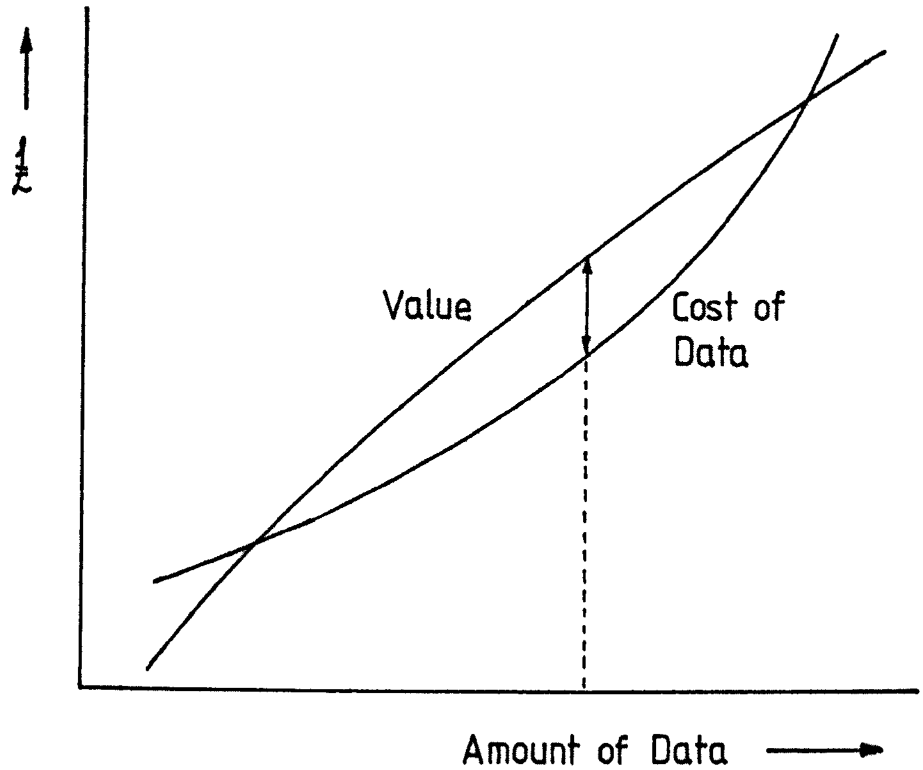
3.1.3. THE ACCOUNTANT AIMS TO KEEP THE COST OF INFORMATION TO A MINIMUM.

"The cumulative cost of providing data increases with the volume of data. Moreover the relationship is not linear; costs tend to escalate as more and more data are handled. True there are plateaux on which extra data can be produced for little extra cost but the curve rises steeply again as the next clerk, new accounting machine, or additional computer has to be added. In these circumstances, the accountant seeks to keep the demands for additional data to a minimum, recognising that each extra report involves the cost of reanalysis, recalculation, perhaps reprogramming and a computer rerun, yet each set of data has a potential information value to a capable decision maker. It is the relationship between cost and value

*1 GRINDLAY. (1973)

that the accountant should have in mind (see figure 19)." *1

Figure Nineteen: Relationship Between Cost and Amount of Data. (this corresponds to Fig 1 Tricker *2)



It is very important not just to try and minimise the cost of information but to look at the relationship between cost and information. It is a difficult relationship to consider because of the problems of determining cost and value of information, these problems being especially apparent when determining the value of information. Stigler said of the value of information:

"One should hardly have to tell academicians that information is a valuable resource: knowledge <u>is</u>

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*1 TRICKER. (1971).
*2 TRICKER. (1971).

power. And yet it occupies a slum dwelling in the town of economics. Mostly it is ignored: the best technology is assumed to be known; the relationship of commodities to consumer preferences is a datum. And one of the information - producing industries, advertising, is treated with a hostility that economists normally reserve for tariffs or monopolists." *1

The estimation of value and cost of information is difficult and therefore often not attempted. One of the aims of this study is to remedy this defect. The ways in which a value can be placed on information will be considered in section 3.4., the cost of information in section 3.5., and the relationship between cost and value of information in section 3.6.

3.1.4. FOR INFORMATION TO BE AVAILABLE INSTANTLY INCREASES ITS USEFULNESS.

"At the operating level, the time from step one to implementation is short. Here decision makers do need access as quickly as possible to data.......

At the managerial level, the decision process is extended. There is a larger thinking process. Instant access to data is less important. At the strategic level, instant information is unnecessary and unreliable. Senior executives involved in strategic considerations do not want to know how

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*1 STIGLER. (1968 Page 171).

many one inch screws are in stock.

They need condensed reports, synthesised from many data sources. Fortunately, the overall length of the decision process can be counted in days, weeks even months. Data can be prepared in advance of the board meeting; the call for additional data need not be met instantly. Indeed calls for instant information at the higher level tend to indicate senior decision makers with low decision horizons." *1

The speed of the requirements of information will vary depending on its use. Paretta *2 uses a slightly different classification than Tricker. Instead of classifying by the level at which the information is used he uses a system of classifying by the type of decision. He uses the following three types of decision:

I. Decisions improved by the speed of the information flow. There are some decisions in the management situation which will be improved by having quick access to information. Most of the decisions within this group will occur with control type decisions within the operational level of management, for example a control mechanism set up to ensure that a production line was producing items within limits. Information needs to be available quickly when the process has gone out of control to enable decisions to

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*1 TRICKER. (1971)
*2 PARETTA. (1974)

be taken to bring the process back into control. (The faster the production the quicker the information is needed to save defective components). The sort of technique to ensure this is carried out effectively would probably be some form of control chart. The same type of decision can occur at the strategic level, for example if the demand of a product changes dramatically then information to show this will be required rapidly so that action can be taken.

II. Decisions unaffected by the speed of the information flow. These are the type of management decision where an increase in the speed of the information will be of no value (it may also be possible actually to decrease the speed of information without any loss of the value of the information and possibly with a reduction in the cost). Deardon makes a valid point in connection with these types of decisions. *1

"In the area of performance evaluation, real-time management information systems are particularly ridiculous. When a division manager agrees to earn, say $360,000 in 1966 he does not agree to earn $1,000 a day or $1000/24 per hour."

Similarly with any decision that must wait for a particular piece of information then the remaining

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*1 DEARDEN. (1966)

information need not be available to the decision maker until the last piece of information is ready. Therefore, any increase of speed of any of this other information will be of no value. If the value of any piece of information for a given decision is completely unresponsive to the speed of the information flow then it would suggest that within the case considered that a particular piece of information is of no value (it may be of value to some other decision within the organisation.)

III.Decision hindered by the speed of the information flow. These are the type of decisions where an increase in the speed of information would only hinder the decision to be taken. Paretta suggests there are two conditions where this could occur. Firstly when dealing with data of a very unstable nature the speed of the data arriving can detract from the decision, i.e. the initial values received could be very different from the overall trend due to wide variations in the data and so if a decision was based on these initial pieces of data it could be faulty. The second type of decision which may be hindered by the speed of the information is where the information arrives faster than it can be dealt with which in the worst case would lead to no decision being taken because the decision taker would be always analysing the most recent information.

There are some fundamental problems in accepting the latter two classifications of decisions which are hindered by an increase in the information flow. With the first case it would seem to be that it is a problem of an 'incomplete decision maker' (i.e. someone not fully versed in decision taking) rather than a problem of information systems. It must be agreed that if the information is for an 'incomplete decision maker' then it is possible for this case to appear. It would seem to be more logical to develop the decision maker's risk taking ability and improve his statistical and other knowledge. Then the increase in speed of return of the information could be reliably evaluated. The second of the two types of decision would seem to suggest that decisions involve definite time from start of analysis to arrival at the decision. A more logical view would seem to be that each decision can be 'solved' within a range of different times (time to some extent being a function of accuracy of the decision). So it could be said that any decision could be solved immediately but the longer the decision takes the better the result and solution. This statement is a generalisation and once a decision passes a certain point in time taken to obtain a result then the laws of diminishing returns are likely to apply. It would seem again that the speed of the information should be determined by the value of the information to the decision process, the length of the decision interval being determined by the accuracy wanted at the end of the process (once this decision interval has been set the information is only required at the speed it is needed and used and any further increase will be of no value).

3.1.5. ACCURACY IN REPORTING IS OF VITAL IMPORTANCE.

> "The popular belief is that accuracy is good, inaccuracy bad. At the operating level this is true. The dispensing of medicine, the control of aircraft, the design of a bridge, all involve decisions for which accurate data are essential. [although not always available or there would be no disasters].
>
> Accuracy, however, is a relevant, not an absolute idea. High levels of accuracy involve high cost. At higher decision levels, great accuracy is irrelevant and a waste of money.........
> If those using published financial reports recognised that the data were probably plus or minus 20% or more there would be less fanatical about accuracy." *1

At the operational level then there are many cases where accuracy is vital. Moving through the organisation to the strategic level then the pursuit of total accuracy can become a red herring, although not all operational level activities need a great degree of accuracy. Slonim *2 gives the following example within the field of sampling. The Chesapeake & Ohio Railway Co. designed a sampling system to estimate their claim on interline freight fees

*1 TRICKER. (1971)
*2 SLONIM. (1968 Page 45)

due to the railroad. During the test period using a sample size of less than 10% of total transactions their claim was estimated to a level of 99•8% accuracy, (assuming the 100% check to be accurate?). This shows an example where a degree of accuracy is accepted (the cost of such inaccuracy being far outweighed by the savings from using sampling) within the field of accountancy, the traditional bastion of accuracy, calculating values to the nearest penny whatever the cost. (It is doubtful this could ever be calculated to 100% accuracy due to errors which will occur in any system designed or operated by man whatever the espenditure has been to eliminate error). If a more statistical approach to date was taken and it was accepted to be within certain limits a far more cost conscious view could be taken in the collection and analysis of such data.

Moving to the strategic level there occurs a different problem in accuracy. Here we are not concerned with using data to determine measures in retrospect but in the use of data and information for the predictions of measures for the future either by 'management intuition' or some statistical or simulation method. There is a tendancy in this technological age to confuse accuracy with complexity of calculation. The majority of the techniques used in the provision of information for use in predicting the future tend to be of a complex nature, a lot of them require involvement with the computer and it is very easy to confuse this complexity with a false level of accuracy (a belief not always dissipated by the expert). Another danger of these techniques is that they produce a single 'answer' to the problems of management in the prediction of future strategies, whereas what would be of more value to management would be a series of alternative strategies and their consequences for use in the changing environment of the organisation.

3.1.6. MORE FREQUENT REPORTING MEANS MORE INFORMATION.

This myth is very similar to the fourth myth and so has been dealt with in section 3.1.4.

3.1.7. TOTAL INTEGRATION IS THE ULTIMATE GOAL IN INFORMATION SYSTEM DESIGN.

This myth was first put about in the sixties with the original computerised information systems and it stems from the natural development of systems thinking into the total system. This way a useful way of thinking of the organisation as a whole but it is very difficult to put into practice. It has now been accepted that it may be possible to integrate partially at different levels but the ideas of total integration will not be possible with the present level of computer technology.

3.1.8. ONE CORPORATE DATA BASE WILL ULTIMATELY PROVIDE COMMON DATA FOR ALL APPLICATION PROGRAMMES AND PRODUCE THE DATA FOR MANAGEMENT INFORMATION.

This myth is very similar to the previous one that total integration to form one data base is sound in theory but almost impossible to achieve in practice. Again the more practical approach is to produce a series of data bases of related information. The problem of data bases will be considered later in the section concerned with the use of computers within information systems.

3.1.9. MANAGERS' INFORMATION NEEDS CAN BE DETERMINED BY A PROFESSIONAL SYSTEMS STUDY.

"This is an outstanding myth. Every systems analyst knows that if a manager is asked what information he needs there will be one of three replies: "I do not know", "I will have what I am getting now", "I will have everything you can give me". Each is as unhelpful as the other in designing an information system. Consequently, the analyst not infrequently takes matters into his own hands and determines what the manager should need." *1

Burgstaller and Forsyth *2 suggest there are at least five responses to the question of a manager's information needs.

(i) Bottomless-Pit Manager:- This is the manager who in response to the question what information do you require to complete your job will reply 'everything'. He requires any information that can be given to him just in case it may be of use to him. There could be many reasons why he requires this information, for example he has in fact not defined his job to himself and so he does not know his information requirements. (assuming the average manager can determine his information requirements).

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*1 TRICKER. (1971)
*2 BURGSTALLER & FORSYTH. (1973)

(ii) Accounting-Information Manager:- This type of manager can only consider management information to be accounting information. He works in Pounds, Pence and Variances, he finds these easy to work with and considers all other forms of information to be of little value. If this type of manager is involved in the design of any information system it can cause serious problems. To quote an example from personal experience. An accountant within a certain organisation designed a cost control system to replace an existing one. The existing system was a series of graphs updated weekly by departmental managers based on departmental costs. This system was replaced by a very sophisticated system based upon a large number of variances. The system lost credibility due to the fact that only a handful of people understood the concepts of variances (this not necessarily being the people who calculated them). The majority of managers extracted basic cost figures from the system and plotted them on a graph, disregarding the rest of the information.

(iii) In-Basket Manager:- When this type of manager determines his information requirements he takes rather a myopic view and determines his requirements from the problems, decisions, etc., he is working on at present, taking no account of future information requirements.

(iv) The Closed Door Manager:- This type of manager is the reverse of the bottomless pit manager. He requires little or no information, usually for the same sort of reason as the bottomless pit manager.

(v) The Mississippi Gambler Manager:- This type of manager 'plays his cards close to his chest'. He is usually reluctant to divulge his information needs for political reasons. This could be because he worries for the safety of his job or he is planning to extend his sphere of influence (empire building).

Although there are many problems in determining the information needs of managers some attempt must be made and there are many different techniques available. The determination of management information needs will be discussed at length in section 3.3.

3.1.10. <u>WE UNDERSTAND WHAT MANAGEMENT INFORMATIUN IS</u>.

"Here, surely, is the supreme myth. Generations of accountants have been providing what they call management information; likewise a decade or so of management scientists has been developing models and methods to provide management information.

Nevertheless, understanding of management, as distinct from data is abysmal. Of course we know how to handle the data processing, to provide reports, to prepare model solutions. We do not however, necessarily understand information.

What is not understood is the decision process, how a human being recognises the need for information, how he perceives problems, seeks information out of available data, evaluates, filters, excludes alternatives and, finally, chooses. This is not only not understood; it has not been accepted into the area of concern. We stop short at providing management information; our subject has been the provision of management data." *1

It would now seem that the statement made by Tricker that we know how to handle data processing is a little in doubt. As Mr. Peter Hermon, Group Management Services Director of British Airways, one of the country's largest computer users stated. *2

"We are enmeshed in a jungle of complexity and somehow we must get out of the softwear straight jacket we have cut for ourselves, reduce the overheads and banish the complexity so as to restore the economies that are fast disappearing down the drain."

When such an important user of computers queries our state of knowledge in the Data Processing field it is difficult to justify a statement that we know how to handle data processing.

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*1 TRICKER. (1971)
*2 HERMON. (1976)

3.1.11. ACKOFF'S FIVE MYTHS.

Ackoff queries five of the assumptions that are made by a number of designers of management information systems.

"1) The critical deficiency under which managers operate is the lack of relevant information.
2) The manager needs the information he wants.
3) If a manager has the information he needs his decision making will improve.
4) Better communication between managers improves organisational performance.
5) A manager does not have to understand how his information system works only how to use it." *1

Assumption two is one of the problems of trying to determine the information needs of an individual, this being a difficult task but one that must be tackled. The techniques used and the problems encountered will be dealt with in section 3.3.

Assumptions one and three are ones that are commonly made when dealing with information systems. They develop from a misinterpretation of the phrase information and the belief in the perfect manager. It is a misinterpretation to assume that the only problem management has got is a lack of information, there are many other problems. This is understandable however as the information analyst is too close to management information to consider the manager's other problems. The third assumption should in

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*1 ACKOFF. (1967)

fact be true except that a lot of management information provided by management information systems turns out to be data which the manager is not necessarily equipped to deal with and turn into information. Even when the management information system produces information the manager may still not be equipped to deal with it. The information analyst should compare his situation with that of a railway. The railways are in the transport business and not the railway business and if they had realised this then they might not be having problems now. Information analysts are in the information business not solely as the providors of data or information but also to assist with the understanding and use of such data and information.

The fourth assumption again assumes the perfect manager. Improving the means of communication between managers does not mean the managers will communicate any more effectively. The improvement of communications between managers is not just the provision of better mechanisms of communication but also an improvement of communicating skills of the manager a behavioural problem.

The last assumption, that a manager does not have to understand how his information system works only how to use it, is a particularly false one to make. It would be fair to say that the manager does not need to know the mechanics of how a computer or a data processing installation works. He will want to know, however, a considerable amount about any information produced by a management information system before he will be able to use any of the information with any degree of confidence. He should want to know how the data has been collected, and the accuracy of the data, he should want to know how that data has been analysed to turn it into information, especially so if some statistical or other technique has been employed, he should want to know how good an analytical tool is the particular technique used, with what accuracy can the information be used and possibly what value the information has. Without such details the information may be of reduced value or it may be used incorrectly, for example a forecast may be taken as being an absolute value when in fact the confidence limits of such value should be taken into consideration. This is best summarised in a quote from Ackoff. *1

> "No Management Information System should ever be installed unless the Managers from whom it is intended are trained to evaluate and have control of it rather than be controlled by it."

Our concept of the process of management may also need to be revised when talking to the manager of his information needs. It is very useful when designing information systems to consider such management activities as planning, motivating and decision making although when a manager considers his information needs he is unlikely to think of his work in such terms. Mintzberg *2 has suggested a new approach to the defining of managers' tasks which

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*1 ACKOFF. (1967)
*2 MINTZBERG. (1973)

appears to be better than the classical definition. Mintzberg's work has already been discussed in section 2.

3.1.12. SUMMARY

In the design of information systems there are a number of pitfalls which must be avoided.

1. Information systems are not solely concerned with computers.
2. There is a significant difference between data and information.
3. More data in reports does not mean more information for managers.
4. Where possible all information should be cost-justified which requires a value to be attributed to it.
5. Any increase in the speed at which information is provided needs to be justified.
6. Absolute accuracy is not essential in every case (it is impossible when the base data itself is not accurate). However, the degree of inaccuracy in any information should be given along with that information.
7. More frequent reporting does not mean more information. Again any increase in the frequency of reporting must be justified.
8. The total integration into one corporate data base should not be the aim of system designers. Integration and the formation of data bases should only be used when they will be of advantage. This will usually

mean only partial integration at varying levels within the organisation and a series of data bases.

9. The information needs of managers are a very difficult factor to determine by interviewing due to the fact that the majority of managers do not know their information requirements. It is equally dangerous for systems designers to 'decide' the managers information needs themselves as few have experience of management. However, with a combination of various techniques an attempt can be made to determine the information needs of the manager.

10. The provision of the 'correct' information is not necessarily going to produce good management. The manager's managerial skills and abilities may need to be developed so he can take full advantage of the information provided. It is however arguable that we should not provide information until the manager has been trained to use it.

11. The provision of communication mechanisms does not by itself mean that the communications within an organisation will improve, the behavioural problems will also have to be dealt with.

12. The managers who are receiving information from an information system should have sufficient knowledge of the system to be in control. The information system should be run to serve the organisation and not visa-versa. This statement assumes a high level of competance from the individual managers and before such a state of affairs could occur in a lot of

organisations there would have to be considered staff development.

There are many problems to be faced by the systems designer in the design and operation of management information systems. A pessimistic view of them would be that we are not capable of designing a system at the present state of knowledge. The optimistic would consider that we are more than capable, the truth lying somewhere between. Reasonable management information systems can be produced, there are problems but providing we keep these in view and try and eliminate them a system can be operated.

3.2. BASIC CONCEPTS IN THE ECONOMIC APPRAISAL OF MANAGEMENT INFORMATION.

There are six basic concepts that need to be considered when estimating the value of any piece of information. In any particular case any one or more need to be considered. These six basic concepts are common to any method that may be used to assess the value of information. The six basic concepts are concerned with

1) Time
2) Knowledge
3) Prior Information
4) Accuracy of Information
5) Quantity
6) Power

and will now be dealt with in more detail.

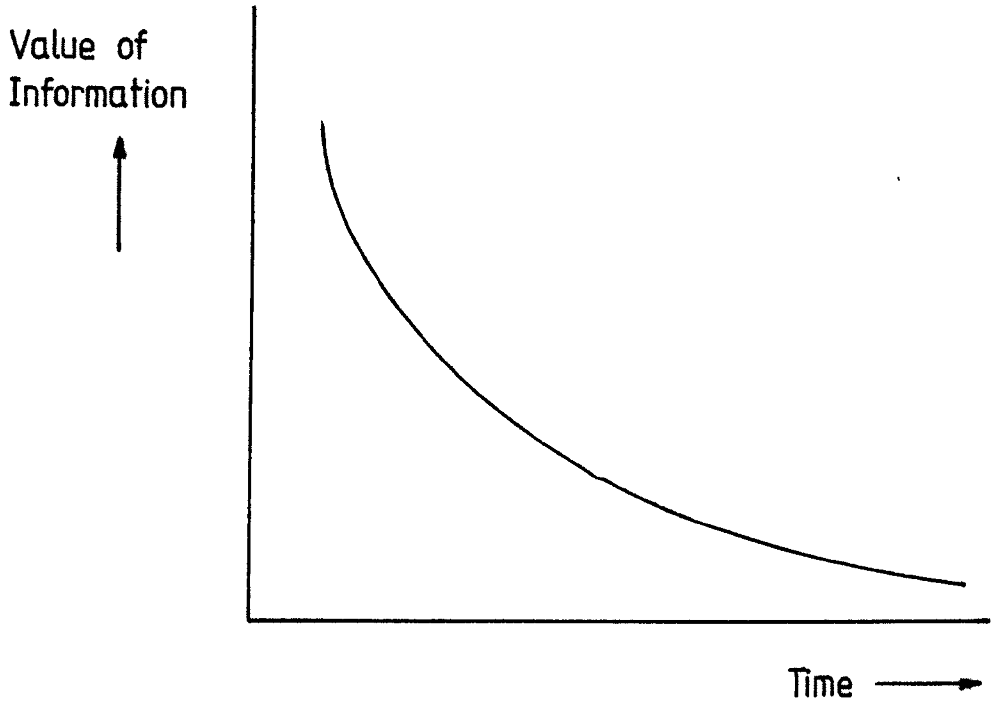
3.2.1. TIME

The value of any piece of information is related to time. The most simplistic view to take is that the value of the information reduces as time increases. This is shown diagramatically in figure twenty.

This view implies acceptance of one of the myths of information that the quicker the information is available the greater its value. The true relationship of time to information is likely to be more complex than this. Paretta *1 suggests that this relationship is connected with the type of decision been taken. (See section 3.1.4. for more detail.) He puts forward the following three

*1 PARETTA. (1974)

Figure Twenty: Simplistic Relationship Between Time and Value of Information.



types of decision.

(a) Decisions Improved by the speed of the information flow.

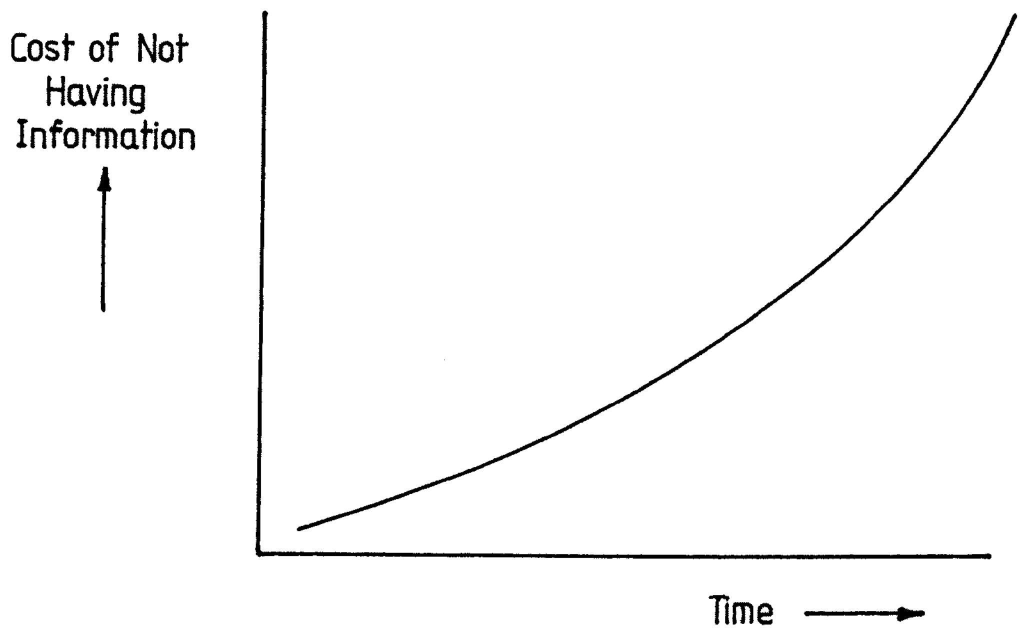
(b) Decisions Unaffected by the speed of the information flow.

(c) Decisions Hindered by the speed of the information flow.

The simplistic relationship described above will apply to decision type (a) for example control information, but even in this case an alternative formulation is more useful.

This will be in terms of the cost of not having the information, which will increase as time increases, and is shown diagramatically in figure twenty one.

Figure Twenty one: Relationship Between Time and Cost of Not Having the Information.



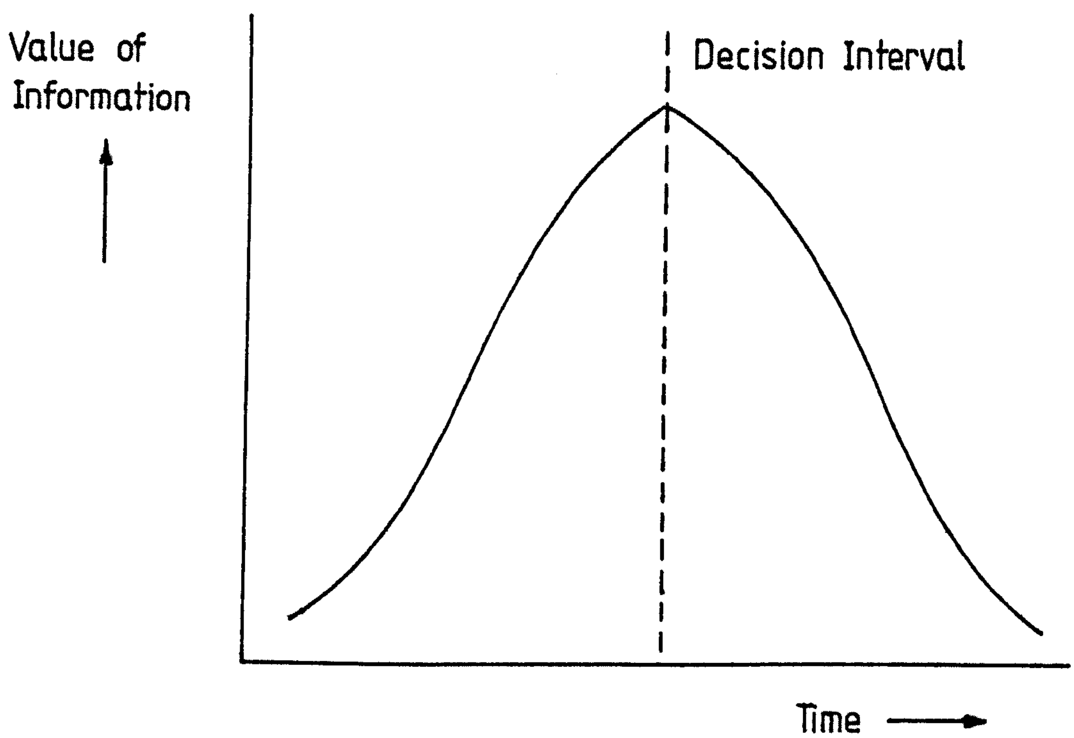
Strictly speaking this will be the case when the process is not in control. When the process is in control the value of the information is limited, but the purpose of control information is that of monitoring and therefore, this relationship will apply whether the process is in control or not.

The second of the three types of decisions are those unaffected by the speed of the information flow. This definition should not be taken too literally. The type of decision is the type where an increase in the speed of the information retrieval will be of no extra value to the decision process. For example the quote from Deardon.

> "In the area of performance evaluation, real-time management information systems are particularly ridiculous. When a division manager agrees to earn, say $ 360,000 in 1966 he does not agree to earn $ 1000 a day or $ 1000/24 per hour". *1

In this type of decision the more important consideration is the decision interval when determining value of the information. The information is of little value until the decision interval is approached, it then increases in value until the decision interval is reached and it may then fall off in value. This is shown diagramatically in figure twenty two.

Figure Twenty two: Relationship Between Time and Value of Information Showing Decision Interval.

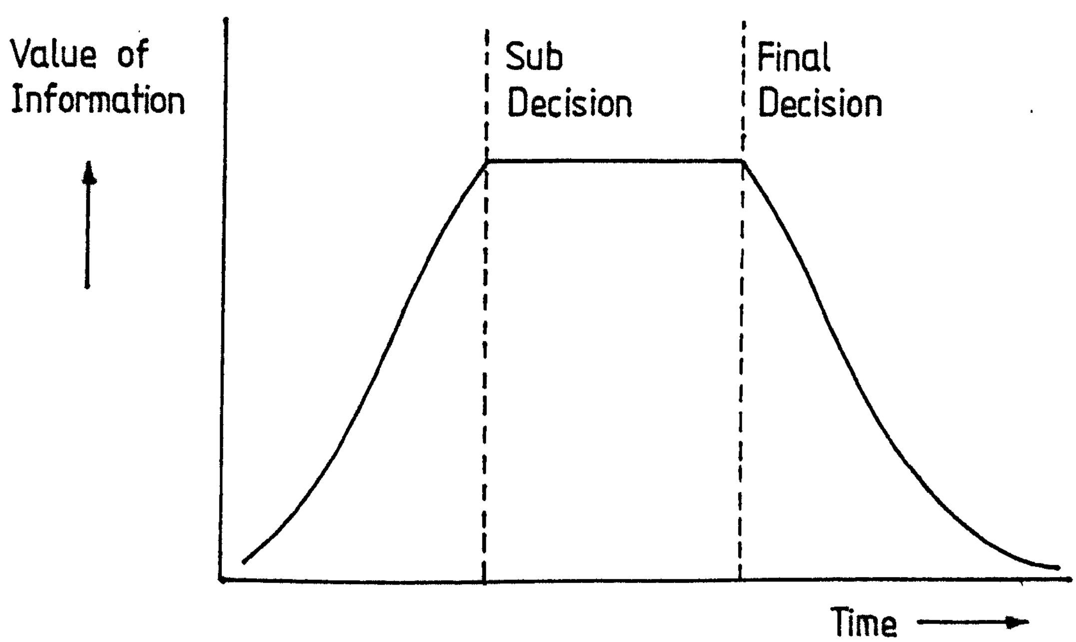


*1 DEARDON. (1966)

In this case of Deardon's example the information concerned with his divisional earnings only becomes of value with regard to performance evaluation at the decision interval i.e. the end of 1966. The information concerned with say the earnings per day, although of no value to this point in time performance evaluation will almost certainly be of value to the manager in terms of his control of the division.

In a large complex decision there may be a series of sub-decisions each of which may involve the gathering of information. Some information may be used to determine further information requirements. Information for this type of decision could have a value time relationship shown in figure twenty three.

Figure Twenty three: Relationship Between Time and Value of Information Showing a Sub Decision and a Final Decision.

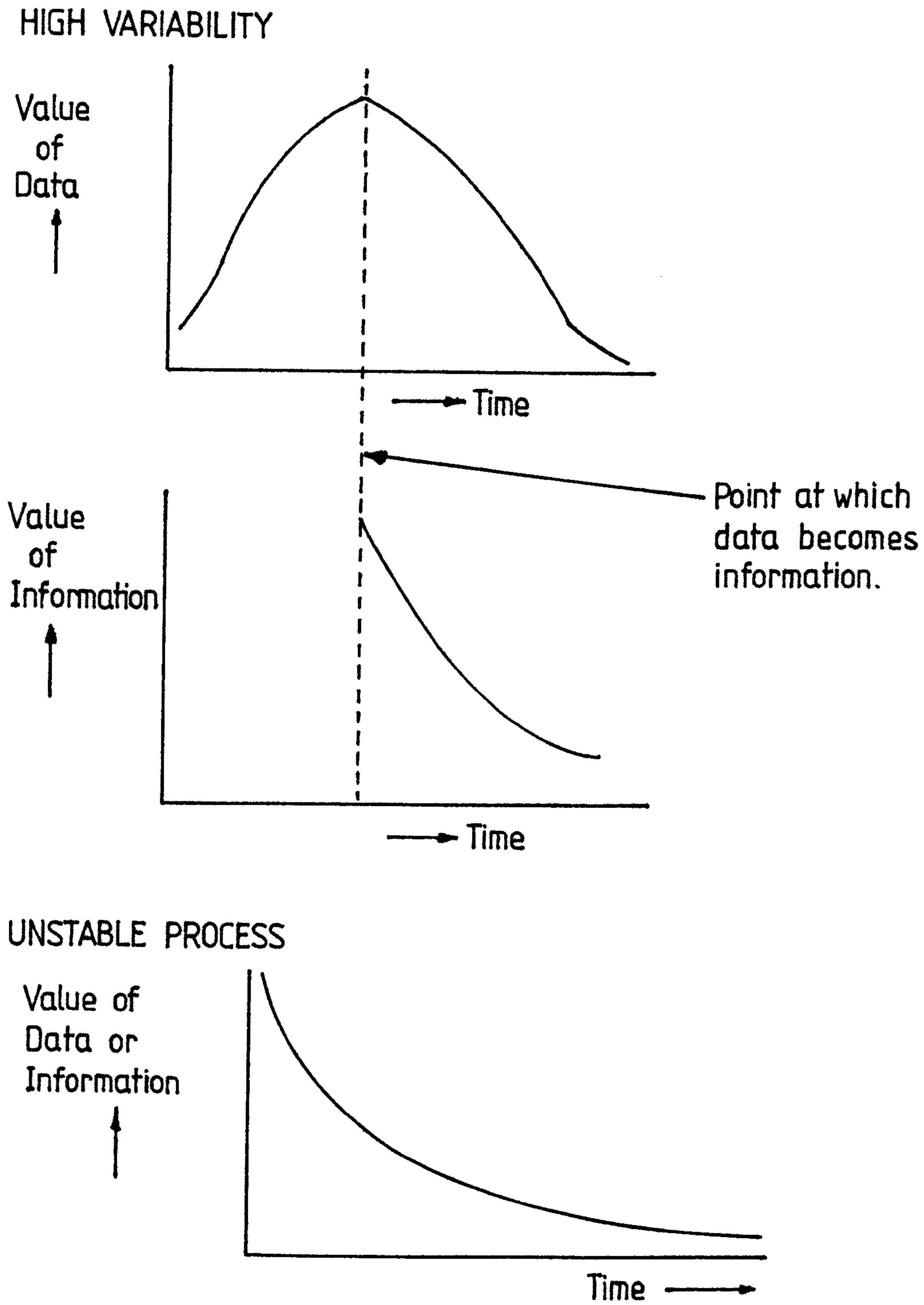


This cannot be considered a general pattern as the value may fall between the two decisions or it may increase for the second decisions or it may decrease. This will become more complicated the more decisions that are involved with the piece of information. It may be possible to consider theoretically information that has a constant value, however, I doubt that such a relationship exists within the managerial sense.

In the third type of decision, those hindered by the speed of information flow, the relationship will vary. These type of decisions must be considered in two states that of unstable data and that of high variability data and also the difference between information and data needs to be considered. An unstable process is one where the underlying trend of the data changes considerably and possibly quickly but with little or no variability, and a process of high variability is one where the underlying trend changes slowly if at all, but there is a high degree of variability about this trend. These relationships are shown diagramatically in figure twenty four.

High variability data requires a given amount of time before the extent of the variability can be assessed so enabling a check to be kept on the movement of the underlying trend. The combined group of data then becomes information. Fresh information being created with the advancement of one time unit by disregarding the oldest piece of data and taking account of the most recent ie.

Figure Twenty four: Relationship Between Time and Value for a High Variability Process and an Unstable Process.



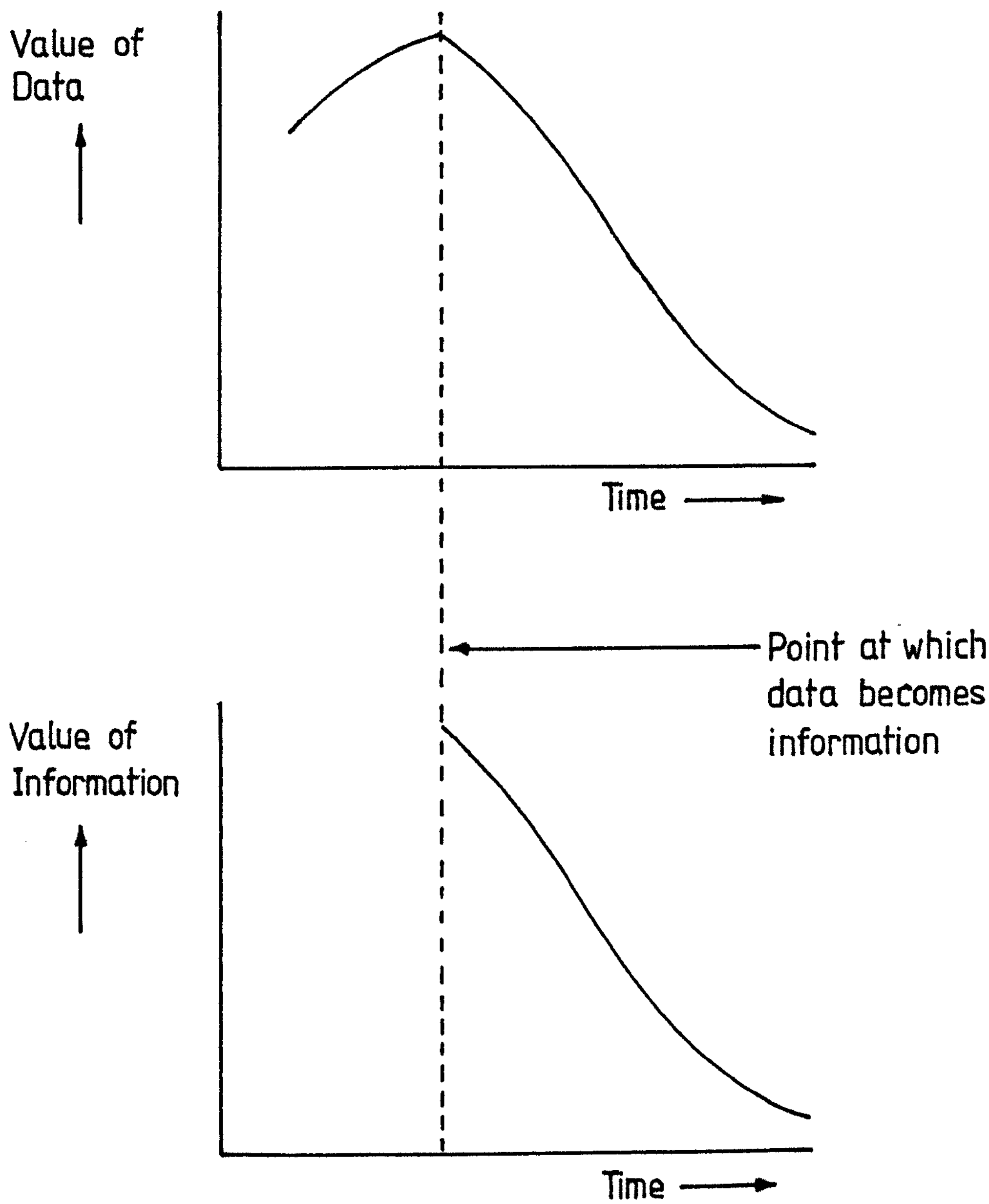
moving average principle or by using exponential principles and not rejecting information so drastically. With the unstable process the most recent information or data is the most important. When as often happens we get a process that is unstable and highly variable then the two relationships are combined. This is shown diagramatically in figure twenty five.

An example of such a process is likely to be found in process control. Here the output of a production process is monitored to ensure that the items produced are acceptable. Some process control systems have fixed time interval sampling of the process but there will be some systems with a variable time interval sampling. With the variable time interval sampling the sampling will be carried out at a fixed time interval until it is thought the process is going out of control. The time interval will then be reduced to check on the process, if it is out of control then this will be rectified, if a false alarm has occurred then the fixed time interval sampling will be resumed. With examples of this type the timing of the information becomes more important when there are indications the process is out of control.

Before leaving the relationship between time and value of information two more points need to be considered. First it may also be possible for information to have a peak value later in its life.

Secondly it must also be remembered that three types of decisions talked of here are not generic groupings but are merely useful groupings for use when talking in terms of information.

Figure Twenty five: Relationship Between Time and Value for a High Variability Unstable Process.



3.2.2. KNOWLEDGE.

Before discussing the effect of knowledge on the value of information the term knowledge must be defined. The Concise Oxford Dictionary defines knowledge as follows:-

"KNOWLEDGE - Knowing, familiarity gained by experience, (of person thing, fact); person's range of information; theoretical or practical understanding (of subject, language, etc.); the sum of what is known."

For the purpose of this thesis a more positive definition of the term knowledge can be used. It may be said to be that body of fact relating to the principles and practices of management and any related facts necessary for the successful management of an organisation (these related facts will to some extent vary from industry to industry). It would be foolish to consider that every manager would personally know all of this knowledge but it would not seem unreasonable to suggest that a manager <u>should</u> be able to have access to this knowledge through the 'management team' of an organisation and through management education.

Knowledge will determine the extent to which the information will approach its true value. Knowledge will not add to the true value of the information but a lack of knowledge will not allow the true value to be achieved. An individual's perception of his state of knowledge is not necessarily reliable. Individuals may have a pessimistic or an optimistic view of their state of knowledge.

The factor of knowledge is extremely important when talking in terms of information needs for there is no point in providing information if the knowledge of how to use it is not there. It would therefore seem to be reasonable that the information analyst should also provide access to the knowledge as well as the information.

3.2.3. PRIOR INFORMATION

In determining the value of a piece of information all the other information connected with this information must be considered. For example a company must decide whether or not to carry out a market survey into the sales of a commodity. The value of the information produced will be affected by the information already available. If the product is new and no other sales information is available the value of such a survey in most cases will be more than if the product is an established one with past sales figures which can be used to forecast i.e. the market survey will only be used to supplement the other sales information in the setting of forecasts. The factor that could reverse this relationship could be termed the surprise factor. The larger the surprise factor of a piece of information the greater the value of that piece of information.

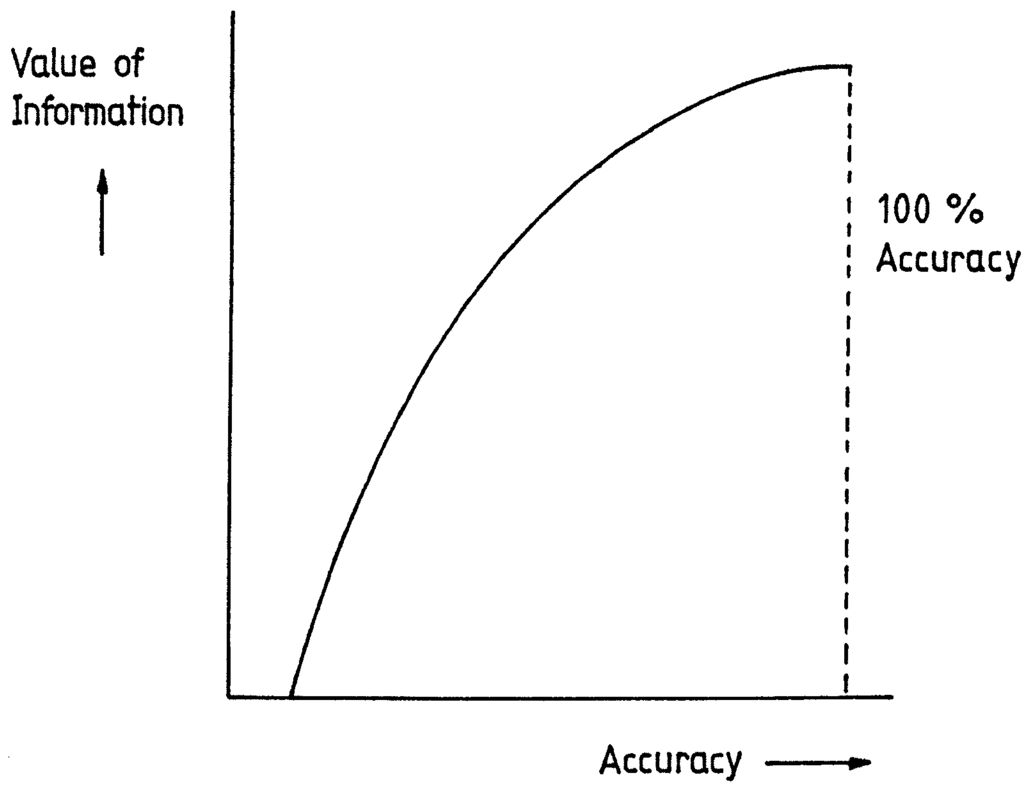
3.2.4. ACCURACY.

In general terms it may be said that the greater the accuracy of a piece of information the greater the value of that piece of information.

There are a large number of cases where accuracy is of great importance especially at the operational level.

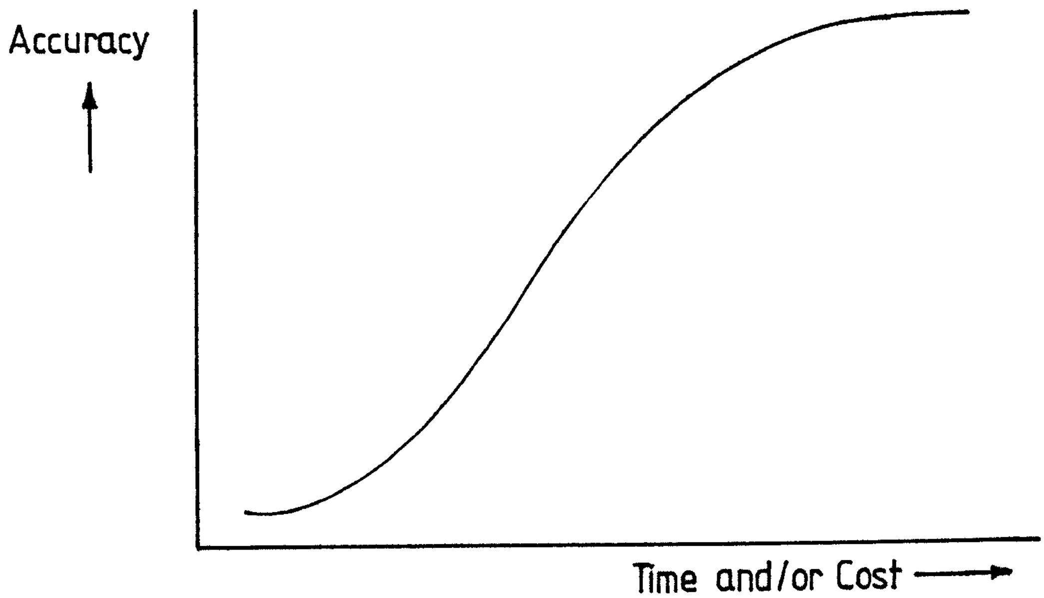
There are also quite a number of cases where absolute accuracy is a both unnecessary and possibly unreliable. (See Section 3.1.5.). This will have the effect of levelling out the end of the relationship. See figure twenty six.

Figure Twenty six: Relationship Between Accuracy and Value of Information.



Accuracy is also related to time and/or cost; as a general principle it could be said that the greater the accuracy required the more time and /or cost will be incurred. If information is being prepared for a time dependent decision the level of accuracy and/or cost could well be forced on the manager by the time constraint. Figure twenty seven shows the type of relationship which could exist between accuracy and time and/or cost.

Figure Twenty seven: Relationship Between Accuracy and Time and/or Cost.



For any particular decision it is likely that several pieces of information will be required. A network representing this information and the time required to collect it could be produced. The critical path of such a network is likely to highlight areas where time and accuracy are likely to cause problems.

It is important to consider the relationship for 'circumstantial or hearsay' information which is often used by senior managers. The actual assessment of the accuracy of given information in these latter cases can only be carried out subjectively. Managers also carry out subjective assessments of accuracy on quantitative data which can lead to problems of personality.

Comments such as follows are now unknown in industry, 'Bill's department has made mistakes in the past therefore his departments information has a low accuracy, whereas David's department is a good one and his information is more accurate.' This sort of statement may owe more to personalities than to true assessment of the individual pieces of information coming from the different departments.

3.2.5. QUANTITY.

The size of a particular piece of information can affect its value. If the piece of information is so large as to overload the manager the value may be reduced. All managers suffer under a time constraint, therefore, there is the chance that some of the value of a large piece of information may be lost because of insufficient time to study it. Similarly if a large number of pieces of information are provided for a particular decision or series of decision there can be a similar effect.

3.2.6. POWER

Before leaving the major factors affecting the value of information the relationship between power and the value of information must be considered. Managers may use some information to create uncertainty rather than to reduce it. It would be an understatement to say that Information is Power. Information is not the only source of power but it can be quite an effective one. It is not suggested that managers hold information back completely for this would be to commit corporate suicide if discovered. To gain power from information it needs to be released but it may be released by a manager only to a select number of other managers or it may be held back and released at an appropriate time to give the manager (or group of managers) a boost to their prestige and power rating in the organisation. This can give a piece of information an increased value although not necessarily an increase in value to the organisation. The increase in value is only personal to the manager concerned. Such information a manager will not release willingly to the information system unless he is sure that any benefits to increase or maintain his power structure (or erode some other managers) will accrue to himself.

3.2.7. SUMMARY

Whichever method of setting a value of information is used one or more of the following six factors need to be taken into account.

1) Time:- the speed at which the information can be obtained and is required.
2) Knowledge:- the knowledge level of the recipient/s of the information.
3) Prior Information:- the amount and type of other information that is available to assist with the decision the piece of information is to be used for.
4) Accuracy:- the accuracy of the information (this may be subjective dependant on personality).

5) Quantity:- the size of the piece of information or the amount of information available for a particular decision.

6) Power:- information can be closely linked to power, and as a result this may enhance the value of the information to the individual but not necessarily to the organisation.

3.3. DETERMINING THE INFORMATION NEEDS OF MANAGEMENT.

Before any attempt can be made to value information it is important to determine the information needs of management. By determining the information needs this will limit the amount of information to be valued (potential information will be an exception to this but this will be dealt with later). In addition the determination of information needs will help both management and the information analyst when valuing information.

3.3.1. DETERMINATION OF MANAGEMENT INFORMATION NEEDS.

The determination of management information needs has been thought necessary by a number of different disciplines. It started before the advent of the computer with organisation and methods. This discipline has now fallen out of favour and since the advent of computers its role is being carried out by the systems analysts and the systems designers. O & M practitioners seem preoccupied with form design and not to be interested in the computer side of information processing. Systems analysts and systems designers seem preoccupied with running everything on the computer (possibly justified in personal survival terms as they usually work for the computer department) and they do not seem to be interested in what happens to data and information before or after the computer except in computer terms, i.e. data capture, etc. This preoccupation with the computerising of everything sometimes leads to jobs being carried out by the computer that could best be carried out by other means.

By taking the best of these two disciplines and some of the more recent work carried out in this area from other disciplines it will be possible to arrive at a reasonable and workable method of determining management information needs. It will then be possible after the needs have been determined to find the value of the information and cost of producing it (possibly by differing means) thus providing a decision framework for information provision.

In determining information needs it must be decided at which level to operate. Are we attempting to produce the perfect information for the perfect manager (or to produce the perfect information in the hope it will turn managers into 'perfection'). This approach seems widely accepted. I would suggest that this approach is a false one and real life is not quite as simple as this. Management Information needs to be considered on at least two levels, the perfect information and the actual information and probably a series of levels in between. It is a very dangerous thing to assume perfect managers and it is also dangerous to assume perfect knowledge on the part of management. Our knowledge of management techniques is changing at a rapid rate. If we could arrive at 'perfect' information then it would be very unlikely we would change the manager or necessarily improve him. There are many other factors involved in management deveopment than just providing managers with perfect information. If this approach is adopted all that is likely to be arrived at is a confused manager not fully understanding the information provided for him. It would therefore seem better to operate at two levels, first provide the manager with the information he needs and understands and then to develop information along with the managers' development to improve management.

The example of the case study Robert Livesey will be applicable here. A cost control scheme was developed by a clever and able accountant. The aim of the scheme was to provide managers with information to enable them to monitor and control their costs. The scheme gave managers four pages of output each week, the first page showed the base data and the remaining three pages giving a series of cost variances which would in theory enable the managers (from departmental managers to Managing Director) to carry out effective monitoring and control of their costs. The scheme was operated for quite a number of years (and only in fact changed due to a merger). With regard to cost accountancy the scheme was advanced for the time it was designed and so it would seem fair to say it was close to providing the perfect management information (it is important not to confuse perfect information with accurate information, the information is only perfect in knowledge terms). The problem was that only a handful of people could actually understand the scheme, the majority of managers either ignoring it completely or just taking some of the base information from the first sheet and using this as a crude basis for cost control. Such a scheme would appear to be a failure because it was designed at the wrong level. The scheme would have been more successful had it been designed to meet the initial requirements and knowledge of the managers, and so provide management with information they can understand and use although it would be unsophisticated in accounting terms. And then as accounting knowledge was developed within the managers (probably with internal courses and discussions) so could the scheme be advanced in accounting terms. I believe it very important to provide the knowledge and then deveop the scheme in that order and not vice versa so as to create confidence on the part of the manager in a field he may not be familiar with. It may also be necessary to incorporate levels in the system, not levels in respect of the organisational hierarchy but levels related to the manager's individual knowledge.

The greater the knowledge of the individual the more complex the scheme he will have access to. To a degree political effects will have to be considered with such access. Some managers may want access to the more complex scheme although they may not understand it. The reason for requiring access could be to boost status within the organisation or some other political reasoning.

It would therefore seem reasonable to split the information requirements of managers into two levels but with each level at a number of stages. The first level being the manager's present information needs. The second level being the manager's potential information needs.

When asking the manager his information needs the futility of the question 'what information do you need?' will soon be appreciated. Answers such as 'I don't know' or 'as much information as you can provide me with' are likely. Consequently some systems analysts/designers draw the conclusion that managers cannot determine their own information requirements. Such a conclusion is not justified, the problem is in the question being asked. Information and data are used by a manager to carry out his function therefore the start of the determination of his information requirement should be to describe his management function. If an organisation produces job descriptions for individuals then these can be of great value although they will probably have to be updated and extended. If there are no job descriptions then the managers function will need to be determined. This could be carried out by the manager and the information analyst although in some organisations a member of the personnel department may be involved because it will be a job description that is produced. The information analyst will find the work of Mintzberg (see section 2.) provides a terminology he can use that will be readily understood by the manager. Once the manager's work has been defined the information required to carry out this work can be determined. If a management function falls across several managers the information analyst should determine with each individual his own job function (each manager may see the shared function in a different light). The information analyst should then form groups of managers to determine needs of the shared function. Informal information needs will also be brought to light by this approach and the information analyst must resist the urge to formalise all of them.

3.3.2. DETERMINATION OF MANAGEMENT'S PRESENT INFORMATION NEEDS.

The approach to this problem is basically the same from both O & M and systems workers. They put forward three basic methods.

(i) Interviews.
(ii) Questionnaires.
(iii) Observation and Record Inspection.

(i) Interviews.

This method is basically face to face contact with the investigator and the operator of the system or the recipient of the information. This method will provide quite effectively the existing information systems at the operational level. It is also more effective when dealing with formal systems. It must be remembered though that it is effective at providing a description of the existing systems which is not necessarily managements present information needs. When it comes to determining information needs in excess of existing systems or information needs at the strategic level or in the informal systems area then the procedure of interviewing as advocated by O & M Systems Worker proves to be ineffective, due to a number of reasons.

1. Interviews are conducted with only one person so one only gets the views of individuals unmodified by group effects and possibly very biased by political motivations (political effects will be moderated by working with groups).

2. Managers information needs in excess of the existing system could be difficult to arrive at. Managers do not necessarily know what further information they need when first asked. This can only be arrived at with considerable discussion with the manager and between managers, and such a discussion is unlikely to take place if the accepted interview practice from the fields of O & M or Systems Analysis are followed. Daniels and Yeates when talking of the skills of the interviewer.

"He should be impartial, tactful and more positively have skill in influencing others to accept advice they would prefer to ignore. Interviewing is the process of obtaining information - without upsetting the other party by means of conversation; this entails being a good listener, being apt at keeping the ball of conversation rolling and being able to keep the subject on the right lines." *1

Such a non-commital and non-involvement role may keep everybody happy but it is unlikely to discover management information needs.

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*1 DANIELS AND YEATES. (1976 Page 21).

3. When managers are being interviewed about informal information or one off strategic decision it must be remembered that the relevant information sources are variable, possibly unrecorded and transient. With information of this nature the interviewer must rely on the memory of managers, and as the memories of managers are not necessarily reliable, they could give excessive weighting to certain information because of its ease of recall or forget some pieces of information completely.

(ii) Questionnaires.

Questionnaires are most unreliable ways of trying to determine information needs. They are open to bias, misinterpretation, lack of involvement by the participant and incorrect completion to name but a few of the problems. The only valid reason for using questionnaires is speed. They can be of use to add a structure to an interview but then they are no longer a true questionnaire.

(iii) Observation and Record Inspection.

This approach to observe the conversation of data to information and the information flows, etc. provides a very useful way of examining existing information systems, the major problem being that it is very time consuming. There has been some work carried out to provide methods to be used in recording informal systems and one off decisions. The method could be said to be part observation and part questionnaire. Stuart *1 developed the

*1 STUART. (1967)

use of diaries (forms of questionnaires that managers fill in as they are completing their normal work) and Edstrom, Broman and Levin *1 developed this into Communication Analysis specifically for use in the management information field. The basic approach is to get managers to fill a diary form (communicogram) as they are performing their normal job. This makes these techniques particularly applicable to the variable, possibly unrecorded and transient information that one tends to find when dealing with informal or one off decisions. It is essential to design the diaries carefully in order to facilitate later analysis.

Standard systems and O & M techniques such as interviews communication analysis, etc., can provide for the information analyst effective descriptions of the existing information systems. In any analysis of management information such information needs will be required. But this information must then be extended to give a picture of management information needs.

Given that the standard methods of O & M and Systems will not completely determine managements present information needs some other method needs to be applied. The method adopted within some organisations is that the analyst assumes what management should need and then provides them with this. The analyst then seems surprised when the manager either cannot understand or will not use the information provided. The only people who can determine the information requirements are the managers themselves.

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*1 EDSTROM, BROMAN AND LEVIN. (1973)

It is often said by analysts that managers do not know their own information requirements. To some extent this statement is correct. Managers at first may appear not to know their requirements, this being due more to poor questioning than lack of knowledge. The interviewer should bear in mind the manager's information needs in relation to his job. It may also be necessary to place managers in groups where information needs are discussed. The picture that then arises may not be perfect but will be better than one arrived at by traditional means.

There are many problems associated with the use of groups and the involvement within these groups of the information analyst. These will be looked at in more detail in the section 3.7. The group should comprise of all the interested parties to the information and the information analyst should act as a catylist and enable the group to develop an effective set of information needs. It can only be through such development that managers will see their information needs developed and will understand and be able to use the information provided for them. If we take the work of Mintzberg to be a reasonable description of the procedures operated by managers, the following quote outlines the characteristics of the information managers seek.

> "These characteristics put the manager in direct conflict with most formal information systems. He seeks trigger, speculative, current information, but the formal system gives him largely aggregated, precise,

historical information. Furthermore, the manager demonstrates a thirst for external information, whereas formal systems provide largely internal information. [This applies more to the senior managers .] The formal system deals with information for control and regulation (production schedules, sales reports, standard costs) that is primarily useful to the specialist in middle and lower echelons. [Although it is very necessary so that they can complete their specialism] . It excludes much of the intelligence information that senior managers need for their unprogrammed decisions.

As a result the manager must often ignore the formal information system. Instead he designs his own system, which provides him with the information that he believes he needs. He develops external contacts, subscribes to periodicals, joins trade organisations and encourages subordinates to circumvent the established lines of communication to bring him information." *1

I would not suggest that the answer to such a problem is to formalise all the manager's information systems. I think such an approach would be doomed to failure as a large portion of the informal system is not suitable for formalisation. I do think that the situation could be improved by actively involving the managers in the determination of information needs at the design stage of such

*1 MINTZBERG. (1973 Page 149).

systems. It should not be forgotten that the needs of the specialist (accountants, production controllers, etc.) must also be met and so they must also be involved in the discussion of information needs. With such an involvement of managers, specialists, etc., it should be possible to arrive at formal systems that satisfy both the specialists and manager (the formal system will not provide all the information needs of the managers some will still need to be met by informal systems). Such formal systems should be made easier to provide with the development of interactive computer systems both in software and hardware terms and these are likely to be developed even further by the advent of the micro computer.

Having determined what management's present information needs are the information must now be justified and a value and cost determined so that manager's can decide which of the needs they can cost-justify.

3.3.3. DETERMINATION OF MANAGEMENTS' POTENTIAL INFORMATION NEEDS.

This is a particularly difficult task. Some attention to this problem needs to be payed when designing information systems. Information systems should be sufficiently flexible to enable changes to be easily made when the information needs change and develop. This problem can be surmounted by encouraging the manager to develop his knowledge (often not considered to be the function of an information analyst). If the information analyst would like the managers to use more advanced information then he must in some way provide the appropriate extra knowledge. There are many sources of such specialist knowledge (accounting, management science, computing, etc.) within the organisation and these could be incorporated with the group system described in the previous section. Alternatively the information analyst could organise 'in house' courses (to prepare managers for more advanced information, either staffed by internal specialists or external educationalists). An extremely dangerous practice is to provide the more advanced information and then expect the manager to find out how to use it. Such a practice can build blocks in managerial attitudes against the person designing the system, the specialism concerned and the system itself. Such blocks can be very difficult to remove at a later date. It is a far better practice to let the managers develop their knowledge (or take an active part in developing that knowledge) and then through the group system allow the managers to develop (with guidance) their own system in conjunction with the specialists. This may appear a slow process but surely it is better to have information systems developed slowly stage by stage becoming gradually better but well understood and used by managers (better used and understood because the manager took an active role in their design) rather than a sophisticated system designed at one stage but not understood or used by the managers it is supposed to serve.

3.3.4. SUMMARY.

One of the most difficult tasks facing the information analyst and the manager is the determination of management's information needs. Management's information needs, can be effectively determined only if they are considered at two levels. These being, managements present information needs and managements potential (future) information needs.

In the determination of management's present information needs the standard O & M and Systems techniques are quite effective in discovering what information is received by managers at present but they tend to fail in discovering what extra information a manager could use (at this stage information which managers cannot understand or use should not be considered). To get a manager to think of his information needs it is necessary to get the manager (or managers if shared information is concerned) to define their jobs and then to use this definition to establish the information needs. Any decision about what information is provided must take into account value and cost.

To determine management's potential information needs is even more difficult. It is necessary to determine these needs when information systems are being designed so that the final system is flexible enough to take account of future changes. These potential information needs can be determined by the information analyst in consultation with various specialists (Accountants, Management Science, etc.)

within the organisation (or possibly external consultants.)

This potential information is by definition information that the managers would not be able to understand or use effectively. Such information should not be presented to the managers until their knowledge has been developed by such things as 'in house' courses, discussions with specialists, etc. The information analyst will have to take an active roll in such management development if he hopes to produce an acceptable management information system. The information analyst must also realise that quite a large proportion of the manager's information will be gathered by the manager through informal systems. It would be a mistake for the analyst to try and formalise such systems. What would be of value to the manager is for the information analyst to help managers improve the organisation of their own informal systems.

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WILKINSON. (1974)

3.4. DETERMINING THE VALUE OF MANAGEMENT INFORMATION.

Before moving to the value of information let us first consider a typical organisation in terms of the information it will need to operate, this is shown in figure twenty eight.

Most methods of measuring the value of information have ignored the areas where the information was to be used and have been claimed to be a general method for the assessment of the value of all information. Most of these were doomed to failure on account of generality but may be found to work reasonably well in specific areas. Therefore, the approach adopted within this section will acknowledge the diversity of types of information required by an organisation and will devise a series of methods to deal with different types of information.

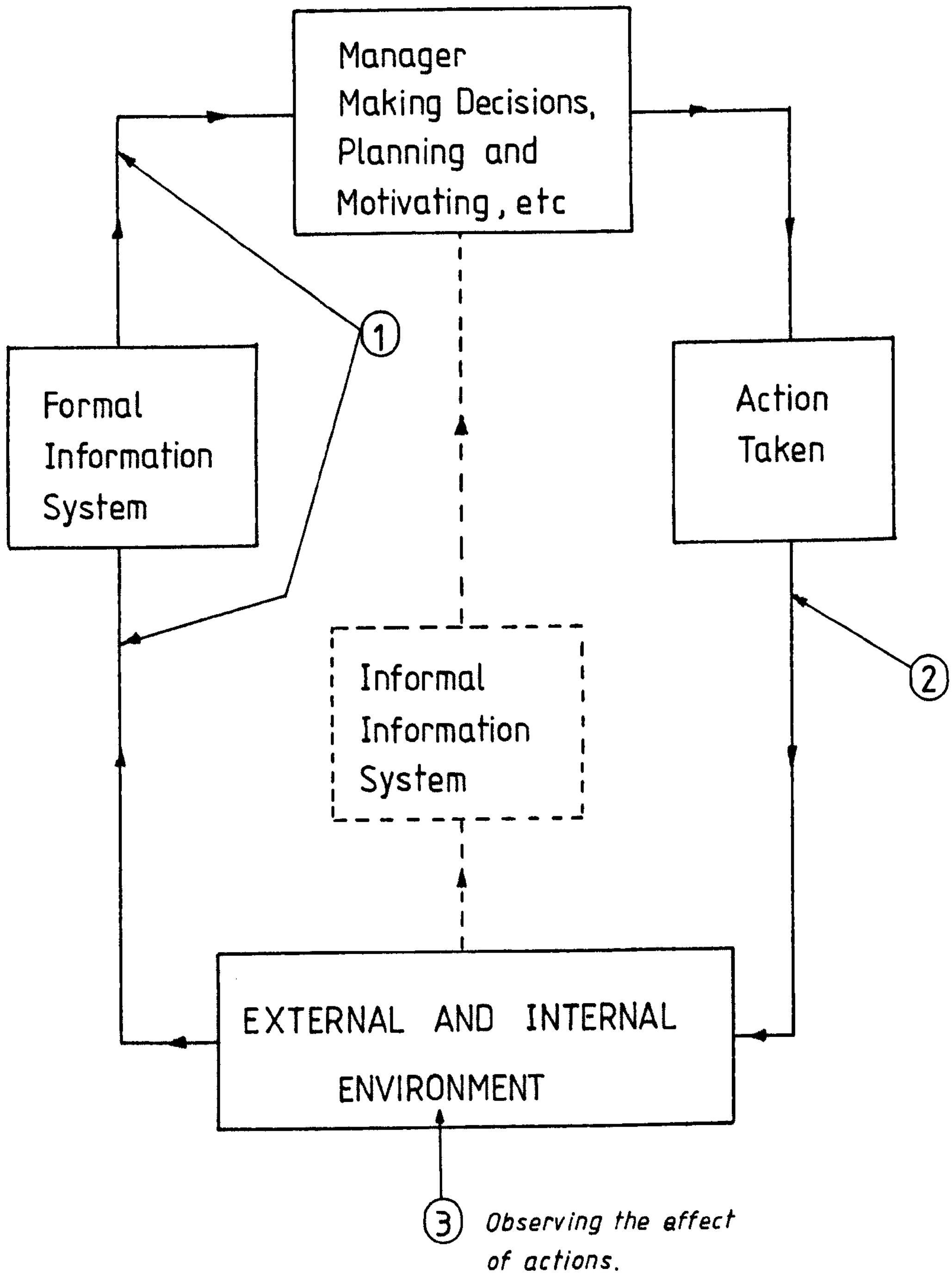
Another key issue is the time at which the value of information is actually determined. (see figure twenty nine). There are three possible points at which the value of information can be determined.

1. At a point before the manager takes any decision or constructs any plans. The data to construct the information may or may not have been collected by the 'information system'.
2. At a point in time after the manager has considered all the available information and decided what action is to be taken.

Figure Twenty eight: Levels of Information Requirements for a Typical Organisation.

	PRESENT ORGANISATION AND ACTIVITIES Comprising :- Men, Plant, Products, etc.	PROJECTS Comprising :- Any changes to existing organisation and / or activities.
OPERATIONAL LEVEL	THE SETTING UP AND IMPLEMENTATION OF OPERATIONAL PLANS To Control and Implement the Strategic Plans. E.G. Production Control Budgets Control of Sales Force, etc	CONTROL AND IMPLEMENTATION OF PROJECTS E.G. Installation of New Plant. Market Launches, etc. EVALUATION OF OPERATIONAL PROJECTS E.G. Reorganisation of Existing Plant, etc.
STRATEGIC LEVEL	The setting up of Strategic Plans	EVALUATION OF STRATEGIC PROJECTS E.G. Setting Up New Factory Introducing New Product etc.

Figure Twenty nine : Times at which Information can be Valued



3. At a point in time when the actions of management have been made and it is possible to observe the effects of such actions on the external and internal environment or both.

At the first point in the process the setting of a value of a piece of information will be concerned with predictions of the value that the information is going to have in the future. It is the logical place to set a value as the information has not yet been obtained and in most cases it would seem reasonable to produce a value and cost in order to determine whether that information should be produced. It will be easier to predict value at the operational level than at the strategic level. The more difficult the prediction (i.e. the more uncertain the information or the effect of actions taken) the more important it is to obtain an estimate at this stage but it will have wider confidence limits.

At the second point in the process the value of the information will be set by looking at the result of the manager's decision or planning process. By looking at the actions that were decided upon and by looking at the process by which these actions were arrived at (i.e. decision rules, etc.) it should be possible to obtain the value placed on the information during the managerial process. The value may be capable of accurate measurement or it may be an estimate. There are a number of problems that can occur with obtaining a value at this stage, the first being that the information needs to be collected before a value can be set, thus making it a little late to decide that the information need not be collected or derived. This is a more acute problem with unprogrammed decisions where the information is required only once. The particular approach assumes the perfect manager. Within this approach if we obtain the value of the information from the action taken we assume that the manager has taken the correct action from all the information available, and understood all the information and used it in a correct manner. Managers being human this will not always be the case. If the value is to be obtained at this stage then questions like, 'is the manager using the best decision rules?' or 'how deep is the manager's understanding of the information?', need to be asked and taken into account when the final value is set. If a value is set for a piece of information for a programmed decision where repeatability is possible it should be remembered that due to the dynamic nature of business organisations such a value can only be an estimate for future decisions. The decision may remain the same but the conditions under which it is operated are likely to vary.

At the third point the value of the information is determined after the effects of the actions taken have been observed on the external or internal or both environments. Valuing at this point suffers the same problems as point two plus additional problems. It is very difficult when observing changes in the different environments actually to attribute any of these changes to a specific action. The time scale involved can also be considerable. The effect of some actions taken when a strategic problem is being considered can take several years to show. It is suggested by some that with simulations the effect of certain actions can be determined (by closely controlling other factors) and the time problem can be overcome. It is true that simulation can overcome the time scale problem but the first problems cannot be overcome. Simulation models can only be predictive in nature therefore any results from them must be considered within their range of accuracy. To a degree a large number of simulation models assume that things in the future will remain as they have in the past (i.e. it is difficult to build the surprise factor into simulation models) and will react in the same manner. Also simulations will only predict what may happen given certain management actions and therefore do not really belong at point three but at either point one or two.

Having considered the level at which the information is to be found and the point at which it is to be valued it is possible to move on to value information. An approximate method of valuation will have already been carried out when the manager's information needs have been determined. The information required by the manager will have some value and the information not required will be of no value. It must be remembered that although the information required by the manager will have a value it may not be sufficient to make it worth collecting or producing. Given that the information is required by the manager then one of the following methods can be used to value it:

1. Decision theory approach.
2. Simulation and valuing information.
3. Accounting approach.
4. Estimation Heuristics.

3.4.1. DECISION THEORY APPROACH TO THE VALUATION OF INFORMATION.

One approach to the valuation of information is by the use of Decision Analysis (Decision trees and Bayes' Decision Theory). This approach has been taken by a number of people being developed best by Emery. *1

This approach is best explained by using an example. The example is the one used in the section on Decision Analysis (2.5.4.) Considered the launching of a new product such that we get a profit if the product is a success and a loss if the product is a failure, the values being given below.

		ACTUAL OUTCOMES. (£000 PROFIT)	
		SUCCESS	FAILURE
ACTION	INTRODUCE	100	-50
	DO NOT INTRODUCE	0	0

*1 EMERY. (1971)

From past information marketing management determine that 60% of the time new products have been successful and therefore 40% of the time failure. The problem is whether or not to produce a Market Research Study, (a Market Survey) and again we find from past records that the predictions of such surveys are correct 80% of the time.

Using these probabilities and Bayes' Theory we can arrive at the following probabilities.

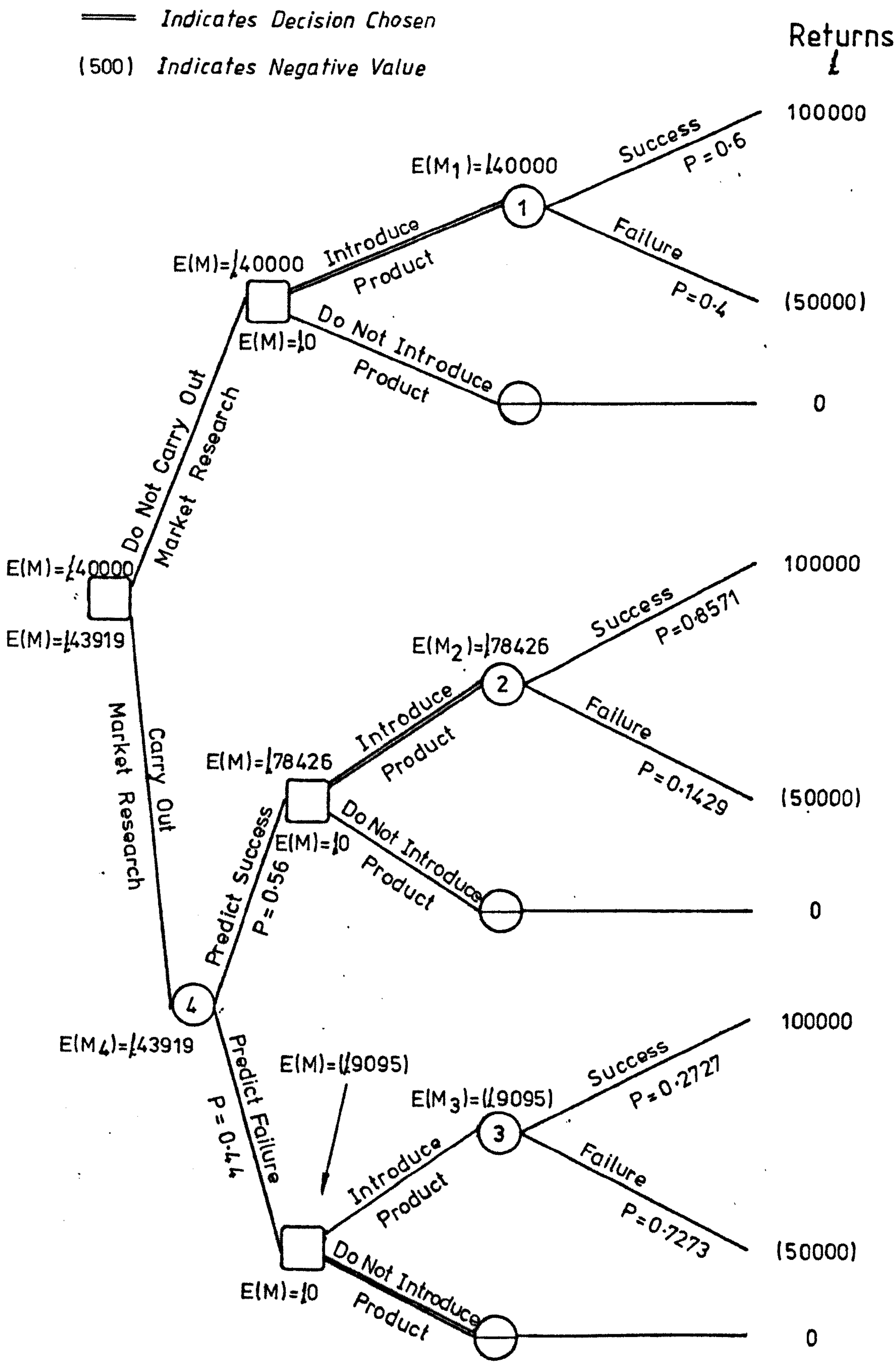
		ACTUAL OUTCOMES	
		SUCCESS	FAILURE
PREDICTION OUTCOME	SUCCESS	0•8571	0•1429
	FAILURE	0•2727	0•7273

Using this information the decision tree shown in figure thirty can be drawn.

For a full explanation of how the values and tree are derived see section 2.5.4.

From the decision tree it can be seen that the expected monetary return if the research is carried out is £43919 compared with an expected monetary return of £40,000 if we do not carry out the research. Therefore it can be said that the value of the research is £3919. How accurate is this valuation of the information.

Figure Thirty: Decision Tree to Market Research Problem.



There is a great danger with this method that it formalises the situation too much. It would appear from this decision tree that the value of the information is £3919 and that the 'automatic' decision open to management is that if the information can be bought for less than this then it is worth obtaining.

The first thing is to consider the value itself, at £3919 it would appear to be quite a precise value. This is a false impression because it is made up from values which are only estimates or averages. The profits used can only be estimates of what may be. The probabilities will either be estimates or average values based on what has happened in the past, and given the dynamic nature of business there is no guarantee the same probabilities will apply in the future. If only one estimate is asked for then the persons optimism or pessimism will affect the result. The same problems in estimation occur when obtaining time estimates for networks. This problem is reduced in P.E.R.T. Analysis by asking for a range of estimates. This also makes it possible to consider the values as distributions and not individual estimates. The three estimates asked for are:

1) An Optimistic Estimate showing all the values at their best possible, i.e. costs at the lowest, returns at the highest, etc.
2) A Pessimistic Estimate showing all the values at their worst possible, i.e. cost at the highest, returns at the lowest, etc.

3) A Most Likely Estimate showing all the values at their most likely or average value.

These estimates can then be used to produce three trees an optimistic, a pessimistic and a most likely and from these then a range of possible values of the information can be arrived at, going from a pessimistic value of the information through a most likely value to an optimistic value. This approach is much more realistic because it gives a distribution of values rather than giving one apparently precise value in this case £3919. For more detail of this approach see section 2.5.3. Simulation can also be used in conjunction with such trees to give 'typical' results to give managers a better picture of what is happening.

Having arrived at an estimate of the values of information the actual decisions need to be considered. It should be remembered that the decision tree does not take automatic decisions, it should be used only to assist managers in <u>their</u> decision taking. It will be up to the manager to take into account all the non-quantifiable aspects of the decision. For example we may have our own Market Research Section who are at present going through a slack period (only of a temporary nature). In such a case even though the survey may cost £6000 it may still be considered necessary to carry out the survey to keep the Market Research Section in full employment. Also within this method it is assumed that management will always take the decision indicated by the tree. This is not the case as there may well be some non-quantifiable reason for not taking such a decision. Such a change in decision making could then well affect the value of the information arrived at.

There are more factors that must be considered to affect the £3919 value of the information. The method as so far used has taken no account of the basic concepts discussed earlier in this chapter. (see section 3.2.).

1) TIME:- no account has been made of time. With such market research information time must be an important factor. The information will not be required until the decision is made to produce or not produce so up to then it will only be of limited value. It will assume its full value during the time the decision is made (this time will include preparing to take decisions). Its value will then fall away, after the decision has been taken. The rate of fall will be dependent on the product, the more unstable the sales figures the quicker the fall off.

2) KNOWLEDGE:- The knowledge of the managers need to be taken into account when using this value. This method of valuation assumes that the manager can fully understand the information, if this is not the case the value of the information may be reduced.

3) PRIOR INFORMATION:- Prior information will not add anything to the value, but having prior information could reduce the value of this particular piece of information. Such a complex decision as deciding whether or not to produce a product is unlikely to be taken on the basis of one piece of information. Figure thirty one shows the relationship between value of information, successful product introduction and the success rate of predictions for this example as calculated by Emery.*1 From this diagram it can be seen that the value of the information rises to £12500 if the prediction rate is 0•9 and a maximum of £20,000 if the prediction rate is perfect 1•0.

4) ACCURACY OF INFORMATION:- This method of valuation does allow for the accuracy to be taken into account by building it into the prior probabilities. In practice it may be necessary to use a little more complex method of prediction of this accuracy level. In this example the figure was set by looking at the result of past market research projects. It would probably be better to predict the probability of an accuracte estimate of market demand by taking into account other factors for example, the type of market being investigated the methods used in the investigation, etc. The accuracy of the information may relate to the amount of money spent. The bigger the

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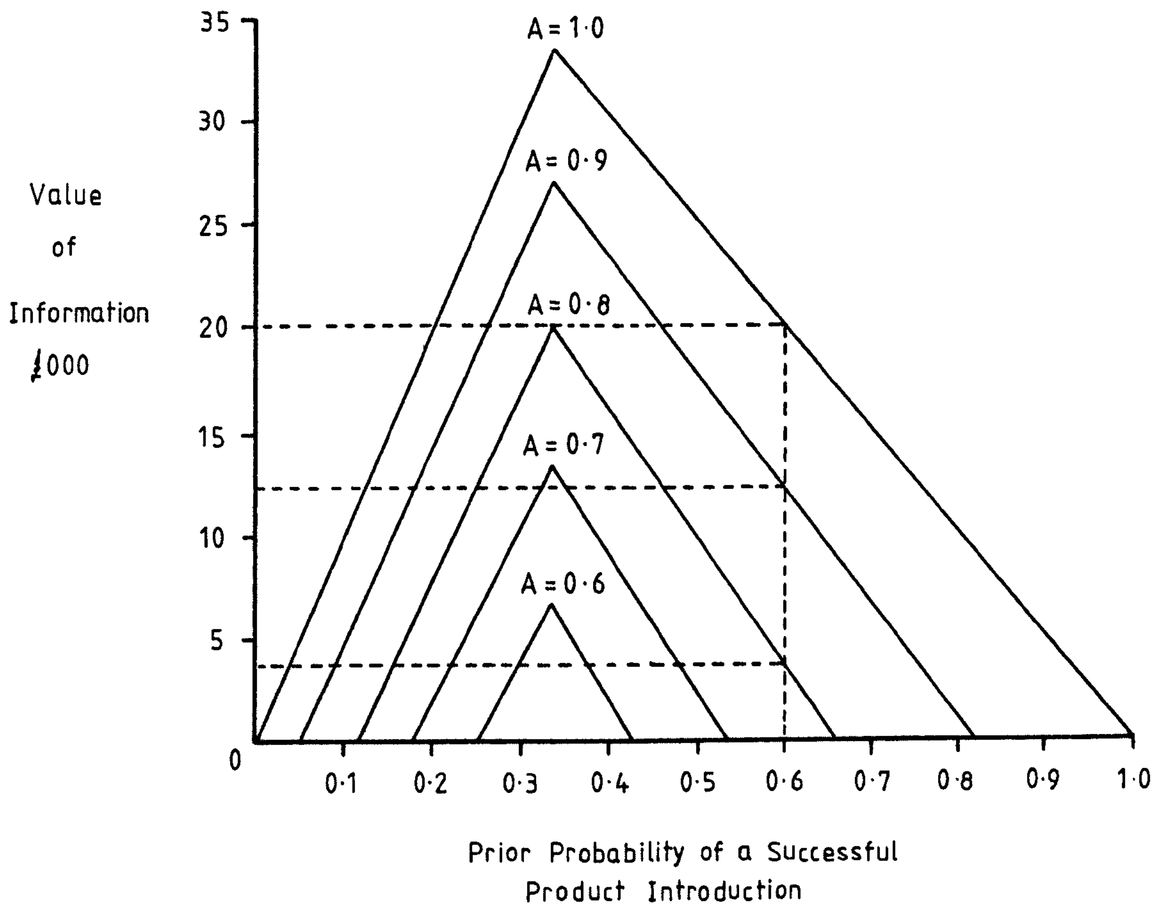
*1 EMERY. (1971 Page 7).

Figure Thirty one: The Effect of Accuracy and Probability of Success on the Value of Information.



Where A = The Probability of an Accurate Estimate of Market Demand.

sample size the greater the accuracy but there will be diminishing returns.

5) QUANTITY:- The quantity of this information is unlikely to have any serious affect on its value. The value could be effected if the report itself was badly written and was either too long or contains much irrelevant information. If the decision taker for the product launch is presented with a large amount of extra information concerning the decision as well as the piece of information being considered then there is a danger that quantity may result in some information not reaching its full value. The decision taker may not have enough time to consider all the information and therefore may miss some valuable information.

6) POWER:- Issues concerning power could well override the procedures for cost justifying the information. Power cannot affect the value with regard to the organisation but it can with regard to the individual. For example suppose the Marketing Director thinks that this survey could affect his standing in the organisation. He may then give the go-ahead to the project whatever the cost or value in order to enhance his position and change his power rating. Such things may not be desirable for the organisation but as any organisation is made up of individuals most of whom will see their

relationship with the organisation in power terms such events must be accepted as a fact of life. If an information analyst expects to survive and operate successfully within an organisation then he must take account of power in the valuing of information especially when dealing with individuals or groups with greater power than himself.

All that has been said up to now does not mean that the decision theory approach should be abandoned completely. What it does mean is that the value arrived at by using decision analysis cannot be taken as a single value but it must be modified by a number of factors.

The way in which the example of marketing information relates to figures twenty eight and twenty nine will now be considered. Taking figure twenty nine first this method of valuation as applied so far is carried out at point (1). This is before the information is collected or collated. Next consider the type of information areas to which it is applicable as classified in figure twenty eight. The example considered is of strategic type and is in fact the evaluation of a project. It would seem fair to say this method of approach will work reasonably successfully within this field of operation. It must now be considered how successful it is likely to be in other areas.

Let us now consider an example from the operational level. Suppose we have the choice of purchase of two machines to carry out a particular function within the organisation. The operating costs and the output and its quality are similar for both machines. The following data is available for the two machines.

M/C A. YEAR	PURCHASE PRICE £	RESALE VALUE (at year end) (of M/C purch-) (ased in year) (1.) £	MAINTENANCE COST (including lost) (production time) £
1	12000	9000	300
2	12500	7500	200
3	13000	6300	350
4	13400	5400	480
5	13800	5000	690
6	14200	4600	1200
7	14400	4200	1800

M/C B. YEAR	PURCHASE PRICE £	RESALE VALUE (at year end) (of M/C) (purchased) (in year 1) £	MAINTENANCE COST (including lost) (production time) £
1	14000	9000	250
2	14100	8250	300
3	14200	7300	380
4	14300	6500	460
5	14400	6100	580
6	14500	5800	1150
7	14600	5500	1600

These situations show that machines gradually deteriorate with age this being shown by the increasing maintenance cost and the decreasing resale value. The purchase price figures have been discounted back using year one as the reference point and the resale value and maintenance costs have also been discounted. The way of deciding between these two machines is to determine the average yearly running cost of using both machines. This will be dependent on the time when they are replaced. So the first step in this problem will be to work out the optimum replacement policy for both machines.

REPLACEMENT POLICY CALCULATION FOR M/C A.

Replacement at end of year.	1	2	3	4	5	6	7
Maintenance Costs.	300	200	350	480	690	1200	1800
Cumulative Maintenance Costs.	300	500	850	1330	2020	3220	5020
+ Purchase Price of M/C.	12000	12500	13000	13400	13800	14200	14400
- Resale Value.	9000	7500	6300	5400	5000	4600	4200
= Total Cost.	3300	5500	7500	9330	10820	12820	15220
Average Annual Cost.	3300	2750	2517	2333	2164	2137*	2174

∴ the optimum replacement policy would appear to be to replace the machine at the end of year 6 at an average cost of £2137.

REPLACEMENT POLICY CALCULATION FOR M/C B.

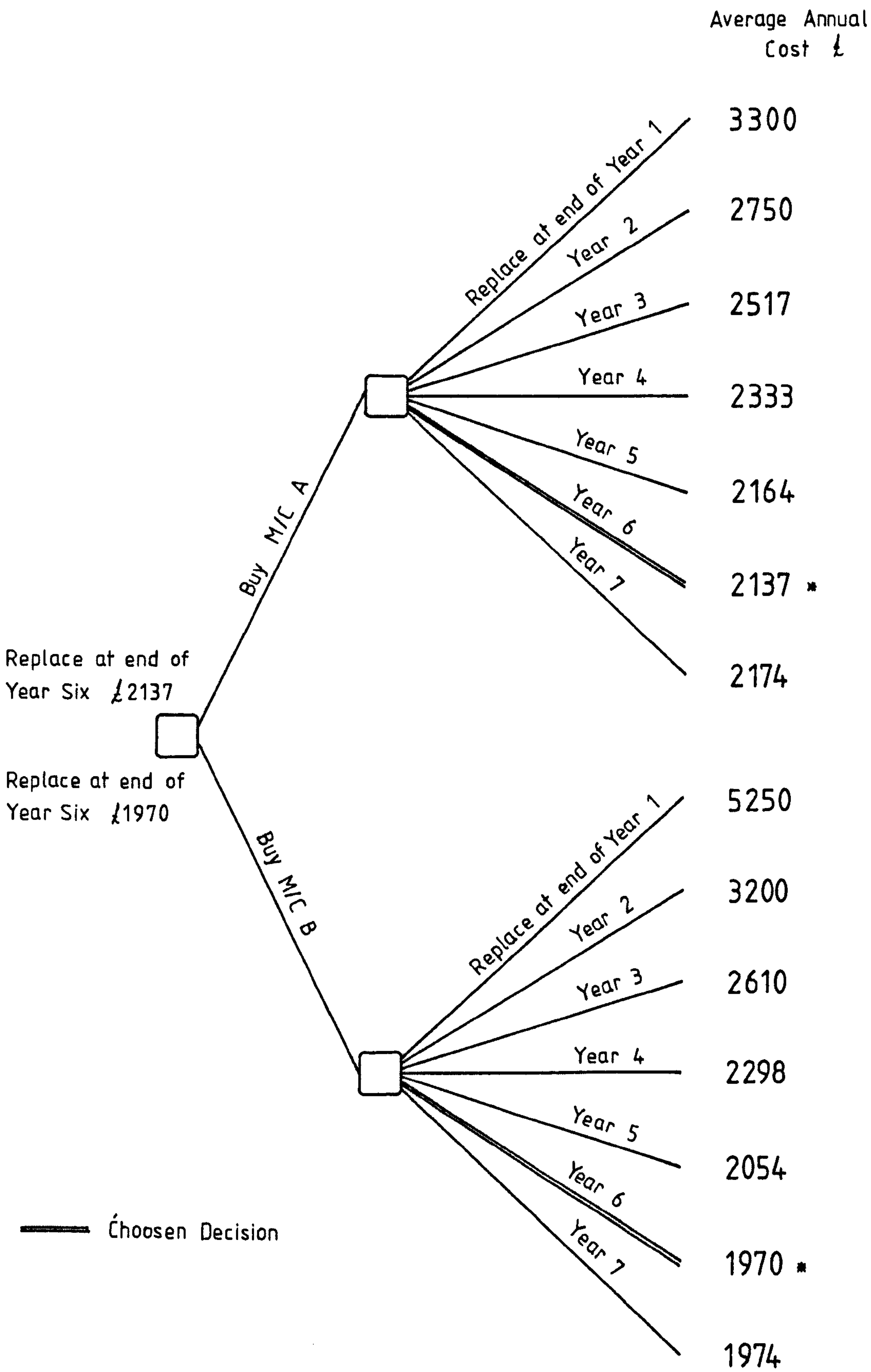
Replacement at end of Year.	1	2	3	4	5	6	7
Maintenance Cost.	250	300	380	460	580	1150	1600
Cumulative Maintenance Cost.	250	550	930	1390	1970	3120	4720
+ Purchase price of M/C.	14000	14100	14200	14300	14400	14500	14600
- Resale Value.	9000	8250	7300	6500	6100	5800	5500
= Total cost.	5250	6400	7830	9190	10270	11820	13820
Average Annual Cost.	5250	3200	2610	2298	2054	1970*	1974

∴ the optimum replacement would appear to be to replace the machine at the end of year 6 at an average annual cost of £1974.

The two machines can best be compared by presenting these average annual costs in the form of a decision tree see figure thirty two.

The best decision would appear to be to purchase Machine B and replace at the end of the sixth year, but the final decision must be made by management using the quantified information on the tree and using this in conjunction with all the non-quantifiable information to arrive at a decision.

Figure Thirty two: Decision Tree for Machine Replacement Problem.



The problem comes now to set a value on the piece of information. This final piece of information is made up of some base data and the knowledge to develop this data into the final information. To value this information let us consider what would be the outcome if there was no information, if this was the case then the decision could be considered to be taken at random, see figure thirty three. The number of years between replacement in this tree has been kept at seven, in theory this could go on to infinity. In reality some limit must be put on the number of years used in the calculations. The error produced by limiting the number of years in the calculation will be on the safe side for it will reduce the amount of value attributed to the information.

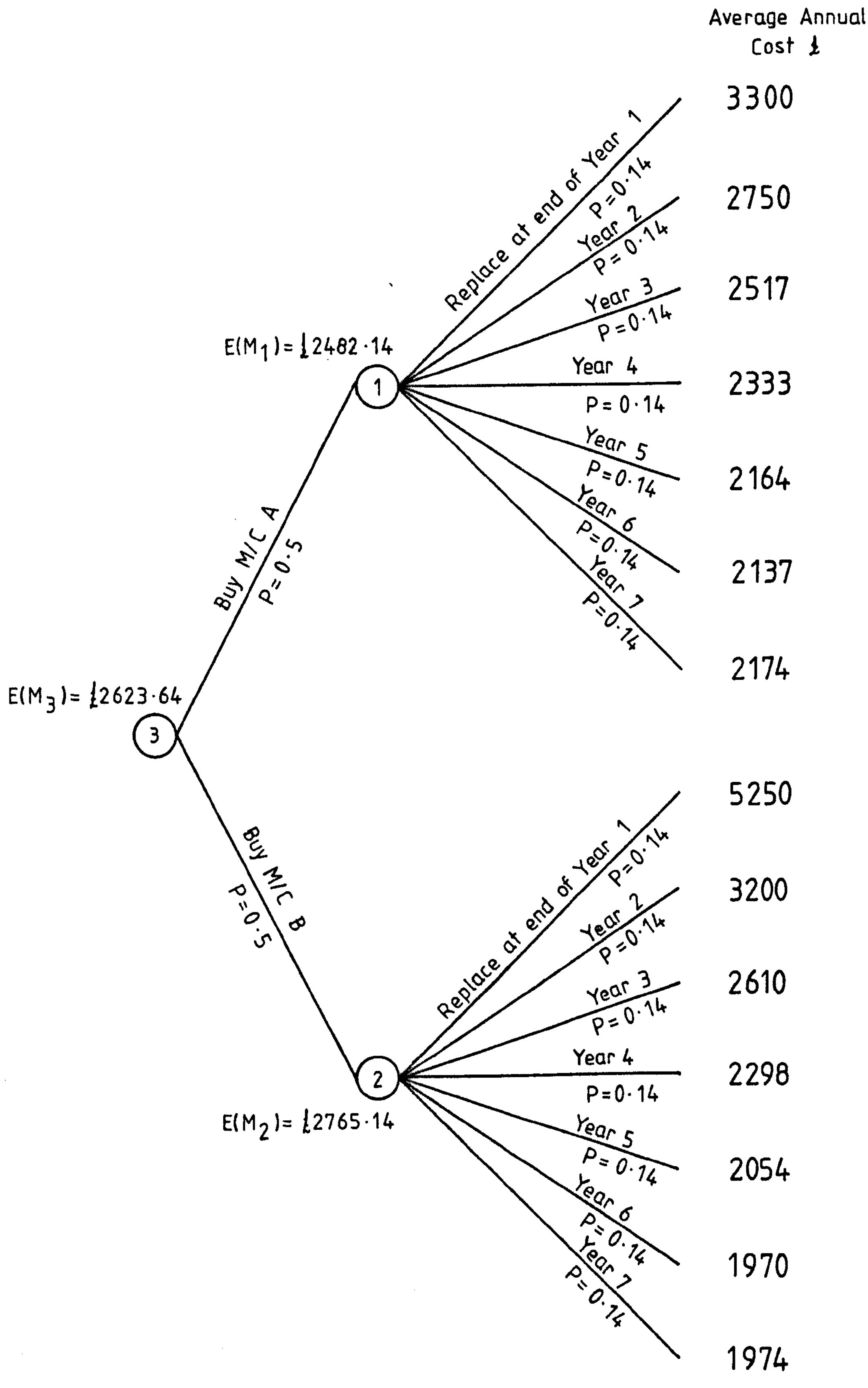
$$
\begin{aligned}
E(M_1) &= (0{\cdot}14\text{x}3300)+(0{\cdot}14\text{x}2750)+(0{\cdot}14\text{x}2517)+(0{\cdot}14\text{x}2333) \\
&\quad +(0{\cdot}14\text{x}2164)+(0{\cdot}14\text{x}2137)+(0{\cdot}14\text{x}2174) \\
&= \text{£}2482{\cdot}14
\end{aligned}
$$

$$
\begin{aligned}
E(M_2) &= (0{\cdot}14\text{x}5250)+(0{\cdot}14\text{x}3200)+(0{\cdot}14\text{x}2610)+(0{\cdot}14\text{x}2298) \\
&\quad +(0{\cdot}14\text{x}2054)+(0{\cdot}14\text{x}1970)+(0{\cdot}14\text{x}1974) \\
&= \text{£}2765{\cdot}14
\end{aligned}
$$

$$
\begin{aligned}
E(M_3) &= (0{\cdot}5\text{x}2482{\cdot}14) + (0{\cdot}5\text{x}2765{\cdot}14) \\
&= \text{£}2623{\cdot}64
\end{aligned}
$$

From diagram nine it can be seen that the average annual cost assuming a random decision pattern will be £2623•64. By using the information and knowledge the average annual

Figure Thirty three: Random Tree for Machine Replacement Problem.



cost can be reduced to £1970 (see diagram eight) and therefore one estimate of the value of the information will be to take the difference of these two values, (the resulting value must then be multiplied by six years the period over which we are concerned).

Information Value: $= (2623{\cdot}64 - 1970) \times 6$

$= 653{\cdot}64 \times 6$

$= £3921{\cdot}84$

within the range of £0 to £19,680

The range is calculated in the following manner. The lowest value to the information (£0) occurs if the random chosen decision is the same as the best decision from the decision tree. The highest value to the information (£19,680) occurs if the worst decision from the random decision tree (£5,250) is compared with the best decision from the decision tree (£1,970). (the resulting difference being multiplied by six years the period over which we are concerned). This range is concerned with the possible values that can result by comparing trees; it takes no account of possible errors in the estimates and figures used in the analysis.

This value must now be related to the other factors involved in the valuing of information.

1) TIME:- This information will not reach its full value until the taking of the decision of which machine is to be bought and until the decision is taken of when

to replace the machine purchased.

2) KNOWLEDGE:- The knowledge of the managers need to be taken into account. It has been assumed that managers have adequate knowledge to make use of the information. Clearly lack of knowledge could reduce the value of the information.

3) PRIOR INFORMATION:- There might be some prior information concerned with the prediction of some of the data parts, for example the maintenance costs and downtime, then this could be built into the analysis by using Bayesian statistics.

4) ACCURACY OF INFORMATION:- In this estimate of the value of the information little account has been taken of the possible inaccuracies in the component data parts, ie. estimates, costs, etc. As previously stated the range so far calculated does not relate to any possibility of errors in estimates, costs, etc. One way of producing such a range is to give three estimates for all the base data as in P.E.R.T. Analysis. A pessimistic, a most likely and an optimistic estimate are given and so producing three decision trees, the tree that has already been constructed is the most likely. The pessimistic and the optimistic tree will give the range. This, however, would considerably increase the amount of work in the production of final values but it would give a reasonable estimate of the range. It is a fallacy to think that

the use of Bayesian statistics and prior probabilities produces results of increased accuracy. This form of analysis still depends on forecasting the prediction rate for future events which is not quite as straightforward as Bayesian statisticians would lead people to believe. One very useful aspect of Bayesian statistics is that the effect of accuracy of the predictions can be related to the value of the information. (as was shown with the previous example, Market Research Survey).

5) QUANTITY:- The size of a particular piece of information can affect its value. Excessive size can reduce the value of the information. All managers are subject to a time constraint and therefore there is the chance that some of the value of the large piece of information may be lost because there is insufficient time to study it. The more complex the decision becomes the larger becomes the decision analysis and therefore, this problem may start to occur.

6) POWER:- Power could well be a factor that overrides the value of the information. Power cannot affect the value with regard to the organisation but it can with regard to the individual. If an individual thinks that the presentation of such information is likely to increase his status within the organisation then no matter what its value it may still be collected and developed. Such things may not be desirable for the organisation, but as any organisation is made up of individuals most of whom

will see their relationship with the organisation in power terms such events must be accepted as a fact of life.

Having taken these six factors into consideration along with the first estimation it should be possible in conjunction with management to arrive at a reasonable value for the total piece of information, ie., the total decision analysis.

This leaves the estimation of the value of the component parts of the information, in this particular case the purchase price, resale value and maintenance costs for each machine (the data) and the knowledge to turn this data into the decision analysis. The value associated with the total piece of information £3921•84 must now be apportioned between the data and the knowledge. It may be that management feels that the data on its own is of no value and only takes on a value when it becomes part of the full decision analysis. Or it may be that management may feel that the data on its own is of limited value. For example management may feel that by just looking at the data it may be possible to estimate a replacement time. If this is the case then management must estimate what proportion of the £3921•84 can be associated to the data itself, eg. they may assume £2000 has an estimate of the value of the data (£1000 for each M/C's data). The value for data in this particular application can never exceed the value of the total piece of information. But the total value of the data to the organisation may exceed this figure because it may be of use in other applications. In the example being considered the maintenance cost data will probably be used in planned maintenance schemes so its total value to the organisation may exceed the initial estimate of £2000 and depending on the value of its other uses it could exceed the £3921·84 value.

The way in which this piece of information relates to figures twenty eight and twenty nine will now be considered. This example is concerned with the operational level as shown in figure twenty eight. It can be considered as the implementation of strategic plans and possibly as a project. When looking at figure twenty nine the information can be valued at point one before the manager takes the decision but after the data has been collected and processed into information

If we apply this approach of valuation to a more conventional decision tree in the operational level, the results will be similar to the case of Concord Insulators Limited. Concord Insulators Limited is a case study given in Appendix E. Concord Insulators is a case study concerned with the operational level decision of a choice between two machines. The product life is expected to be three years with probabilities of achieving particular sales at each stage. Each of the machines can be either bought or hired. One of the advantages of hiring is that the type of machines can be changed at the end of each year. The full decision tree and all the calculations are given in the case study. Because of the size of the tree and the calculations only a summary of the tree is given in figure thirty four.

For a full analysis of the decision see the case study itself. If we assume that without this information only a random decision can be taken and at each point where a decision is required the routes are given equal probabilities of occurrance then the resultant tree will be the information value tree given in the case study and summarised in figure thirty five.

The expected return from the best decision using the tree is £38656. The expected return from random decision making is shown in the information value tree and is £33895·75.

VALUE OF INFORMATION = 38656 - 33895·75
(all information and)
(knowledge)

= £4760·25

within range of £0 to £7871

For a full analysis of the other factors involved with this value see the case study itself. In terms of figure twenty eight and twenty nine this study is very similar to the last example. It can be considered as the implementation of strategic plans and possibly as a project. When looking at figure twenty nine the information can be valued at point one before the manager takes the decision but after the data has been collected and processed into

Figure Thirty four: Summary of Concord Insulators Ltd Decision Tree.

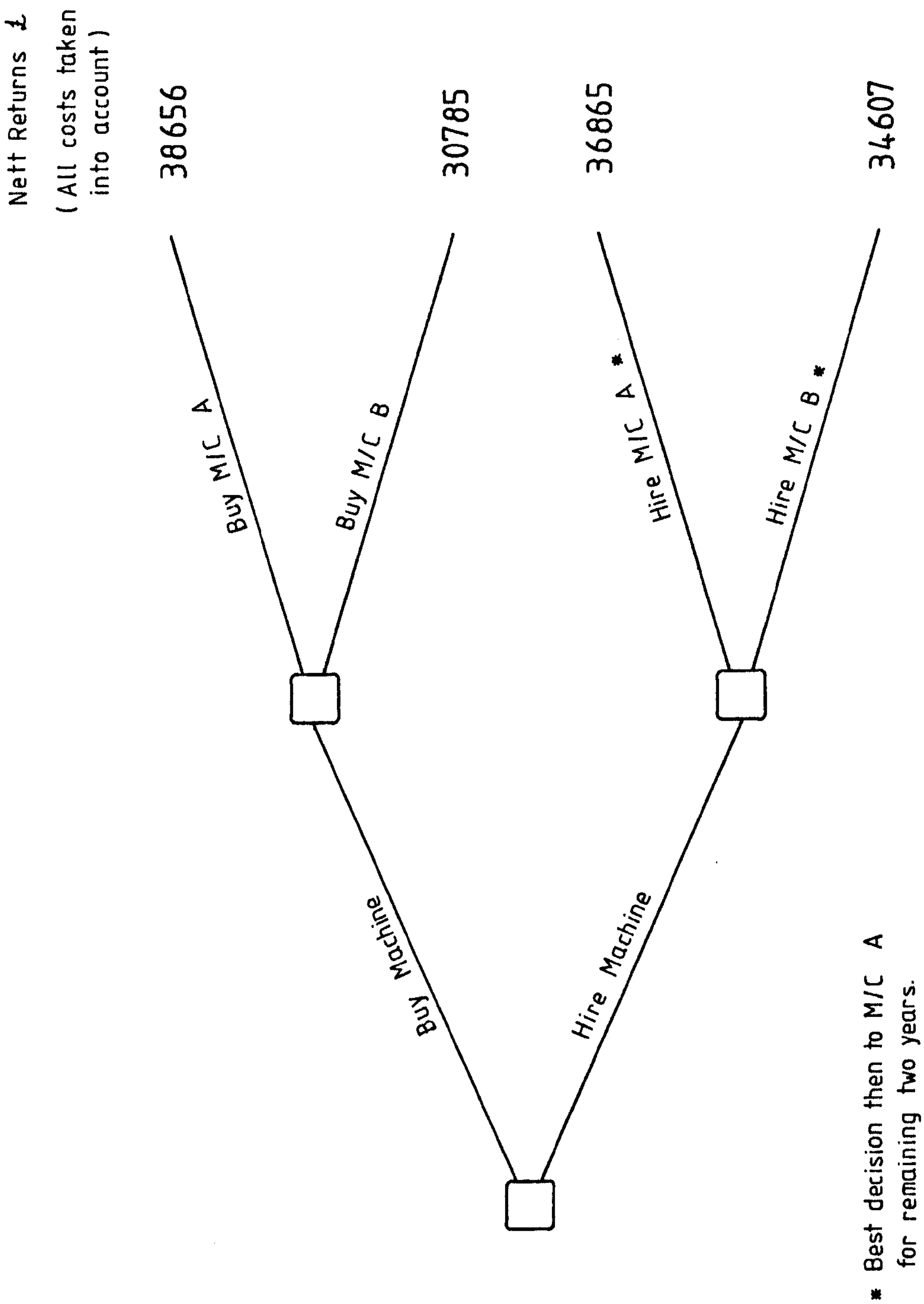
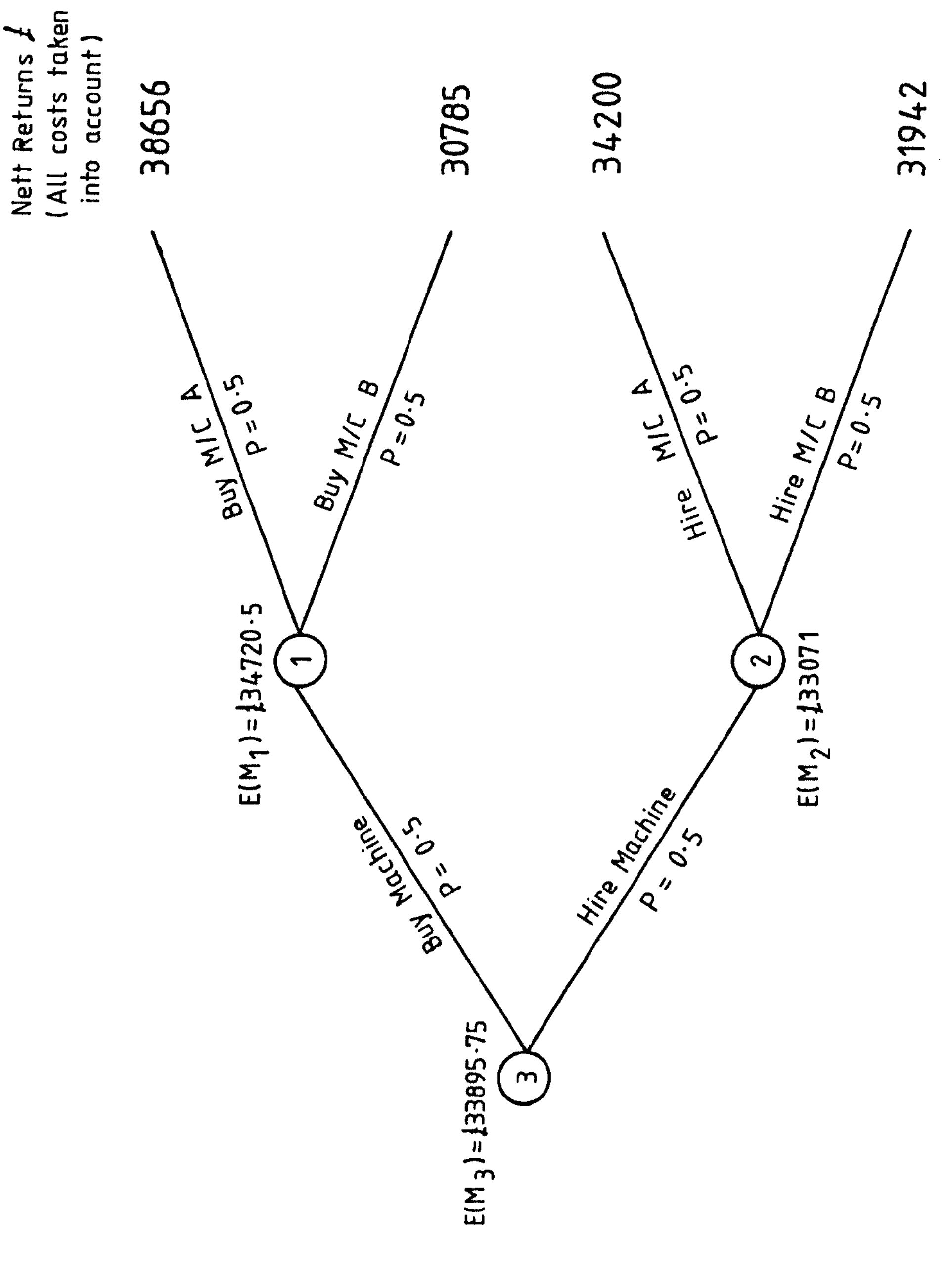


Figure Thirty five: Summary of Concord Insulators Ltd Information Value Tree



$E(M_1) = (0{\cdot}5 \times 38656) + (0{\cdot}5 \times 30785)$
$= £34720{\cdot}5$

$E(M_2) = (0{\cdot}5 \times 34200) + (0{\cdot}5 \times 31942)$
$= £33071$

$E(M_3) = (0{\cdot}5 \times 34720{\cdot}5) + (0{\cdot}5 \times 33071)$
$= £33895{\cdot}75$

information.

One important aspect of Concord Insulators is that it shows how large decision trees can become. The problem before Concord Insulators is not a particularly large one but as can be seen the decision tree itself and the calculations involved have become quite extensive. In this particular project I estimate there to be 130 man hours of work from data collection to presentation to management. A reasonable estimate for the total cost of management services personnel at the time of the case study (March 1979) would seem to be £6 per hour (£10,920 per man year). This would give a total cost of the information of £780. Taking this into account gives an information profit of £3980·25. For this information to be of no value we would need to take 793 man hours which is nearly half a man year. So even with quite a large analysis as in Concord Insulators there is still plenty of information profit.

SUMMARY OF DECISION ANALYSIS APPROACH TO VALUING INFORMATION.

The first example considered uses Baye's theorem to create a decision tree which presents the two alternatives-to produce the information or not produce the information. This is accomplished using prior probabilities (past success rates) to predict values for what will happen in the future. There are however some problems with this technique. First it assumes that the future will be like the past and that the prior probabilities will be valid in the future, unfortunately this is not always the case for management. This problem can be overcome to an extent by producing results based on a series of alternative prior probability values. For example figure thirty one shows the effect on value of information of varying the prior probabilities of a successful product introduction and the probability of an accurate estimate of market demand. These types of illustration are also of value in demonstrating this effect to management also to help them in assessing the other factors involved in valuing information. The second problem with the Bayesian approach is that there may not be any prior probabilities because the project concerned may be a novel type. This problem can be overcome by getting management to estimate these probabilities and provided that management is trained in the estimation of probabilities (see section 2.4.) this should present few difficulties.

Classical Decision Theory provides a further method of valuing information. A value can be achieved by comparing the best return from the decision tree against a value obtained by taking random decisions (this would be the case if no information existed), the resultant difference being the value of the information. This approach can be applied across a wide variety of quantitative techniques and the second two examples show this method of valuation. The first is a replacement theory problem, and the other, Concord Insulators, being a standard classical decision analysis problem. This method can be applied in many areas such as simulation, queuing and others and provides a way of measuring the contribution of such techniques to the value of the total piece of information. Like the Bayesian approach this approach suffers from the possible inaccuracy of the base data used to produce the analysis. This problem can to an extent be aleviated by taking a similar approach to that of P.E.R.T. and produce three estimates a pessimistic, an optimistic and a most likely estimate of values in the tree. This will give rise to three trees and so provide a range of values for the total piece of information. Such an approach is also of use to the managers in their decision analysis.

These two approaches suffer from the fact that neither of them makes any allowance for the basic concepts discussed earlier of time, knowledge, prior information, accuracy, quantity and power. As can be seen from the examples these can be taken into account later when the value has been produced by making adjustments in consultation with management.

Each of the two approaches can be applied at both an operational and a strategic level within the organisation. However, they are best applied to the project type of decision which will include a large proportion of non-programmed decision and some programmed decisions.

It would be difficult to apply either of these two approaches to the type of information used for control, e.g. process control, stock control, financial control and other control information. These methods value the information at a point in time after the data has been collected but before the decision has been taken. It may seem a pointless exercise to value a piece of information after it has been produced, for it would be of no value at this stage to say the information is not of sufficient value to warrant production. However, by keeping records of information value it would be possible before the data is collected to produce a reasonable estimate of the value of information, the final value of the information being determined to update the records and improve the estimation of the future values.

Decision Analysis also provides a useful tool for examining decisions after they have been taken and the results of the decision seen. It can be used in retrospect with the decision taker to examine the information, and also to try to determine what extra information would have been of value (this is always much easier in retrospect). Such analysis can then be used in improving estimates of value.

3.4.2. SIMULATION AND VALUING INFORMATION.

Simulation techniques can be used to provide a value for information. This should not be confused with the use of simulation to provide information. The technique of simulation is often used for prediction under varying conditions, so providing management with information they can use in their planning and decision making. This form of information can be valued in a similar manner to the decision tree techniques by providing a datum from which to measure. The most reliable datum would seem to be the result of a random decision, as used previously. Other datums such as the decision that would have been taken without that particular piece of information would seem to be less reliable. Such a datum would also be difficult to actually determine. Managers would not take kindly to being given a little information and being asked to take a decision or produce a plan then being given a little more information and then being asked to repeat the process so that any changes in the pattern of the decision or plan could be noted. This process would then be repeated until the information analyst had valued the information. For such a process to produce reasonable values for the information would require a large time committment on behalf of the manager by repeatedly taking the same decision but with different information. It would also require that the manager would be totally consistent with his decision making which being realistic is unlikely. The approach of producing the random decision would get around most of these problems.

Having obtained the best result for the decision from simulation this can be compared with the random decision results and so a value for the information can be determined in the same way as previous examples (Concord Insulators). When dealing with a piece of information that is made up of a series of small parts care should be taken if it is to be compared with a random datum. There will be no extra problems if the information as a whole is compared with the random datum but problems can occur if each part is separately compared to the random datum. There will be a danger of over estimation of the total value of the piece of information if it is arrived at by summing the value of the parts.

Simulation can also be used to provide information for the imput into decision analysis, for example market models and so can be used to provide a value for the information as in the first section. Simulation models can also be produced to provide a value for information more directly. The model when initially devised would have to be designed specially for this application which would, with the cost of production of such complex models would almost certainly make such an application uneconomic.

Possibly the most important aspect of simulation as applied to the measurement of information is in the training of managers in the setting of subjective measurement concerned with information. This involves the provision of initial training in assessment followed by the provision of consistence checks, etc., to ensure that the manager's ability in subjective assessment is consistent and developing. Such a use of simulation will be discussed later in this section.

Simulation can be used at any level within organisations and on any form of decision. With regards to figure twenty nine simulation is best used at point 1 but because of its predictive nature it allows a prediction to be made of the results of actions at point 3. Although simulation models can produce predictions with a reasonable degree of accuracy it must be remembered they are still only predictions of what might happen at point 3, they are not what will or has happened at point 3.

3.4.4. ACCOUNTING APPROACH TO THE VALUATION OF INFORMATION.

It is possible to approach the valuation of information from an accounting point of view, that is to determine the value of the information by equating this to the cost of not having the information, and determining this cost. To illustrate this method of valuation let us consider the example of the use of moulds in the production of ceramic ware.

In the production of a plate a plaster of paris mould is used, the surface of the mould being in the shape of the upper surface of the plate. Clay in a plastic form (green clay) is then placed on this mould, the mould is rotated and a former is lowered to produce the desired shape of the underside of the plate. The plate in its green clay form is allowed to dry before being removed from the mould. The mould is then used to produce further plates, but before the process can continue the mould needs to be dried due to the fact that the plaster of paris draws moisture from the green clay. The mould will eventually become unusable for the following major reasons.

1) Wear on the edge of the mould caused by contact with the upper former resulting in incorrect sized plates and plates with faulty profile.
2) Deterioration of the plaster of paris with the continued wetting and drying of the mould. This causes a flaking to take place on the surface of the mould giving incorrect dimensions and poor surface finish.
3) Damage to the mould may occur in various stages of handling varying from total smashing to chips and cracks.

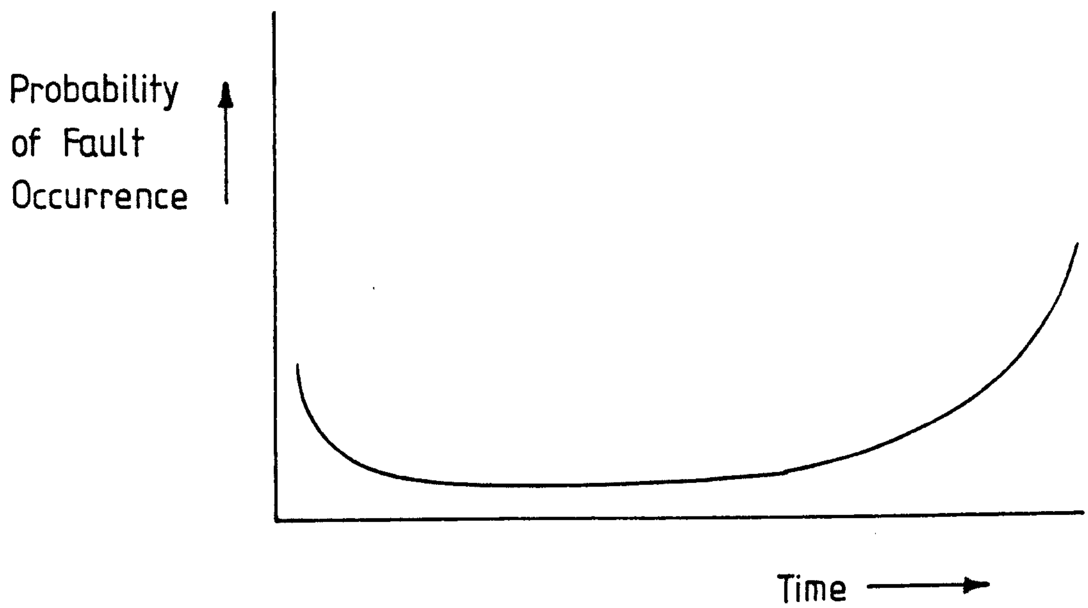
Let us now move on to the other major use of moulds in the ceramic industry. This is in the casting process to make larger or more complex shapes for example W.Cs. and figures. In order to cast complex shapes the moulds are made up of several parts. In use the mould is filled entirely with slip (slip is water with clay in suspension). When the slip comes into contact with the plaster of paris mould the mould absorbs the water and so a skin of clay is formed on the inside of the mould. The longer the slip is left in the mould the thicker the layer of clay becomes. When the product reaches the required thickness the remaining slip is poured from the mould. The product is then left in the mould to dry until it is sufficiently rigid to be removed. Slight shrinkage usually takes place during this drying which eases the removal of the product from the mould. The mould when it has been dried can then be reused. The mould eventually becomes unusable for two major reasons.

1) Deterioration of the plaster of paris with the continued wetting and drying of the mould. This causes a flaking to take place on the surface of the mould so giving incorrect dimensions and poor surface finish. This fault is much more prevalent with this type of mould than with plate moulds due to the fact that the slip gives up more water to the plaster of paris than the plastic clay so causing the need for more drying.

2) Damage to the mould may occur in various stages of handling varying from total smashing to chips and cracks. Such chips and cracks can cause problems if they occur at the union of parts of the mould and so causing flash to occur on the final product.

Having described the process involved with the use of moulds in the ceramic industry it is now possible to look into methods of valuing the process control information concerning the moulds. The basic aim of the process control information is to determine the optimum point at which to replace moulds. It will also (almost incidentally) provide data to be used in product costing, etc. The way in which moulds produce faults will be similar to that of machine tools and can be shown diagramatically in figure thirty six.

Figure Thirty six : Distribution of Faults in the Life of Moulds.



This type of distribution is standard for most items that deteriorate with time. After the peak at the beginning, caused by defective mould production then the level of faults will settle down (most faults at this stage being produced by operative error, material error, etc). As time goes on then the problems previously explained start to take an effect and the number of faults starts to rise, and it becomes necessary to decide the point where the mould should be replaced. Other factors that are relevant to replacement policy are:-

1) The cost of the mould. Moulds themselves are relatively expensive to produce, requiring a high degree of skill in the labour force and being made from a

relatively expensive material.

2) When a fault occurs, provided it is found when the clay is green it is possible to recycle the clay. There will, however, still be a loss due to the loss in overheads, etc., already used in the production of the product. The next stage, firing produces a chemical change in the material so not making it possible to recycle defective products. If a moulding fault goes undetected to this stage the cost incurred is obviously much higher. If a moulding fault goes undetected through further stages of glazing and refiring then the fault can become very expensive.

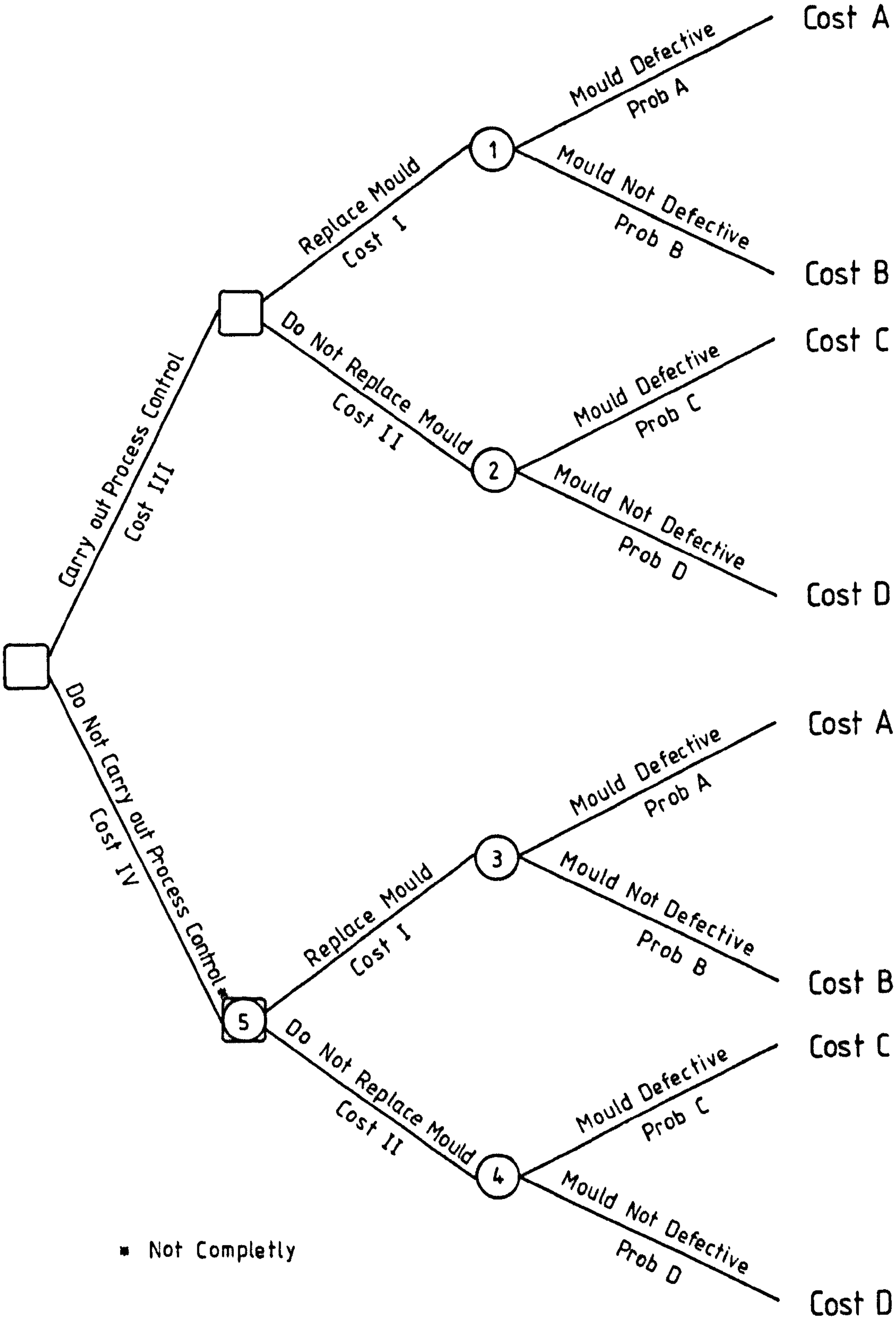
3) At present the production of larger castings and hollow ware castings (teapots, coffee pots, etc.) is labour intensive where the mould can be monitored by the operative. With the present trend towards a more automated process it will not be possible for an operative to monitor the mould and so the product will need to be monitored. A large producer of sanitary ware has already developed a machine that will automatically cast W.Cs although it is experiencing union difficulties in getting the machine into production. The production of plates and cups is also becoming more automated and the production of ceramic tiles has become totally automated so making it necessary to monitor the product and not the moulds to identify the defective moulds. The moulds used to produce tiles are metal and the tiles are stamped out

of powder and not plastic clay.

The actual methods of process control which could be used are well tried and reasonably successful. The important thing at this stage is to determine the value of the information they provide. The approach so far used, decision analysis, requires that the value of the information be based around the decision. The decision in this case is when to replace the mould. The moulds are sufficiently expensive to make it necessary to treat them individually, so each mould is used until it produces poor products. At any point in time the decision could be represented by the decision tree shown in figure thirty seven.

This figure shows how the decision concerning the replacement of moulds would appear at any one point of time. Point five on the tree causes somewhat of a problem which is why it has been shown with symbols both for a decision and an alternative outcome. Having taken the route of not carrying out process control the possibility of a company not changing moulds at all can be discounted as such a strategy would end with the liquidation of the company similarly a random approach to replacement would also be discounted by any right thinking management. The only approach to the removal of process control at the casting stage would be to replace all moulds at fixed intervals, the interval being fixed by the probability distribution of faults in moulds (see figure thirty six). It is a decision to replace moulds at a fixed time but in a formal

Figure Thirty seven: Decision Tree for Process Control.



sense it can also be considered an alternative outcome so at this point both symbols are used. Having now looked at the tree in general terms the individual components of the tree can be dealt with in turn, firstly the costs.

COST A:- This cost will be zero due to the fact that the appropriate action has been taken.

COST B:- In this situation a non-defective mould has been rejected so the cost involved will be the lost good production from that mould. This is not an actual loss of production. Production will continue as a new mould replaces the mould rejected. What will be affected will be the unit cost of the mould that has been rejected because it could have produced more good production. Such a cost would be almost impossible to determine exactly so only an estimate could be used.

COST C:- If a defective mould is not replaced then defective items will be produced. Thus cost C will be the resulting cost incurred. The further such items get through the process the greater the cost becomes (especially if they are put through kilns and glazing processes).

COST D:- Like cost A this cost will also be zero because this is also a correct situation not replacing a non-defective mould.

COST I:- To replace a mould incurs the cost of the actual replacement mould which are expensive items.

COST II:- Not to replace the mould must be zero (the effect of the length of use on the unit price of the mould will be allowed for in cost I).

COST III:- This cost will be the one involved in the carrying out of process control. It may be as small as the marginal cost of an operator checking that the item has been produced correctly in a manual casting process or a greater cost for more sophisticated systems required for automatic processes.

COST IV:- The cost of not carrying out any process control will not be zero. The only sensible alternative to carrying out process control is to replace the moulds at fixed intervals. Studies will need to be carried out to determine the optimum time to replace the moulds. The cost of these studies would be included in cost IV. Additional cost will be incurred with the good moulds that are thrown away when the fixed replacement time arrives.

After considering the costs the next thing is to consider the probabilties all of which will be related to time(in the lifespan of the mould). The relationship between time and the probability of a fault occurring has already been shown diagramatically in figure thirty six.

Probability A:- Probability A can be calculated using Bayes Therom as follows -

$$\text{Prob A} = \text{Prob (D/PD)} = \frac{\text{Prob (PD/D)} \cdot \text{Prob (D)}}{\text{Prob (PD)}}$$

$$= \frac{\text{Prob (PD/D)} \cdot \text{Prob (D)}}{\text{Prob (PD/D)} \cdot \text{Prob (D)} + \text{Prob (PD/ND)} \cdot \text{Prob (ND)}}$$

Where Prob (D/PD) = Probability of defective mould given that a prediction of a defective mould has been made i.e. bad mould rejected.

Prob (D) = Probability of a mould being defective at a point in time. *1

Prob (ND) = Probability of a mould not being defective at a point in time. *1

Prob (PD/D) = Probability of predicting a defective if a defective mould would actually occur (the success rate of the method of process control in predicting defective moulds when defective moulds actually occur). A detailed study of the operations and the process control system would need to be carried out to determine this probability and it would also only be an estimate of what might occur in the future.

Prob (PD/ND)= Probability of predicting defective mould if a non-defective mould would actually occur 1 - Prob (PD/D).

Probability B:- Probability B can be calculated as follows

Prob B = Prob (ND/PD) = 1 - Prob A.

or the expression can be expanded using Bayes Therom.

where Prob (ND/PD)= Probability of a non defective mould given that a prediction of a defective

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*1. N.B. Both these probabilities will vary with the point in time taken in the mould life cycle. (see figure thirty six).

mould has been made i.e. good mould rejected.

Probability C:- Probability C can be calculated using Bayes Therom as follows -

$$\text{Prob C} = \text{Prob (ND/PND)} = \frac{\text{Prob(PND/ND)} \cdot \text{Prob (ND)}}{\text{Prob (PND)}}$$

$$= \frac{\text{Prob (PND/ND)} \cdot \text{Prob (ND)}}{\text{Prob (PND/ND)} \cdot \text{Prob (ND)} + \text{Prob (PND/D)} \cdot \text{Prob(D)}}$$

where Prob (ND/PND/ = probability of a non-defective mould given that a prediction of a non-defective mould has been made i.e. good mould not rejected.

Prob (D) = probability of a mould being rejected at a point in time. *1

Prob (ND) = probability of a mould not being defective at a point in time. *1

Prob(PND/ND) = the probability of predicting a non-defective mould if a non-defective mould would actually occur (see Prob (PD/D) in last expression for further expansion of determination of this probability.

Prob (PND/D) = probability of predicting a non-defective mould if a defective mould would actually occur = 1 - Prob (PND/ND).

Probability D:- Probability D can be calculated as follows:

Prob D = Prob (D/PND) = 1 - Prob C.

or the expression can be expanded using Bayes Therom.

where Prob (D/PND) = probability of a defective mould given

*1 N.B. Both these probabilities will vary with the point in time taken in the moulds life cycle. (see figure thirty six).

= that a prediction of a non-defective mould has been made i.e. bad mould not rejected.

A large part of all the data making up the tree is related to time, the point in time at which the mould is in its life cycle. Such time related variables make the analysis and final results in any situation very difficult to produce and understand. The results will vary with the point in time so much that process control appears not needed when the process is under control it is only needed when the process goes out of control. To carry out process control in this way is a nonsense because it is the job of process control to determine when the process does go out of control.

Due to the time factor the standard valuation approach of expected values and probabilities so far used will not be successful for any type of control information. Although a different approach to valuation will be required it will still be necessary to determine the costs and probabilities used on the tree. These costs and probabilities can then be used in a different approach.

Given that the system of valuing based around decision analysis will not be particularly successful another approach must be taken, I have called this alternative approach the accounting method because it is based around cost. It is an approach used by managers but not much considered in theoretical studies in this area. The approach is to consider the cost of not having the information and using this to determine a value. This is similar to the approach used in the Non-Bayesian Decision Analysis method where the result in using the decision analysis was compared with the result not using the decision analysis, the difference in the result giving the value of the information.

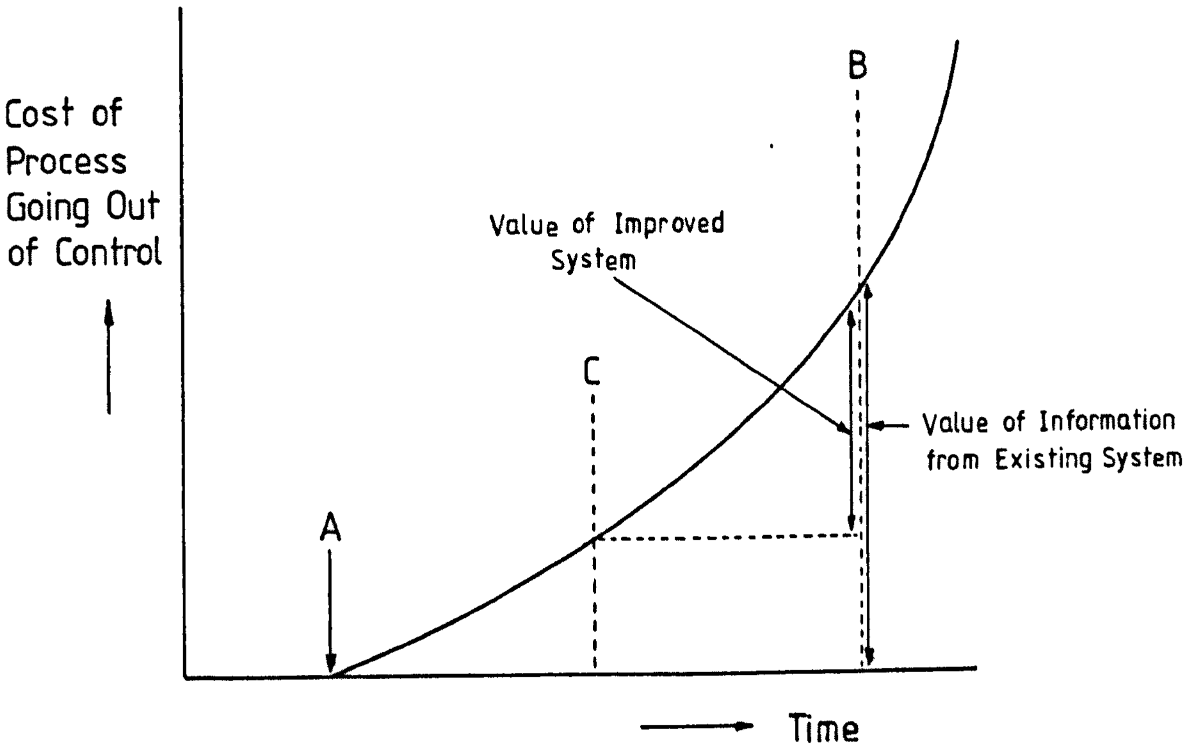
In the accounting approach it is required to determine the cost of the process going out of control. Some of the cost is easily quantified, e.g. the cost of waste raw material, rectification of the product, lost labour content in producing defective pieces, waste in later processes if defective pieces pass through, etc. Some of the costs will be a little more difficult to quantify and may need to be estimated, e.g. the loss of customer good will when defective pieces are delivered, etc. It should be possible to obtain a reasonable value for the cost, of the process going out of control which will be related to time and will be zero while the process is in control and then rising relative to the production rate, when the process goes out of control.

This cost could then be translated into value. As a result of having the information the process would be brought under control and the cost would be zero without the information the cost would continue to rise; therefore the value of the information will be equal to the cost of going out of control. Such a valuation of the information should be used with care because the value would behave in the same manner as the cost and rise with time, so making it possible to arrive at the incorrect conclusion that the longer the correction to the process takes the greater the value of the information. The approach to take with this valuation is to relate it to the cost of providing the information. When the two are equal or the cost is less than the value then the information is viable. The value of the information will be related to the time taken by the information system to respond to the process being out of control. The value of the information at this point in time should be related to the cost (see figure thirty eight).

There will always be some delay in any systems response to an out of control process due to the normal variations in the process (normal variation of the process must not be interpreted by the system as being out of control). More about how quickly information is required can be found in section 3.1.4. The approach of relating value to cost in this manner would make sure that the system provided would be cost effective and would also make sure that the system would respond at the economic rate.

The Accounting Approach to valuing information, that of determining the cost of not having the information and using this to determine the value of the information would appear to be effective in arriving at a value for process

Figure Thirty eight: Valuing Process Control Information.



POINT A: The point at which the process goes out of control.

POINT B: The point at which the process is discovered to be out of control by the existing control system.

POINT C: The point at which the process is discovered to be out of control by the new improved control system.

control information. Such a valuing system could be successfully applied to any control information for example cost control, production control, stock control, etc. Such an approach would not be successful for the type of unprogrammed decision information considered previously, the best approach to this is to use the decision analysis method.

There is one more technique to add to the accounting approach. This approach is basically to determine the cost of not having the information. In this case the value is produced as part of the information itself. It is produced in most management services projects (e.g. work study, O.R. O. & M., Systems, etc.). When a report, for example a stock control report, is produced it is good practice as part of that report to include a section on savings. This work can be defined as information for management, therefore, the savings must be the value of that information. Such values have to be produced before the information will be accepted or used by management.

3.4.4. ESTIMATION HEURISTICS APPROACH TO THE VALUATION OF INFORMATION.

Information can be valued by determining how much the information reduces uncertainty. The method of valuing using statistical decision theory comparing a random decision to the best decision using the decision tree follows this basic approach. By comparing the random decision with the best decision the amount the information reduces uncertainty can be quantified. This method can also be used with other O.R. techniques, an example already given in the text being of Replacement Theory.

The amount that information reduces uncertainty can be quantified in some cases but there are situations in business when it is not possible to formally quantify. In these situations the approach that is left is to use heuristics to estimate the value of the information. It must also be remembered that in some of the cases where the value has been quantified the basic probabilities are obtained by estimation rather than direct measurement i.e. subjective probabilities (see section 2.4.2., 2.4.3., 2.4.4., and 2.4.5.). The value of information in some cases will be variable because of the dynamic nature of business.

The production of estimates of the value of information must be carried out with care. To ask the average manager for a value for a piece of information is almost as bad as asking him how many beans make five. Information valuing is an area that is not very effectively carried out intuitively. In the section Myths of Management Information some of the common pitfalls of management information are examined. A knowledge of these will be absolutely vital to a manager if he is going to be able to produce meaningful values for the information. The manager having made himself conversant with the pitfalls in the area of measurement of information is then likely to apply one of three basic approaches or some combination of them. The basic approach of estimation of information value is similar to that of estimation of uncertainty, the three heuristics being the same.

1. THE HEURISTIC OF REPRESENTATIVENESS.

This process involves determining how representative a piece of information is of a general class of information and so determining the value. There are some problems involved with using this heuristic some of which are in common with measuring uncertainty and as these have already been dealt with in another section they will only be listed here; there are however, some problems specific to valuation of information.

a) Not allowing for prior probabilities.

b) Insensitivity to sample size.

c) Lack of understanding of the element of chance.

d) Misconception of validity.

e) Misconception of regression.

f) Lack of representative classes to use as reference: Most managers have limited experience if any of valuing information and so lack a set of representative classes to use as reference points. Such sets could be provided for managers as part of their training in the setting of information value. Problems with the lack of representative classes are more likely to be encountered with the valuing of information than with estimating uncertainty.

2. THE HEURISTIC OF AVAILABILITY.

This is where the information is valued by bringing to mind other such similar occurrences. Again like the first method there are some problems in using it that are common to measuring uncertainty and as these have already been dealt with in another section they will only be listed here.

a) The retrievability of instance.
b) Biases due to the effectiveness of a search set.
c) Biases of imaginability.

The first two of the problems tend to be more important in the valuing of information because of managers' limited experience in this field.

3. THE HEURISTIC OF ADJUSTMENT AND ANCHORING.

When valuing information this last approach is to start from an initialisation value and then adjust until a satisfactory value is found. When setting subjective probabilities it was found that two problems were encountered these being:

a) Difficulty in setting the initialisation value,
b) Once this value has been set there is a reluctance by people to move away from it.

The first of these problems can be solved to a degree by setting the initialisation value to the cost of obtaining the information. In some cases this cost also will be an estimated value. If the adjustment moves below the cost then the information is not viable. If it moves above the cost it is viable. The second problem will probably still occur; there will be a reluctance to move away from the initialisation value. It must be emphasized to the setter of the information value that there is no relationship between cost and value, that the cost cannot affect the value and it is merely a start point. It could be argued that once it is established that the value is greater than the cost it is worth obtaining that piece of information, but unfortunately this simplification is not always true. For a piece of information to achieve its full value it must be used by management. With the present reducing costs in information technology the cost of providing information is falling. Also with advancing technology and information theory it is possible to improve the quality of management information. This means that with costs falling more information will have a value greater than its cost. If the above simplification is taken then management will be provided with more and more information until the stage is reached where there is more information than management can use in the time available. If there is more information than management can use then two things are likely to happen.

1. The information that has not been used by management will not have contributed any value, therefore, any cost incurred in collecting, collating, analysis, etc., of the information will have been lost.

2. When the manager is presented with too large a volume of information there is a danger that some pieces of

important information could be overlooked or not fully used. Such missing of important information could have considerable bearings on particular decisions of the manager.

The way to avoid these problems is to take the initialisation value as the cost and adjust this to the information value. The adjustment could be made in the light of other values given to information (some of which could have been determined by one of the quantifying techniques already discussed). The other values would provide a reference list to compare the new value with. Such a list would provide a consistency check for the information value setter which would be made even more powerful with the addition of some quantified values into the list. Such a list would also help to remove the problem of reluctance to move from the initialisation value by providing a realistic framework onto which the value being considered can be placed. Also the use of a framework will allow the dynamic nature of business to be taken into account each time a new value is added to the list, the rest can be updated if necessary either a global update or a partial update, because specific conditions have changed.

It is not suggested that these three heuristics should be used individually or that one is better than the other. The best approach would be to use the cost of the information as the initialisation value and then use representativeness and availability to adjust the value and set it into a framework of past valuations (these valuations including some carried out by one of the quantification techniques). At the same time as valuation the framework can be updated if this is thought to be necessary. This approach will lead to certain problems which can be dealt with as outlined previously with the setting of subjective probabilities. Techniques such as cumulative density functions (CDF), gaming simulation to give a training and then as on-going backup in the setting of information values, a training in statistical theory and techniques, and the use of groups (the Delpli techniques, etc.) can all be used to remove the problems associated with setting estimated information values. (see section 2.4.). Also will be required a knowledge of the basic concepts in management information measurement:

1) Time,
2) Knowledge,
3) Prior Information,
4) Accuracy,
5) Quantity,
6) Power,

For more detail on these points see section 3.2.

3.4.5. SUMMARY.

There are a number of ways of valuing management information the most useful of which have been considered in this section with the aim of producing a methodology of value measurement. The following summary gives the techniques considered with their applications and limitations.

1. Classical Approach using Statistical Decision Theory in this approach. This approach is the one used in most papers on the measurement of information value. It uses Classical Statistical Decision Theory and/or Bayesian Statistics to arrive at a value. This approach can be applied at either the operational or strategic level within the organisation. However, it is best applied to the project type of decision which will include a large proportion of non-programmed decisions and some programmed decisions. It would be difficult to apply this approach to the type of information used for control, e.g. process control, stock control, financial control. The valuation of the information is carried out after the information has been gathered and the anlysis produced.

2. Simulation used as a technique for valuing information. Simulation can be used to provide information but here we are concerned with the use of simulation in valuing information. Although it is possible to produce simulation models purely for the valuation of information, because of the high cost of producing them it is very unlikely that any of them would be economic. The best use of simulation

in the valuing of information is in the use of gaming simulation to train managers to set values for information.

3. Accounting Approach to information valuing. There are two ways to approach this method of valuation. First to determine the cost of not having the information and then equating the cost to value. This approach works well for control information but due to the amount of estimation does not truly quantify the value of project information. The second approach works within some project applications and is the saving accrued due to using the information i.e. the savings from carrying out the project.

4. Estimation Heuristics:- The best approach of the heuristics available would appear to be to use the cost of the information as the initialisation value and then use representativeness and availability to adjust the value and set it into a framework of past valuations (the valuations including some carried out by one of the quantification techniques above). At the same time as valuation the framework can be updated if it is thought to be required.

Given that there are four major ways of valuing information, which should be used? The answer to this is that all of them can be linked in a methodology which can produce reasonable, realistic values to information at an economic cost.

The first part of the methodology will be to train the information value setters, managers, in some basic ideas. Because uncertainty plays such an important role within information valuing, training in this will be necessary. Training will also be required in the basic concepts of information measurement and the methods of valuation. This training could be given in a number of ways from formal training to the use of programmed texts backed up with gaming simulations.

Having been trained in the basic ideas the managers will be able to set estimates of information values. The initial process in information valuing will be to estimate the information value using technique four. The other techniques cannot be used at this initialisation stage due to the necessity to actually obtain the information before they can effectively be used. If the estimates show that the information is sufficiently economic it can be obtained.

If the information has been collected and it is possible and economic to obtain a quantified value using techniques one or three then this value can be fed back into the estimation framework. Such a feedback should help to ensure updated and consistant estimates in the future. Good effective records are absolutely essential if this procedure is to be carried out successfully and when a new valuation is added to the framework then there may be a need to update the whole or part of the framework. To supplement this framework and keep it up todate it may be necessary to carry out attitude surveys on existing ongoing information, e.g. control information to ensure it is maintaining the value associated with it. It should be remembered that the use of groups of managers involved in estimating will usually achieve better results than individual managers estimating.

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3.5. DETERMINING THE COST OF MANAGEMENT INFORMATION.

It might be expected that the cost of information will be easier to determine than its value. This may not be the case.

Although the word cost is used with apparent confidence it can have different meanings to different people; economists, businessmen, managers, accountants, etc. Therefore, the word cost should not be used on its own; a more full definition of the type of cost being considered should be used. The following is a selection of some of the types of costs; fixed costs, variable costs, sunk costs, marginal costs, acquisition costs, operating costs, and so on. It would be very time consuming to list and define all the different types of cost. Moreover some of these costs will not be relevant to the determination of the cost of information, so I shall only consider the types of cost which are relevant to the determination of the cost of management information. This is not an exhaustive list but a definition of some cost types that will be required before methods of measurement can be discussed, some other cost types will be introduced within the section on methods of measurement of costs.

3.5.1. SOME TYPES OF COST.

There are two basic levels on which costs can operate, these being macro and micro levels but in the sense of the organisation and not the economy. Macro costs are incurred when equipment to run a new information system is purchased and micro cost incurred when additions are made to existing systems. The purchase of a new computer would incur costs at the macro level but the running of a new program on an existing machine would only incur costs at the micro level. Another approach to separating costs is to talk in terms of acquisition costs and running costs. These cost categories are relatively self explanatory the first being the purchase cost the second being the cost of operation. Yet another approach to separating costs is to use fixed costs and variable costs. These may be defined in terms of production of information as follows. Fixed costs are the costs which will remain constant for different levels of information production (either quantity or quality) whereas the variable costs are costs that will vary directly with the level of information production. The above costs should not be confused with each other as all the three classifications of costs are different. Macro and micro costs refer to the level at which the costs are operating. The other two categories refer to the way a cost can be split up. The two however, should not be thought of as the same, consider the following example. Suppose there is a main frame computer with 9 operators operating a three shift system. If the first system of splitting costs is used, the cost of the computer will be the acquisition cost, the cost of the operators going to form part of the running cost. If the second way of splitting cost is used then the cost of the computer will form part of the fixed cost. The cost of the operators would also become part of the fixed cost as the number would be difficult to reduce at will and the number of hours the computer is being run cannot be increased beyond three shifts. This cost therefore would remain fixed despite the amount of work carried out on the machine. The variable cost in this case being paper, cards, electricity, etc. In this case the two systems are not similar but it is possible to find examples where the fixed cost will be the same as the acquisition cost and the running cost the same as the variable cost but this should not be taken as a general rule.

When costing management information then only costs that are relevant should be used. There will appear an area of cost that will have already been allowed for and claimed back from the result of a past decision. As these costs have already been allowed for and claimed back it will be wrong to claim them or some portion of them for present or future decisions. Suppose a computer has been cost justified and purchased and then it is to be considered whether or not to run a new piece of work not previously allowed for in the cost justification of the computer. The original cost of the computer, or some portion of it, would appear to be relevant to the cost of the new work. It would be wrong to charge this cost or some portion for a second time the only fair approach would be to use a marginal cost approach and just to count extra cost to that already occurred.

Another approach to using costs in decision making is that of using sunk costs. Sunk costs are all past costs.

When taking decisions past costs can no longer represent meaningful alternatives, they can only be represented by future or incremental costs. This can be a useful way to look at costs affecting decision taking.

3.5.2. METHODS OF DETERMINING COSTS.

Having outlined some of the terms used in costing, methods of determining such costs can be examined. There are three basic approaches that can be used when determining information costs.

1. Estimation of resources required and their costs:-

   This approach is to determine the resources required to collect, process, distribute, etc., the information and then to determine their costs. The total cost of particular pieces of information can be split into the following elements using classical accounting terminology.

ELEMENTS OF TOTAL INFORMATION COST.

```
DIRECT MATERIALS    )
DIRECT LABOUR       )   PRIME COST)
DIRECT EXPENSES     )             )
                                  )
      INDIRECTS           )       )  TOTAL
      ADMIN.EXPENSES      )OVERHEAD) COSTS
      DIST.EXPENSES       )COSTS   )
```

Direct Materials.

All the materials that are part of the final product can be classed as Direct. With information as the final product these costs can be quite small.

Direct Labour.

Monies paid to people actually employed in the production of the product. The product being information this means that Direct Labour will be made up of people actually working on the production of the information. They may include clerks, computer operators, etc.

Direct Expenses.

These are expenses other than direct materials or direct labour that are directly attributable to the production of the information. These will be things like systems and programming costs, O & M costs, and any facilities bought in from Bureau whether Software or Hardware.

These three cost elements then form the Prime Cost of the information. These prime costs will vary directly with the amount of information produced.

Indirects.

These Indirects will include Indirect Materials, Indirect Labour and Indirect Expenses incurred during the production of the information. This cost element will include the proportion of maintenance, maintenance staff, rates, electricity, heating, special conditions, depreciation, etc.

attributable to the production of the information

The last two elements of the total cost are also Indirects but they are separated as they can be important costs areas in taking some decisions.

Administration Expenses.

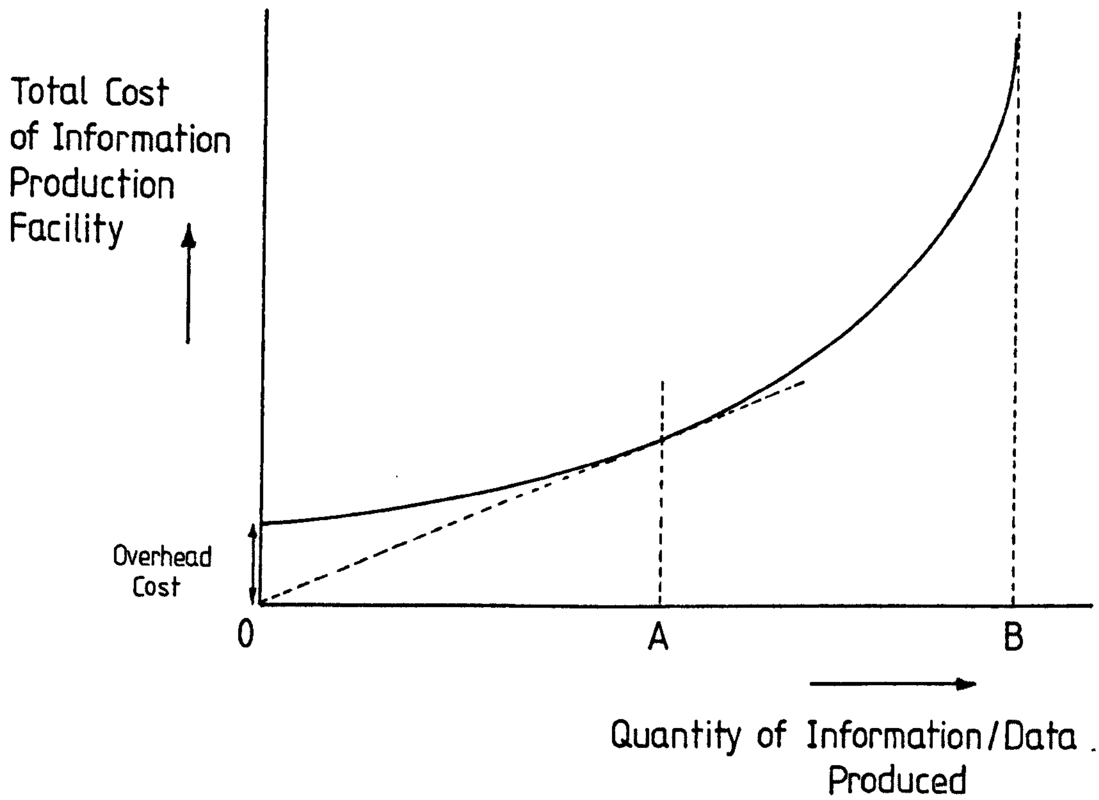
These are all the costs incurred in the running of the information production unit such as Data Processing Manager's salary, etc. It will also include an element of administration charge from the organisation within which the information production unit is operating.

Distribution Expenses.

These are all the costs incurred in the distribution of the product, information. Cost like data transmission costs, postage, transportation of documents and information will be included in this element.

Indirects, Administration and Distribution Expenses are added together to form the Overhead Cost. Unlike the Prime Cost the Overhead Cost within limits is fixed and will not vary with the amount of work carried out. Although the Overhead Cost itself is fixed the way in which it is apportioned will vary with the amount of work carried out by the information production unit. The more information produced the more the Overhead Cost can be spread. The Total Cost is given by adding the Prime Cost to the Overhead Cost. The relationship of total cost of information production facility against the quantity of information produced can be shown diagramatically in figure thirty nine.

Figure Thirty nine: Relationship of Total Cost of Information Production Facility Against the Quantity of Information Produced.



A = Normal capacity of facility

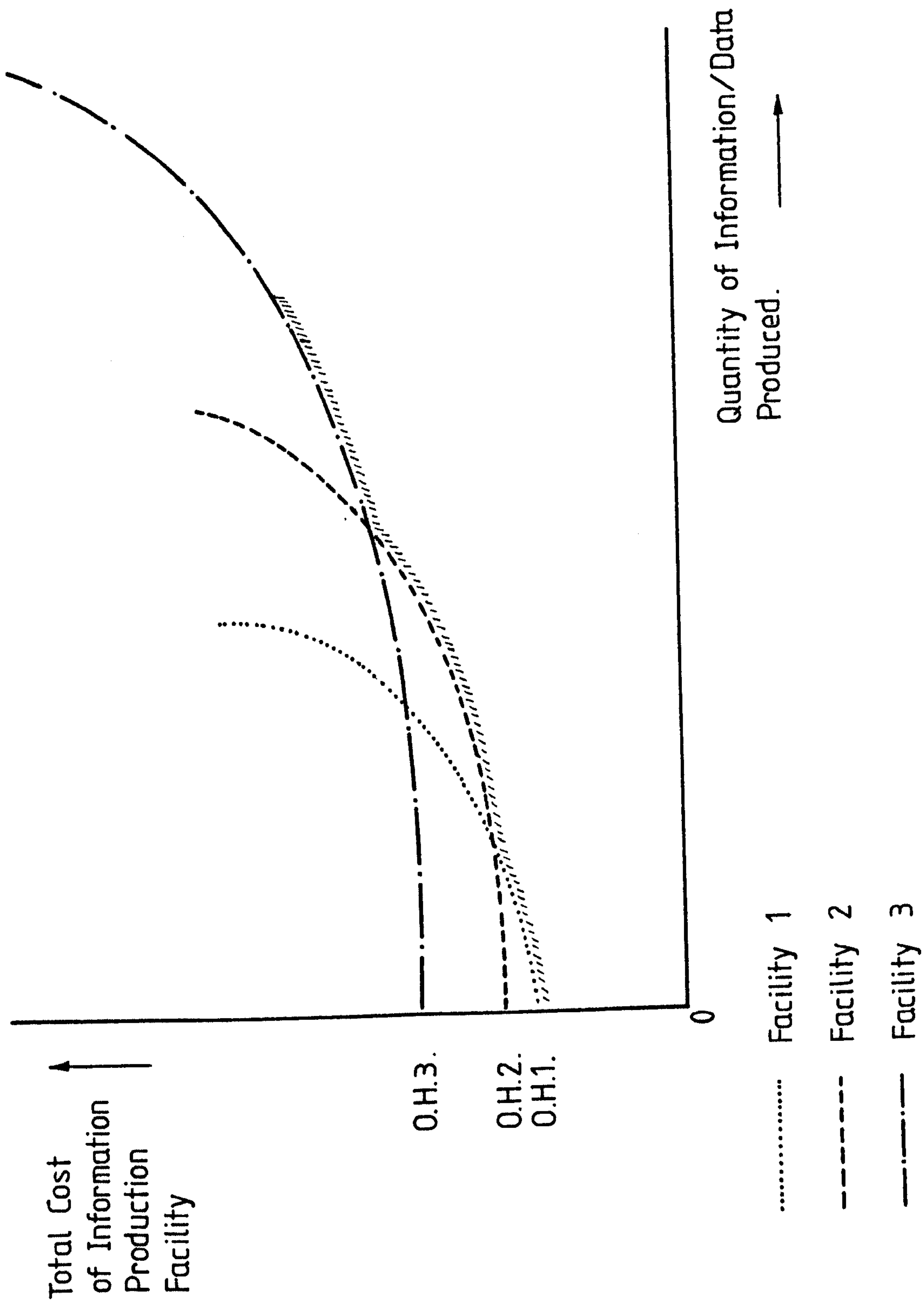
B = Absolute limit of facility

If no information is produced the fixed portion of overhead cost is still incurred the figure therefore starts at this point. Prime costs and additional overheads are then incurred as the quantity of information produced increases. In the figure this has been smoothed out in a real graph it would be a series of steps as more direct labour, etc., is incurred. These prime costs in the majority of cases are likely to rise consistently until the information quantity for the normal capacity of the facility is reached (Point A). This is a level at which the facility can operate over a long period. Moving past this point starts to put stress on the facility and so the rate of change of cost increases to the absolute limit of the facility (Point B). Such an absolute limit is difficult to determine in precise terms but can be estimated from the rate of change of prime cost increases. When point A has been passed then the stress put onto the facility makes it difficult to sustain such a level of information produced, and it becomes more difficult the closer one gets to limit B. When a facility is consistently being asked to produce information beyond its normal capacity then a change of facility should be considered. Figure forty shows the total cost curves for various facilities of differing capacities.

Due to the increase in capacity the Overhead Cost also increases. The hatched line on the figure shows the optimum facility for any given level of quantity of information produced.

This form of costing applies to total facility costing for such things as data processing departments, etc., facilities whose main purpose is producing information. In section 3.5.1. it was suggested that once a cost has been charged it should not be charged again. This will lead to additional work carried out being charged at the incremental

Figure Forty: Relationship of Total Costs of Information Production Facilities Against the Quantity of Information Produced.



cost of completing it, i.e. Marginal Costing.

There will exist in organisations places which produce information as a by product of their normal function. For example this can occur with production control departments. The function of such a department is to control and monitor production. Such a department will produce information, for example production schedules, as part of its function. This information should be costed at full cost relating to the resources used in the production of the information. Some information produced by the production control department will not be part of its prime function, for example a one off production summary for a particular product. It would be wrong to cost out such a piece of information at full cost it should only be costed out at the incremental charge of completing it i.e. the marginal cost.

The same problem will occur when managers produce information. Part of the manager's function is to produce information. (see section 2.1.4.2.). Information produced as part of the manager's prime function should be costed at full cost but information produced in addition to this prime function should be marginally costed.

When costing resources some costs cannot be precisely determined and will need to be estimated. Two techniques could be used in this area to reduce the amount of estimation required. The first of these is work measurement. Work measurement is used a great deal, and with a high degree of success, when determining, for costing and control purposes the time taken to complete production jobs. Work measurement was also applied to office work by O&M practitioners particularly in America but with the decline of this function and the increase of systems analysis, which seems to totally disregard work measurement, its use is on the decline. Work measurement, if used correctly, could provide for information management standard times for carrying out various information processes. This would be extremely useful in costing, planning and control of information processing.

The second technique to help cut down the amount of estimation is simulation. It is possible to simulate events and make more informed predictions concerning costs. It should be borne in mind that simulation will not produce absolute accuracy the greater the accuracy required the greater the cost.

2. Identification of alternative use of the resources required and the value of such lost opportunities:-

This approach is to identify the alternative uses of the resources required to produce a piece of information and then to determine the value of the loss of such opportunities. Consider the following example. Suppose a programmer finishes a particular job a week early. This extra week has been costed out to the previous job therefore some people would say that whatever the programmer does for this extra week it has cost nothing because that cost has already been recovered. This is not true, there will be cost attached to the weeks work this being the Opportunity Cost, Lipsey defines Opportunity Cost as:-

> "The cost of using something in a particular venture is the benefit foregone (or opportunity lost) by not using it in its best alternative use." *1

To arrive at the opportunity cost of the programmer consider all the alternative activities he could have carried out in the week. The value of all the options would then need to be determined and highest of these value represent the programmer's opportunity cost. It must be remembered that opportunity cost does not only apply when there is spare time but whenever resources are being used.

There are a number of problems that might be encountered when trying to arrive at opportunity costs. The first problem will be encountered when trying to produce a list of alternatives. Such a list is likely to be very large even if limits are put onto it for example that all the resources used must be within the organisation. The list will become smaller with people or machines as they will not be as versatile as money. As well as producing this list each alternative on the list needs to be valued and ordered to determine the best. Such a process is likely to be time consuming and costly.

3. The third approach is a combination of both costing

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*1 LIPSEY. (1966 Page 248)

resources and valuation of alternatives foregone:-

The first part of this process is to list the resources required to collect, process, etc., the information required. These resources should then be costed either at full cost or marginal cost depending on the case. It must be remembered that the final cost can only be an estimate of something to happen in the future so it can only be correct within certain limits. This completes the first part of the process. The second part is to look at opportunity cost. It has already been said that to work out the true opportunity cost will be very time consuming and costly but it should be possible to obtain a reasonable estimate. If the determination of management's information needs (section 3.3.) and the valuation of management information (section 3.4.) have been carried out there will be within the organisation a list of managements information needs with their values or estimates of their values. Such a list would not include all alternative uses of the resources but would be comprehensive as far as information uses are concerned. The estimated value of the project could be compared with the list to see if there is any other piece of information with a greater value still not being provided. The difference between them being an opportunity cost which then should be added to the previous cost. If an opportunity cost is incurred on a piece of information then there should be a good reason why that piece of information is being considered instead of the one with the higher value. Such a reason may be due to the nature of the resources available. For example an analyst may be free to take on a new project. Management may feel that he would be better carrying out a project for which he is more suited but which returns less than another potential project. Management may feel that the lost opportunity is worth matching the right analyst to the right project. The analyst being capable to carry out a wide range of projects but he will be more suited to some than others.

Any particular cost will include one or more of the following components:

1. Money expenditure.
2. Other costs that can be quantified; labour etc.
3. Estimates of other non-quantifiable costs.
4. Opportunity costs.

3.5.3. DISCOUNTING AND COSTS.

Time can become important to the calculation of cost. Some of the costs of information system projects can be quite a distance into the future so there is a case for relating all costs at various points in time by discounting. The technique of discounting has already been discussed in previous sections and has been used to discount such things as returns and value so it should also be used on costs.

3.5.4. SUMMARY.

This section is not intended to be a full exposition of cost theory. Such a summary is beyond the scope of this thesis. This section aims to provide a reasonable method of providing cost estimates of management information to fit into the methodology for the economic appraisal of management information. When talking in terms of costing management information the first stage is to establish consistent and correct definitions of the cost terms invo-lved. The word cost is only a general term and can be taken to mean different things to different people so more precise terms should be used whenever possible.

The cost of information can be determined by the following process.

1. List all the resources required to produce the information.
2. Cost the resources using cost accountancy principals using either full costs or marginal costs depending upon the case. An estimate should also be made of the non-quantifiable factors.
3. Determine an opportunity cost if applicable. This will be limited to other information applications for the resources. The opportunity cost will be determined from the lists of information requirements and their values (see section 3.3. and 3.4.).
4. To arrive at a Total Cost the cost calculated

in two should be added to an opportunity cost if there is one. If an opportunity cost is incurred there should be good reason for this means there is more valuable information still not being collected.

5. If the Total Cost will be incurred over quite a long time scale then the costs should be discounted to bring them into line with returns and values used elsewhere.

The above process will arrive at a reasonably true cost estimate for management information. Before leaving the area of costing information it is worth noting that with the advent of technology change (the use of the silicon chip) automated information processing costs are falling and look set to continue falling. This fall is occuring both in actual and real terms. Such a fall in cost will affect the work of costing in that it will make opportunity costs more important. If more and more information can be produced it becomes very important to ensure that the information with the greatest value is collected, produced and used first. Opportunity cost will show whether this is being carried out.

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STERMOLE. (1974)
TURVEY. (1969)
VICKERS. (1973)

3.6. COST BENEFIT ANALYSIS OF MANAGEMENT INFORMATION.

There are two terms used within this area than can lead to confusion, these being cost benefit analysis and cost effectiveness analysis. Cost benefit analysis is where numerical values of cost are compared with numerical values of benefit. Cost effectiveness analysis is where the resources required are compared with the benefits accruing and is used when it is difficult to arrive at precise numeric values. Both cost benefit analysis and cost effectiveness analysis are more associated with large scale public utility projects especially the latter.

3.6.1. COST BENEFIT ANALYSIS.

To carry out a cost benefit analysis there are three stages:

1. Determine costs.
2. Determine benefits.
3. Selection of indicator.

1. Determine Costs:- Costing Management Information has been considered in section 3.5. Here a procedure was outlined to arrive at a cost of management information. It would seem reasonable to assume that a cost for information can be arrived at without too many difficulties.
2. Determine Benefits:- The determination of a numeric value for the benefits of the management information will not be so straight forward as that of cost. The numeric value for the benefits will be the same as the value of information and

has been discussed at length in section 3.4. In this section it was found that for some pieces of information reasonably precise estimates could be produced but for other information the estimates were inprecise and so could cause problems in cost benefit analysis.

3. Selection of Indicator:- The indicator selected will determine whether to carry out a particular project. It will depend on factors such as interest rates and will compare the cost against value and see if the return is sufficiently high to justify the project. When management information is being considered it can be sufficient for the benefits to equal the cost to justify the information.

The greatest problem with cost benefit analysis is that it can appear to take decisions automatically in some organisations it can become institutionalised.

3.6.2. COST EFFECTIVENESS ANALYSIS.

Cost effectiveness analysis is similar to cost benefit analysis and has the following three stages:

1. List resources required.
2. List benefits.
3. Compare resources and benefits.

1. List resources required:- This corresponds with the first stage in cost benefit analysis. Cost effectiveness analysis is sometimes used to compare

a series of alternatives to achieve a given benefit level. This can mean the production of a series of costs for the different alternatives.

2. List benefits:- One method of the estimation of a value of management information is to list the benefits. This solves the problem for information which is difficult to value. It is possible to draw up a list of benefits generated by most items of information.
3. Compare resources and benefits:- The last stage is to compare the resources and benefits and to decide if the information is worth producing, or choose from a series of alternative methods of producing the information.

The principal problem with cost effectiveness analysis comes in the third stage. It is difficult to compare lists of resources and benefits without using numeric values or indicators.

3.6.3. <u>SUMMARY</u>.

By taking parts of two techniques a useful method of comparing cost against value can be produced. This combined technique can be called management information cost benefit analysis. There will be three stages to such a technique:

1. Determine Cost.
2. Determine Value (if not possible list benefits).
3. Compare cost and value.

1. Determine Cost:- The cost of producing the management information will be determined by the procedures given in section 3.5. Part of this procedure will include listing the resources required to produce the information. There will be very few cases where it will not be possible to estimate the cost within the field of management information.
2. Determine Value:- The value of the information will be determined by the procedures given in section 3.4. With some information it will be possible to arrive at a reasonable value for the information. With other information the value may be less precise and with some information management may be reluctant to place a value on it at all. In the case where information does not have a very precise value or where management are reluctant to set a value on it, a list of benefits should be drawn up.
3. Compare Cost and Value:- The cost and value of the information that have been determined will be compared and provided the value is greater than or equal to the cost the information will be considered worth producing. In the cases of information with an estimate of value which is considered imprecise or where management are reluctant to place a value on it, (i.e. the information which at stage 2 had a list of benefits produced for it), the list of benefits will be

compared with the cost. Providing that management considers that the benefits will exceed the cost the information will be considered worth producing. This will be better than simply comparing two lists as the cost will be a numeric value.

This procedure for applying cost benefit analysis to management information will work for the majority of cases. There will only be a few cases where it will not be possible to determine a reasonably accurate numeric value for cost. With these cases a list of resources required will have to be compared against a list of benefits, even though this is not a very satisfactory method. It must be remembered that the procedure for management information cost benefit analysis does not automatically take the decision as to whether a piece of information should be produced. This decision must rest with the manager or managers requiring the information, therefore it must be possible to override the procedure so that managers can take account of non-quantifiable factors affecting the decision to produce the information or not.

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PREST & TURVEY. (1965)
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3.7. MANAGEMENT INFORMATION CONSULTATION.

This section of the thesis deals with the role of the information analyst as a consultant within his own organisation. To consider all the behavioral implications of such a role would probably take a volume as large as the present thesis. Therefore in this section I shall confine myself to a brief survey of the work of others that has been of value to me in dealing with managers.

The information analyst must deal with managers when producing the information needs of management. It is an easy option when producing information needs to record the information produced at present and then merely produce similar information from a computer installation. An approach such as this will not result in the determination of management's information needs, it can only be considered a computerisation of existing information. The sensible approach to the production of management information needs is for the manager to determine them. This can be achieved by careful discussion and group discussions relating information needs to the manager's function. This approach will require two extra skills on the part of the information analyst/designer. First he needs a working knowledge of the process of management and second he will need behavioral skills in dealing with managers individually and in groups.

The process of management has been discussed at length in section 2.1. These behavioral skills present a problem in that they are developed through experience but it is useful to consider the experience of others when developing these skills. Schein has been involved in the field of organisational development (the development of the structure of the organisation) for a number of years and has produced an excellent book called Process Consultation *1. This book is a practical study of consultation with managers, individuals and groups. The role of consultancy within organisational developments transfers almost completely to study the information needs with one exception. In the study of information needs a more active role is required by the information analyst than the passive role suggested in Process Consultation. The book also contains a good set of references to take the reader further. The work of people such as Warr *2 and Cherns *3 in the field of Action Research will also prove to be valuable to the information analysts in the development of their behavioral skills.

Another important area where the information analyst will find himself operating as a consultant will be that of setting subjective estimates. This will involve face to face contact with individual and groups of managers. Subjective estimates may be required for probabilities but are more likely to be encountered by the information analyst in the subjective estimate of information value and cost. The behavioral skills already discussed will be of value in such work and in addition there are other techniques that may be of use. The use of cumulative density functions (CDF), Delphi techniques and weightings

*1 SCHEIN. (1969)
*2 WARR. (1977)
*3 CHERNS. (1976)

are discussed in section 2.4.5. The Tydeman and Mitchell *1 study, Subjective Futures for Decision Making, provides a good practical discription and case studies of the use of the Delphi technique and other techniques such as cross event analysis which are transferable to the use in the subjective setting of information value and cost.

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*1 TYDEMAN & MITCHELL. (1978)

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3.8. METHODOLOGY FOR THE ECONOMIC APPRAISAL OF MANAGEMENT INFORMATION.

There are four main stages in the economic appraisal of management information. These are:-

1. Determination of management's information needs.
2. Determination of management's information value.
3. Determination of management information cost.
4. Cost benefit analysis of management information.

It is possible with some management information that stage three will be carried out before stage two.

STAGE 1. Determination of Management's Information Needs. This stage will produce a list of management's information needs which will include formal and informal information and information about the internal and the external environments. The list will be produced at two levels at least, management's present information needs and management's potential information needs.

The information the manager is receiving at present can be determined by using interviews, questionnaires, observation and record inspection. These techniques will be reasonably successful at determining the information managers receive at present. The diary techniques and communication analysis are especially useful to record the information managers use when taking unprogrammed decisions. The information the manager receives at present does not necessarily define his present information needs. Some information the manager needs may not be included and some information may be provided that the manager does not need. This list of information provided must be modified to give the information needs of management. This can be carried out only in discussion with the managers. When the information analyst opens discussion with managers questions like 'What information do you need?' should be avoided because they will usually bring unhelpful responses like 'I don't know', 'What I get now' or 'All the information you can give me'. It would be wrong of the analyst to assume from these replies that the manager does not know his information requirements, the problem lies in the question. The approach to be taken in the determination of managers' information needs is to carry this out by examining the manager's job. It will be helpful if the manager has a job specification if not one needs to be drawn up. The analyst in conjunction with the manager can then examine each part of the manager's job in detail and determine the information required to carry it out. When information needs are discussed in such detail and directly related to the managers job then the manager can successfully determine his information needs. The list of information needs produced will include both formal and informal information, also information about the internal and external environments. The analyst should be concerned, not only with the formal information about the internal and external environments but should use his expertise to help the manager develop his informal information system. It would be wrong of the analyst to try to formalise the manager's informal information. Such an approach will be doomed to failure because of the nature of the informal system, but assistance to the manager to develop his own information system would be of value.

If management functions are shared by a number of managers then the analyst should first discuss the function with each manager individually to examine his role in the function and the information needs. This may vary from manager to manager as each is likely to see his role and the function differently. The group of managers should then be brought together to decide the information needs for the function from their individual lists. Care should be taken by the analyst to ensure that managers are not embarrassed by their previous individual discussions with him. The group approach may also be of use even when dealing with individual manager's information requirements as they may introduce the manager to fresh ideas. Such fresh ideas may also come from the analyst or specialists in fields such as accounting, production control, etc.

In order to determine management's information needs the analyst will require two extra skills in addition to his information skills. First he will need a knowledge of the processes involved in management, both at a management system and a behavioral level. This will be essential if he is to communicate effectively with managers and to discuss with them in detail their jobs and the information needed to perform them. The second additional skill will be behavioral. The analyst will need to know how to act as a catalyst to get the best out of individual managers or groups of managers in terms of the determination of information needs.

The result of the analysis so far will be a list of management's present information needs. If systems to produce some of this information are to be designed they should be flexible enough to allow for the development of managers' information needs. To build in this flexibility a list of managers' potential information needs will be required. These potential information needs will be more difficult to define than the present information needs. The manager is unlikely to be aware of all his potential information needs so the analyst will have to include various specialists (accountants, management, scientists, etc.) in the discussions to arrive at these potential needs. It must be remembered that as these potential needs are concerned with the future which is by nature dynamic, they will be liable to errors.

The final result of stage one will be a list of management's present information needs and an estimate of management's potential information needs.

STAGE 2. Determination of Management Information Value. Stage two takes the list of information needs and orders them according to the importance to the manager, i.e. value to the manager. Again this can only be carried out through discussion with management. This ordered list will provide a framework within which information can then be valued. Before methods of valuation are discussed the timing of valuation must be considered. There are three points at which the information can be valued.

(i) Before the information or data has been collected or extracted from a data base, i.e. before the manager takes any decision or constructs any plans.

(ii) After the manager has considered all the available information and decided what action is to be taken.

(iii) When the actions of management have been carried out the effects of such actions on the external or internal environment or both can be studied.

The logical place to economically evaluate information will be before it has been collected or extracted from a data base for at this stage if it proves uneconomical it need not be collected. If the information is valued at the other two points then it is too late to decide it was uneconomic for it will have already been collected and evaluated. Valuation will involve two phases, these being the initiation of a valuation framework and then the continuing valuation of information. To carry out the valuation of management information three groups of valuation techniques can be used, these being:

a) Decision theory approach,

b) Accounting method,

c) Estimation heuristics.

a) Decision Theory Approach to the Valuation of Management Information:
This approach uses either Classical Statistical Decision Theory and/or Bayesian Statistics to arrive at a value. This approach can be applied at either the operational or strategic level within the organisation. However, it is best applied to the project type of decision which will include a large proportion of non-programmed decisions and some programmed decisions. It would be difficult to apply this approach to the type of information used for control, e.g. process control, stock control, financial control. When using Classical Statistical Decision Theory the valuation is carried out after the information has been gathered and the analysis produced. Although the Bayesian approach values information before it is collected the analysis involved in this approach can involve a considerable amount of work.

b) Accounting Method of Valuing Management Information:
There are two approaches within this method of valuation. First, determine the cost of not having the information and then equate the cost to value. This approach works well for control information at both the operational and strategic level but due to the amount of estimation required does not truly quantify the value of project

information. The second approach works with some project applications at both the operational and strategic level and consists in valuing the savings accrued due to using the information, i.e. the savings from the project. Both approaches value the information after it has been gathered and the analysis produced.

c) Estimation Heuristics Approach to the Valuation of Management Information:

There are three heuristics that can be used in the estimation of information value. First the heuristic of anchoring and adjustment, which involves starting from an initialisation value and then adjusting until a satisfactory value is found. Second the heuristic of representativeness, which involves determining how representative a piece of information is of a general class of information and so determining its value. Third is the heuristic of availability, in which the information is valued by bringing to mind other such similar occurrences. The best approach to use is a combination of the three heuristics, to use the cost of the information or its position within the needs framework as the initialisation value and then use representativeness and availability to adjust the value and set it into a framework of past valuations (the valuations including some carried out by one of the quantification techniques above). At the same time as valuation is carried out the framework can be updated. For these heuristics to operate successfully the information value setter/s will require two things. First a training in information value setting, which could be best provided by simulations, case studies, examples and training packages. Second will be required frameworks of information needs and information values. These will provide consistency checks for the information value setter as well as effective search sets for carrying out the two heuristics of representativeness and availability. Such frameworks could also provide an initialisation value to start the process of estimation. The methods of estimation heuristics will operate on strategic and operational information and can be carried out before or after the information has been gathered and any analysis produced.

The initiation of the process of valuation presents a few problems. Stage one produced a list of management information needs and the first part of this stage orders them in importance to the manager (i.e. value). This ordered list is the information needs framework. Although this framework contains some form of valuation each piece of information from it now needs to be valued individually. The logical time to value such information is before it has been collected or analysed so that if it proves not to be economic it need not be collected. The technique that is most effective at valuing information before it has been collected is the estimation heuristic approach, but unfortunately this technique only really works well when a valuing framework is already in existence. To initialise the valuation framework, decision analysis and the accounting approach should be used on a number of representative pieces of information from the information needs framework. The problem with valuing information in this way is that the information has to be collected before it can be valued (with the exception of some Bayesian analysis) and this stage is a little late to decide that the information is not worth collecting. This problem is unfortunate but it is the best way to initialise the valuation process. The quantified values of the information will provide the skeleton for the information value framework. This partial framework along with some form of training provided by simulations, case studies, examples and training packages will enable the estimation heuristics to be carried out successfully on the remaining information in the needs framework. This will then complete the initialisation of the information value framework, with a technique that allows the information not to be collected if it proves uneconomical. When the values are recorded it should be shown which are quantified and which are estimated values. The two frameworks, needs and values, should be checked together to ensure consistency between the needs and valuing processes. Any inconsistencies should be investigated with the aim of removing them.

Given the dynamic nature of business and the fact that managers will develop with time, the information needs will change. When new information needs are added to the list, the first valuation will be made by using estimation heuristics to decide if the information is economic. The framework will also need to be updated. This may be a total update for example to take account of inflation or it may be an update on a particular piece of information whose importance has changed. Consistency in estimation can be maintained by carrying out the quantification techniques on a sample of the information collected. The lower the accuracy of estimates the greater the sample size needs to be. Such a problem of inaccurate estimates may be overcome by improved training for the information value setter. The inaccurate estimates may of course be due to high variability within the business concerned. The use of groups may improve the estimates and the help of a group may improve the estimation abilities of individuals. Also to supplement the information value framework and to keep it up to date it may be necessary to carry out attitude surveys on existing ongoing information to ensure it is maintaining the value associated with it. This total process of valuation will work well for the majority of management information. For some information managers will not estimate a value or they may not feel confident of estimates made. With this information a list of benefits accruing from the information should be made in place of the valuation.

STAGE 3. Determination of Management Information Cost.
The next stage in the methodology is to determine the cost of the management information. In some cases this stage may be carried out before stage two, the valuation. This will be when the cost is required at the initialisation stage of the estimation heuristic. The cost of the information can be determined in the following way.

a) List all the resources required to produce the information.
b) Cost the resources using cost accountancy principles using either full costs or marginal costs depending upon the case. Which of the two costing methods is used will depend on whether the cost of any of the resources used has already been set against some other information or function of the organisation. Estimates may need to be made at this point to take account of non-quantifiable factors.
c) Determine an opportunity cost if applicable. This will be limited to other information applications for the resources. The opportunity cost will be determined from the lists of information requirements and their values. This cost will be a surplus in value of an alternative piece of information not already produced that could be produced with the resources being considered i.e. the more attractive opportunity foregone.
d) To arrive at a Total Cost the cost calculated in

b) should be added to an opportunity cost if there is one. If an opportunity cost is incurred then there should be a good reason, for this means there is more valuable information still not being collected.

e) If the Total Cost will be incurred over quite a long time scale then the costs should be discounted to bring them into line with returns and values used elsewhere.

The cost of information can be used to produce a separate list or better still the costs can be added to the information value framework making it an information value and cost framework. Before leaving cost of information it is worth noting that because of technological change (especially the silicon chip) automated information processing costs are falling and look set to continue falling. This fall is occurring in both actual and real terms. Such a fall in costs will affect the work of costing in that it will make opportunity costs more important. If more and more information becomes economic to be produced it becomes very important to ensure that the information with the greatest value is collected, produced and used first. Opportunity cost will show whether this is being carried out.

<u>STAGE 4.</u> Cost Benefit Analysis of Management Information. There will be three parts to the cost benefit analysis of management information although two of these parts will

have been carried out within stages two and three. The three parts are:

a) Determine the cost. The cost of the management information will have already been determined within stage three.

b) Determine the value. A numeric value for the value of the majority of management information will have been produced in stage two. In the case where information does not have a very precise value or where management are reluctant to set a value on it, a list of benefits will have been produced during stage two.

c) Compare cost and value. The previously determined cost and value will be compared and provided the value is greater than or equal to the cost then information will be considered worth producing. In the cases of information with an estimate of value which is considered imprecise or where management are reluctant to place a value on it, (i.e. the information which at stage two had a list of benefits produced for it), the list of benefits will be considered in relation to the cost. Providing that management considers that the benefits will exceed the cost the information will be considered worth producing.

It must be remembered that the procedure for management information cost-benefit analysis does not automatically take the decision as to whether a piece of information should be produced. This decision must rest with the manager or managers requiring the information, and therefore it must be possible to override the procedure so that managers can take account of non-quantifiable factors affecting the decision to produce the information or not.

Whichever method of setting a value for information is used one or more of the following six factors needs to be taken into account.

1) Time:- the speed at which the information can be obtained and is required.
2) Knowledge:- the knowledge level of the recipient/s of the information.
3) Prior Information:- the amount and type of other information that is available to assist with the decision the piece of information is to be used for.
4) Accuracy:- the accuracy of the information (this may be subjective dependant on personality).
5) Quantity:- the size of the piece of information or the amount of information available for a particular decision.
6) Power:- information can be closely linked to power and as a reulst this may enhance the value of the information to the individual but not necessarily to the organisation.

Along with these six factors the information analyst and manager should be aware of the following pitfalls which should be avoided.

1. Information systems are not solely concerned with computers.
2. There is a significant difference between data and information.
3. More data in reports does not mean more information for managers.
4. Where possible all information should be cost-justified which requires a value and cost to be attributed to it.
5. Any increase in the speed at which information is provided needs to be justified.
6. Absolute accuracy is not essential in every case (it is impossible when the base data itself is not accurate). However, the degree of inaccuracy in any information should be given along with that information.
7. More frequent reporting does mean more information. Again any increase in the frequency of reporting must be justified.
8. The total integration into one corporate data base should not be the aim of system designers. Integration and the formation of data bases should be used only when they will be of advantage. This will usually mean only partial integration, at varying levels within the organisation and a series of data bases.
9. The information needs of managers are very difficult to determine by interviewing due to the fact that the majority of managers do not appear to know their information requirements. It is really dangerous for

systems designers to decide managers' information needs themselves as few have experience of management. However, with a combination of various techniques and a reasonable approach a realistic estimate can be made to determine the information needs of the manager.

10. The provision of 'correct' information is not necessarily going to produce good management. The manager's managerial skills and abilties may need to be developed so he can take full advantage of the information provided. It is however arguable that information should not be provided until the manager has been trained to use it.

11. The provision of communication mechanisms does not by itself mean that communications within an organisation will improve. The behavioral problems will also have to be dealt with.

12. The managers who are receiving information from an information system should have sufficient knowledge of the system to be in control. The information system should be run to serve the organisation and not vice-versa. This statement assumes a high level of competance on the part of individual managers and in many organisations considerable staff development would be necessary to achieve this.

CHAPTER 4. EMPIRICAL STUDIES.

This chapter is concerned with the empirical studies carried out as part of the research project. The studies are of three types. The first is a detailed look at the overall management information system of one company. (4.1. A Company Information Study). The second type of study was carried out by observing the way in which management students, all of whom were practising managers, solved certain problems presented as tasks and case studies (4.2. Personnel Information Study, 4.3. Marketing Information Study and 4.4. Small Business Information Study). The third type of study isolates certain applications within the area of management information in case study form. (4.5. Concord Insulators Ltd. and 4.6. Robert Livesey and Sons Ltd. The bulk of the detailed work of the studies has been included in the six appendices.

Detailed Contents of Chapter 4.

4.1. A COMPANY INFORMATION STUDY.

This piece of empirical work was carried out to examine the information system of a particular company. The manner in which the management of the company determined their information needs and then set about producing systems for the collection and analysis of such information was also studied.

4.1.1. TYPE OF STUDY.

The company which prefer not to be named employs one hundred and nineteen people with a turnover of £2·5 million in 1980/81. The principal market of the company is the provision of interconnection harnesses for the electronic industry. The company was founded in 1969, has grown to its present size rapidly in the last few years and is now partly owned by a larger holding company.

The study involved the examination of the procedure manuals and information flows existing in the company. Discussions were undertaken with the management team of the company and the monthly management meetings and other meetings were attended to observe management in operation.

Extracts from the procedure manuals are given in Appendix A. The first group of extracts are from the production procedures manual. The index of the production procedure manual is given to show the full range of the manual and a sample of procedures in the index are given in full (these being Production Control and Materials Control). Extracts from the sales procedure manual are also given. Again the index is given to show the full range of the manual and a sample of procedures are given (these being Processing of Orders, Receiving and Accepting Orders, Generation Distribution of Quotations, and Follow-up of Quotations). Also given in the Appendix is the flow chart for a Management Control System and examples of the forms used within this system.

4.1.2. RESULTS FROM STUDY.

The results from the study will be given for each function within the organisation. This does not mean that each function operates independently, far from it with this organisation, it is merely a convenient way of presenting the information.

The first function to be considered will be production. When the company first started, being small it did not require many formal systems to control and manage the production of goods. The majority of the information concerning work in progress, stocks, etc., was informal either being carried in someone's head or in someone's personal information system. When the company started to grow the systems remained mostly informal and consequently management control of production started to decline. The lack of control increased to the stage where jobs were completed as and when parts became available. This meant that some jobs were being completed a long time before they were required while other jobs were not being completed on time because they were awaiting parts. To further aggravate this situation there was no formal system to chase the missing parts or when common parts arrived to ensure they first went to the job that most urgently required them. The only parts chasing that was undertaken took the form of a fire fighting exercise when customers complained that their job had not been delivered on time. As a consequence of this the company acquired a very poor delivery reputation with customers, they either delivered too late or too early, rarely on time.

Some three years ago senior management in the company recognised the problem and decided to do something about it. The people then employed in production management had been able to run the small business but were having difficulty in running the larger enterprise so it was decided to bring in somebody from outside. Senior management then set about the task of finding a production manager, somebody who would be able to introduce systems into the production area to make the area controllable and manageable again. The person appointed to the job of production manager had a wide variety of production experience, his most recent post being Works Manager with quite a large company. He moved because he felt the new appointment would give him greater freedom of operation.

The Index of the Production Procedure Manual (given on pages A.1. and A.4.) shows the number of detailed procedures introduced by the Production Manager by the end of

1980. There will be more new procedures to come and refinements made to the existing procedures but the ones so far introduced were considered by the Production Manager to be the most important. This is an interesting point and shows the value placed on the procedures by the Production Manager, the order in the index giving the importance placed on the introduction of each of the procedures. It must be remembered though that this idea of value covers much more than just the information coming out of the procedures, it will also cover management aspects, etc.

A sample of the detailed procedures as written into the Production Procedure Manual has been included in Appendix A. The production control system has been included along with the purchasing procedure, purchase requisition and goods receiving procedure parts of the material control system. If these procedures are examined the detail involved can be easily seen. This is especially shown in the purchase requisition procedure 4.4.1. on page A.14 of Appendix A. Here the exact detail of how to fill out a Purchase Requisition is given and the discipline of carrying out exactly what the procedure requires is reinforced. The systems produced by the Production Manager are good, providing much improved management control and management information. On examining the procedures in operations it is clear that a high level of systems discipline is operated in the production area, the procedures operated in practice being the same as those written in theory.

The data bases which provide management with information from the production area are contained on the shop loading sheet (Page A.23), material shortage list (Page A.30), weekly production schedule (Page A.31), and the jobs kitted list (Page A.32). Useful information can be provided by the production Q.C. traveller (Page A.24), which moves around the factory with the job. The material shortage list has been steadily reducing in size as the other planning systems have become more effective but when the production manager took over he considered this to be the most important document in the production system. As the new systems have brought the production area under control the production manager considers this document as fallen in value but still has its uses. From the other documents it is possible for example to find the whereabouts of any job, any free time on production facilities, to supply to the sales office delivery dates. The new system enables acceptable delivery dates to be quoted and achieved, however it is taking time to live down the reputation built up in the past for poor delivery dates. Problems were encountered when the production control clerk was absent from work. A temporary clerk had to be trained to carry out this function, consequently some operating problems developed. Partly to try to avoid such problems and partly to extend the analytical capacity and management information output of the system it was decided to computerise the system. The computer chosen was a microcomputer which was to operate in the production office. The plan was to computerise the system in the same format as existed before computerisation and major problems were not envisaged because the systems discipline necessary to operate the system was already in existance. The major change to the system was the extension of the analysis and management information output from the computer. This was previously carried out manually by examining the relevant sheets. When the computerised system was being tested major problems did develop in the file organisation parts of the programs. The problem initially was thought to lie in the software and considerable time was spent trying to remove this problem. The problem was finally found to be incorrect floppy discs (secondary storage devices) for the disc drives. The computer manufacturer had supplied single density discs for a double density disc drive unit. When this problem had been remedied it was possible to get the programs operational although the access times of the system proved to be excessive. The company has now decided to purchase a larger minicomputer system to deal with all the company's data processing requirements. Initially the accounts system will be put onto this machine but at some later date it is hoped to transfer the production control system onto this new machine and so improve access times.

The production department also had problems with some of the information sent from the sales department. To inform production that an order had been given the sales department would fill in a production instruction, this form giving the go-ahead for production to proceed with the job. For some jobs the product specification was not completed correctly on these forms and this lead to problems. Fortunately most of the errors were identified in production before the jobs had been started.

Having considered the production area the sales area will now be examined. Similar problems to the ones that had occurred in the production area also occurred in the sales area. As the company grew the person appointed to the position of sales manager had grown to that position with the company. He was a good product engineer and a competant salesman, unfortunately he was not very successful as a sales manager. The lack of sales was hidden to a degree by the early inefficiencies in the production area (the failure to meet delivery dates contributing to this lack of sales). With the appointment of the new production manager the production area became more efficient removing the back-log of orders and so making the lack of sales more apparent. Some two and a half to three years ago senior management in the company decided to introduce monthly management meetings to improve communications within the company. The sales manager's performance in these meetings was poor and he did not inspire any confidence in the other managers, a feeling fairly widespread throughout the company. To try and give the sales manager some support and to assist in his development it was decided to employ a marketing manager to operate in conjunction with the sales manager. The marketing manager would have no direct line responsibility over the salesmen but would provide sales support and initiate an export effort. This plan of senior management was not a success, the new marketing manager proving to be no more effective than the sales manager. The marketing manager has now left the company.

About a year ago senior management decided that some more positive action was needed to improve sales. They decided on a similar action to the one taken in the production area. The sales manager was made the product manager of a new product that was being launched and the managing director took over the role of sales manager in the short term until a suitable replacement could be found.

In the interim period the Managing Director tightened up the existing systems in an attempt to eliminate some of the problems in the sales area. These actions included the introduction of a sales inquiry system (see page A.51) to ensure that full advantage would be taken of all enquiries and an order checking procedure (see page A.54) which intended to remove errors on instructions sent to the production area. These innovations solved most of the problems associated with the formal system and it is interesting to note that there was an imporvement in the system discipline throughout the sales area. Some of this improvement however may have been due to the presence of the Managing Director in the sales area.

To improve communications within the sales area (informal information system) the Managing Director introduced monthly sales meetings between the personnel involved in the sales area, ie. sales office supervisor, salesmen and sales estimators. These meetings did improve communications within the sales area. Along with these monthly sales meetings another series of sales meetings was organised. This second set of sales meetings was part of the salesmen development programme, the purpose of these being twofold. First the development of the salesman's product knowledge (especially with new products) and second so that the less experienced salesmen could benefit from the experience of the better salesmen within the company. This second set of meetings were not held on a regular basis but arranged as and when they were thought necessary. Initially there was high frequency of these meetings their frequency then falling.

Prior to the time when the Managing Director took over directly the sales area the approach to forecasting was not very successful. The sales forecast produced for the budgets proved to be very optimistic (thus causing problems in profitability of the company). The short term forecasting was also poor, nobody knowing when orders would arrive. In this company because of the nature of the product quotes are given for all business. As it takes time for quotes to mature into sales and the salesmen are involved in this process it should be possible to arrive at a system of short term forecasting (up to three months) that should prove reasonably accurate. As a first step to improve the short term forecasts the Managing Director introduced a prospects list. This list was of orders on quote and associated with these potential orders was the probability of the order maturing in the next month. So as not to over complicate this initial system only the quartile points were used i.e. 0, 0·25, 0·5, 0·75 and 1·0. This system proved reasonably successful once the initial problems of training the salesmen to operate the systems had been overcome.

This interim period during which the Managing Director took direct control over the sales area lasted approximately six months. During this period a suitable replacement for the Sales Manager was found and recruited to the company. Care was taken during the search for the replacement to ensure that the successful applicant should be able to design successful procedures as well as effectively control and operate the sales area. Upon taking up the position of Sales Manager the new applicant took some time to get to grips with the company, the products, the personnel and the systems in operation. His previous position had been Sales Manager with a manufacturer of components for textile machinery. When he had become familiar with the company he decided initially not to radically change any of the systems with the exception of forecasting. He quickly identified the 20% of customers that accounted for 80% of the business, these he called prime customers who were to have priority and were to be visited regularly. He made some changes to improve communications between the sales force and he instituted some additional checks to ensure the correct information was appearing on quotes and being sent to production.

The short term forecasting system was changed to a three month rolling forecast. This forecast will be updated each month, the old month dropped off and a new month added on. The forecast will contain all prospects of orders likely to mature within the three month period. The order will be placed by the salesmen in the month that it is most likely to mature in. The salesman will also estimate the probability (now using all points of the scale) of the order maturing in that month. The short term forecasts are then obtained by multiplying probabilities by order value and summing for the separate months and so obtaining an Expected Value for sales each month. Also by comparing successive forecasts it will be possible to trace the strength of the prospect, it will be increasing if successive probabilities increase decreasing if the reverse is true. Such a system of short term forecasting should prove to be accurate, the new sales managers estimates ± 5% once the salesmen have gained experience and confidence in setting the probabilities which he estimates will take approximately a year from starting the system. Such a short term forecasting system with this level of accuracy will be of great value to the production department for planning future capacity etc. The new sales manager considers that in the present economic climate forecasting over longer periods is likely to be difficult but it must be carried out. The past sales figures cannot be used to predict the future for two major reasons; first the electronics industry is in such a state of flux that any past sales figures are not necessarily going to relate to what is going to happen in the future; secondly the sales figures of the company do not represent the true potential of the company because of the previous problems encountered in the sales and production areas. The long term forecasts are going to be produced (that is until the above reasons are no longer significant) by sales staff and other personnel within the company estimating the sales potential of the prime customers which will involve the use of many informal information sources. The new sales manager from his showing so far seems to be a success and more than capable of solving the problems that existed in the sales areas.

The last area to be considered is accounts. The accounts area also suffered some personnel changes but for different reasons than the other areas. The accountant who had been with the company from early on felt for personal reasons that he had to resign. This accountant had wide experience of business and was capable of extending accounting into management and fortunately he decided not to leave the company completely but remained in a consultant capacity. The accounts manager appointed in his place was young with little experience but with high technical abilities in the accounts field. He has no problem in ensuring what might be termed the book keeping aspects of accounts (invoicing, ledger keeping, etc.) are carried out correctly. He does however still have more to learn about the management aspects of accounts (the interpretations of the figures, designing systems that can be used by managers etc). The accounts department produces two levels of reports to managers within the company, these being monthly and quarterly. The monthly reports contain profit and loss account gross nett margins, materials costs, labour costs, overhead costs, sales figures, outstanding orders, debtors and creditors outstanding and labour establishment. The figures are given for the current month and cumulative for the year. The report tends to lose impact because it is circulated two weeks after the monthly management meeting and by the time of the next management meeting any points raised by the reports tend to be superceeded by other events. It has been planned that the accounts manager should discuss with the managers any variances between actual overheads and budgeted overheads. This has tended not to happen and before it is likely to be successful the accounts manager will need to develop his behavioral skills in dealing with the other managers. The quarterly accounts report consists of a summary balance sheet. This report would be improved with the addition of some management accounting ratios to aid in its interpretations.

Besides the reports sent to managers in the company the accounts department sends a series of reports to the holding company, these being a weekly, a monthly and quarterly report. The weekly report contains a return of sales checked against budget and the cash flow. The monthly report contains a copy of the company's monthly accounts report, profit forecast and capital expenditure forecast (the latter two being the month's figures and cumulative for the year). This report also contains four graphs, these being: profit/sales ratio, profit per employee ratio, sales per employee and the added value (the company operates an added value bonus scheme). The quarterly report contains a copy of the company's quarterly accounts report along with a graph of profit to capital employed. Although much of the information sent to the holding company is circulated to management the graphs are not. It is difficult to see why these graphs are not circulated to the whole management as they would be useful and the amount of extra effort to circulate them would be minimal.

The new management control system has been included in the accounts area because it was designed by the old company accountant now acting as a consultant to the company. The need for the system arose out of a problem that occurred with quite a large order the company quoted and won. When the order came into production some discrepancies were discovered in the quote. It was found that it took twice as long to make the order as had been allowed in the estimate for the quote, but fortunately an error that almost cancelled out this one was made in pricing the material. This meant that the company did end by making a small profit on this order but the consequences of making a loss on such a large order prompted the investigation of the estimation system. The problem was not only due to errors made by the estimator but with some of the information given to him to produce the quote. The investigation was then widened to produce the management control system shown in flowchart form in Appendix A (Page A.50). This flowchart does not use standard flowcharting symbols but does illustrate the system successfully. The system was designed very well and with great care. The people in the company who were to be affected by the system were consulted from an early stage in the design process. When the system had been designed it was verified to ensure that it was performing exactly as the designer intended and it was validated by testing the system in situ to ensure it could cope with the real situation and that all people dealing with the system could operate and understand all the outputs from the system. The management control/system is an excellent system that shows the way in which systems which are to operate in the management area should be designed.

CONCLUSION FROM STUDY.

The first conclusion that can be drawn from the study is that some of the managers employed by the company are capable of designing, implementing and controlling excellent formal systems and procedures, the outputs from such systems procedures producing good management information. This information may be for the manager's own use of for use by other managers. It cannot be said that all managers within the company are capable of designing systems in such detail and quality as the ones discussed in this study. Clearly this is not the case otherwise people from outside the company would not have to be brought in (people were brought in to solve management problems poor information being incidental to poor management). The design and implementation of the management control system showed that all the managers and personnel involved with the system could cope with this development. They showed that even if they were not able to carry out the work themselves they were able to work with others to carry out the work of development and design of efficient procedures.

The study also showed that small firms that grow may need to take in new managers with wider experience to expand the experience-base of the organisation. A lack of good procedures in such an organisation can be a sign that some managers are not coping with the growth of the organisation. It must be remembered that some managers can grow with the organisation and find the change from the less formal to the more formal organisation possible. Because this study is a sample of one it makes it dangerous to apply the conclusions to managers in general.

4.2. PERSONNEL INFORMATION STUDY.

This piece of empirical work was carried out to examine personnel management information needs and the way in which personnel management determine such needs.

4.2.1. TYPE OF STUDY.

In the study, groups of people working in personnel management considered the information needs of personnel management. The people involved in the study were all students from the Department of Management Studies of the North Staffordshire Polytechnic. They were studying part-time for professional examinations to gain membership of the Institute of Personnel Management. The entry requirements for the course were that students must have a degree or equivalent and be employed in personnel management. The students jobs' ranged from junior personnel assistants through to personnel managers.

The study was carried out on the course residential period in March 1980 with one set of students and in March 1981 for another set of students. The students were split into groups of approximately six, three groups each year and were given approximately six hours to carry out the tasks required. They were required to produce the information needs of the typical personnel department. Also they were asked to consider the value and cost of this information but because the study was general in nature they were asked to consider these as benefits and resources required. Part of the function of the personnel department is the provision of information for other departments and therefore this will show in the information needs.

The groups were given the problem with minimal input so as not to affect the way in which they would tackle the problems. They were then split off into syndicate rooms to determine the information needs and asked to produce a written and verbal presentation at the end of the time period. The written presentations are given in full in Appendix B.

4.2.2. METHODS EMPLOYED BY GROUPS.

In order to minimise the influence from external sources a limited briefing was given. The 1980 students soon decided that the only way to arrive at the information needs of personnel management was to examine the function of personnel management. Group C of this set of students unfortunately developed considerable internal group conflict. This conflict led to considerable argument within the group which eventually caused the fragmentation of this group, into two. Conflict such as encountered within this group would be unlikely to be found within an organisation. I would not suggest that organisations are free from conflict, far from it, but in organisations there will be a power hierarchy. This will tend to ensure decisions and conclusions are reached by groups although some individual members of the groups may be dissatisfied with the decision and conclusions. On the whole the groups from the first set of students were successful in the determination of information needs, the source of the information and the benefits. Most of the groups though had difficulty attributing numeric values to the information, but this was expected due to the general nature of the study.

The 1981 students operated in much the same way as the first set with the exception of group C. This group had a great deal of difficulty in finding an appropriate method to tackle the problem. When it became known that the group was in difficulty it was suggested to the group that an approach to the problem might be to first examine the function of personnel management and then to arrive at the information needed to carry out this function. The group then tried to apply this approach but they still found difficulty because of the generality of the problem. It was then suggested to the group that they become more specific and fit the need around a particular company. The group then invented a company employing 5,000 people, and then had no difficulty in producing the personnel information needs the sources and the benefits. Unfortunately because of the time lost initially the final report produced by this group was a little disjointed. This should not be allowed to detract from the contents of this report for despite the two false starts the group produced some good results.

From the reports and observations of the groups of both sets of students I considered that the methods employed by the groups produced reasonable estimates of personnel management information needs, sources and benefits.

4.2.3. SUMMARY OF RESULTS FROM GROUPS.

The reports produced by each of the six groups are given in full in Appendix B. The summary of results will be given for each group in turn.

Group A. 1980.

If any of the reports can be singled out as being better than the rest then this is the one. This may be due in part to the fact that this group contained the most senior personnel executive involved in the study. (Personnel Director of local company), but is probably more due to this individual's personality and ability. They divided their report into four areas for which information would be required.

1. Industrial Relations.
2. Education, Training and Development.
3. Working Conditions.
4. Manpower Planning.

Each part has been extended to form a list of information required to carry out each function. Also given for the information is its source. The cost of producing the information is given but in general terms being in most cases a list of resources required. The value of the information has also been considered and has been given in most cases as a list of benefits accruing from the information. There is one value given that is of particular interest being a numeric value. This value is given in part II section C, Legislation (Page B.4) and it concerns the information giving legislation related to industrial relations, the source of which has been given as Croner's Law Reports costing £25 per annum. Also given under the heading of cost is 'up to £16,000 for unfair dismissal claim'. This is a cost of not having the information therefore it can be included in the value of this information.

Group B 1980.

This group broke their information needs into seven categories although they reduced this number later in the report.

1) Personnel.
2) Information in.
3) Information out.
4) Training.
5) Company information.
6) Informal information.
7) Safety.

The group produced a comprehensive list of management information needs and uses that can be made of such information. They did not add to this list the cost or the resources needed to collect the information. They did produce, however, an interesting pie chart. This pie chart is shown on page B.20. and gives the relative costs in man hours per forty hour week of information requirements. It is an interesting way to show how time is spent producing and dealing with information. Such a chart can only be accurate for the people who produce it and will vary considerably from organisation to organisation.

Group C. 1980.

This was the group in which considerable internal conflict developed and the group eventually split into two after sub-dividing the work, which resulted in a report that was disjointed. The report was divided into five sections.

1) Management Planning.
2) Industrial Training.
3) Conditions of Employment.
4) Recruitment and Selection.
5) Unions.

The group produced a detailed list of information needs and the uses and benefits of such information. They did not take the analysis on to consider the cost and resources to produce the information. This was due to the time lost in the initial stages of the analysis because of the internal conflict within the group.

Group A 1981.

This group split the information needs into the following categories.

1) Employment and Recruitments.
2) Training and Development.
3) Industrial Relations.
4) Salary Policy and Administration.
5) Employee Services - Welfare, etc.
6) Organisation and Manpower Planning.

The group produced a list of information needs and considered the information uses to a degree but did not produce any costs or resources required to produce the information.

Group B 1981.

Group B split the information by considering the people with whom the personnel department communicates and using these as groups of people to give the broad information categories. The four categories used were:-

a) The individual employee.

b) The Government/Legislators.

c) The Environment including competitors and the 'market'.

d) The individual operating units of the company.

This report although brief produces a reasonable list of information needs including the cost and benefits. The approach taken by this group is an interesting one in that it is slightly different from the other group although communications can be considered part of the function of the personnel department.

Group C 1981.

This is the group that had difficulty finding an approach to determine the information needs. It settled for an approach relating information needs to the functions of the personnel department of its own hypothetical firm. In looking at the report from this group it is hard to see why the group found it difficult to work in general terms and required a specific firm. The report gives the information requirements in very general terms the only specific parts being the staffing levels of the personnel department. This group split the information requirements into the following categories:-

a) Recruitment and Selection.
b) Training and Development.
c) Manpower Planning and Job Evaluation.
d) Absence Control and Welfare.
e) Industrial Relations.
f) Health and Safety.
g) Salaries, Wages, Pensions and Superannuation.

Despite the false starts this group produced an excellent set of information needs with the sources and benefits of the information. Cost or resources have not been included in general terms but the staffing levels of personnel department have been included. These cannot be considered to be wholly the cost of information for the people employed in these jobs will carry out the normal functions of the personnel department as well as providing the information.

4.2.4. CONCLUSIONS FROM THE STUDY.

There are a number of conclusions that can be drawn from this study. The groups of students within the study appeared to be able to produce their information needs with reasonable success. Most of them started by relating to the function of personnel management and then determining the information needed to carry them out. The group that did not start with this approach found difficulty when trying to relate information needs in abstractions but with a little guidance found the approach of first determining the function of personnel management and then determining the information needed to carry this out to work reasonably well. Most of the groups found it easy to produce benefits and resources required to produce the information as these came out from the approach used. Most groups found it difficult to relate to the value of the information although some of this difficulty was probably due to the general way the problem was set.

Having seen the conclusions that can be drawn from the group of students studied how can these conclusions be related to personnel management in general? This will depend on how representative the sample of students is of the total population of personnel management. It cannot be considered to be a completely representative sample in that all the people in the sample had taken the decision to extend their knowledge of personnel management and all the people had the qualifications to enable them to register on the course. But this may not be as unrepresentative as it may seem at first sight. Although the entrance qualifications are high (degree or equivalent) this can now be considered the normal qualification of most managers. This is due to the increased number of graduates entering management and the increase in the professionally based courses. The Institute of Personnel Management for example now operates a foundation course to give students without the entrance qualifications a route onto the graduate membership course. The bias due to the fact that all the members of the sample have taken a conscious decision to extend their knowledge in personnel management is a problem that would be difficult to avoid. It would be difficult to persuade personnel managers to take part in such a study unless it was part of a structured programme from which they would be likely to benefit.

In spite of the biases in the sample it should nevertheless be possible to reach some tentative conclusions which are applicable to personnel managers in general. It can be said that groups of personnel managers will require little assistance in determining their information needs. The only assistance required is that of ensuring that the most effective method of determining information needs is used. The information needs being produced will be the present information needs. The group of personnel managers will also not require much assistance when listing the benefits from the information and resources required to produce it. They are likely to have problems attributing numerical values to benefits and costs. They will probably need to be given training in information value setting and an information value framework should be provided to assist in this. Help with costing the resources could be provided from the accounts department. The potential information needs can then be determined by bringing in outside specialists or using specialists within the organisation. The production of a standard list of information needs for personnel management would not be a good step to take as the personnel management information needs are likely to vary from organisation to organisation, the differences being due to factors such as size, industry and managers' knowledge levels.

The study was concerned with groups of personnel managers and wherever possible groups should be formed to determine information needs. It should be remembered that other managers in the organisation will be involved with the function of the personnel department and so should be involved in the group. This will enable a group to be constructed even when there is only one or a small number of people in the personnel department.

4.3. MARKETING INFORMATION STUDY.

This piece of empirical work was carried out to examine how management tackle specific information-related problems. The information-related problems were presented in the form of a case study.

4.3.1. TYPE OF STUDY.

This study is based on a specially devised case study of Plas-Tex Ltd. The case study is concerned with information-related problems in the marketing area but the people involved in the study were from all areas of management. The people involved in the study were students on the second year of the Diploma in Management Studies from the Department of Management Studies, North Staffordshire Polytechnic. The Diploma in Management Studies (D.M.S.) is a national, post graduate, post experienced general management course. Due to the general nature of the D.M.S. the range of students taking part in the study varied from junior to senior management with the majority being middle management. The following are examples of the job functions of the students taking part in the study: Managing Director, Sales Manager, Production Unit Manager, Management Services Manager. The case study was presented to the students as part of the course residential study period and they were given sixteen programmed hours over a two day period to complete the tasks set in the case study. The students were split into seven groups of approximately six members.

The students were given a minimal briefing and were presented with a copy of the case study each. The case document contained the background information to Plas-Tex Ltd. and the tasks involved in case study. The groups were then sent to syndicate rooms to solve the problems and tasks in the case study. From this point on the groups were allowed to ask any question on the Plas-Tex situation or to seek advice from members of departmental staff present on the residential including marketing specialists. A range of Plas-Tex type products were on display to help the students to relate to the case study. The students were asked to produce a twenty minute verbal presentation and a written report containing the detail. The case study documents and the seven written reports have been produced in Appendix C.

4.3.2. THE CASE STUDY.

The case study is not based on one particular actual company but all the problems built into the case have been taken from a series of actual companies and built into the fictional company Plas-Tex Ltd.

Plas-Tex Ltd. is a company in the plastic moulding industry that specialises in the production of plastic yarn package supports for the textile industry. The Marketing Department of Plas-Tex Ltd. was subject to mounting criticism from other senior managers which eventually resulted in the resignation of the Marketing Manager. It has been 'felt' by other managers that the company had been missing sales opportunities due to a poorly managed and co-ordinated sales force and a misdirected sales effort. The company had also lost money and goodwill due to inaccuracies in the completion of order forms.

The groups were asked to adopt the role of a newly appointed marketing manager. They were asked to design a marketing information system for Plas-Tex considering both formal and informal information. It was suggested that to carry out the following would need to be considered:

- the information needs of the situation.
- the costs of obtaining such information.
- the benefits accruing from the information.

They were asked to produce detailed plans on how the information should be collected, who should collect the information, procedures required to collect and process the information, reports that need to be produced, and the timing and circulation of such reports, etc.

Within the case study the students were given background information to the company and the company's products. The formal information and documentation systems already existing in the company are given in detail in the case study. Also given in the case are the details of the interface between the marketing department and other departments within Plas-Tex. The case study is given in full in Appendix C.

4.3.3. METHODS EMPLOYED BY GROUPS.

All the groups appeared to work well and effectively together and no major confrontations appeared to take place within the groups. All the groups started by discussing, in general terms amongst the members of the group, the problems confronting the new marketing manager. They soon realised that before information needs could be produced the function of the marketing department had to be defined and then the information needs to carry out this function can be determined. After considering the problems and tasks in general terms each group decided to sub-divide. Each sub-group was responsible for a selection of tasks, the final report being produced by the group as a whole.

All the groups in this study behaved in a more organised way than the groups in the Personnel Information Study. Whether this was due to the fact that this case gave plenty of detail to work with or the fact that the students in this study had greater and more varied management experience is hard to say, but both factors probably contributed.

4.3.4. SUMMARY OF RESULTS FROM GROUPS.

The reports produced by each of the seven groups are given in full in Appendix C. The summary of results will be given for each group in turn.

GROUP A.

From the report this group appears to have got a good grasp of the situation. They realised that the order system works for the majority of orders so they decided that the best approach would be to close the loopholes in the existing system rather than to change everything. They stressed the importance of the informal system (especially in a marketing situation) and that the dynamic nature of business makes it essential for systems to be flexible. The nature of the report shows that the approach adopted by this group was first to examine the function of the marketing department and then to determine the information required to carry it out.

Group A also made some good detailed changes and introductions to the marketing information system. They introduced a Customer Visit Report which become an important link document within the new system. It would provide good market intelligence and given the way the group have designed the form it would provide validation checks on other aspects of the system. The group provided a number of cross checks and validation checks to ensure that the other systems operate correctly. The Order/Advice Note on page C.44. suggested by the group may create problems in that the group has tried to get too much onto one form so making it rather overcrowded. They have introduced a product code system and designed an improved sales analysis (the sales analysis in the present system at Plas-Tex being very poor). The group considered the original system for paying expenses to be lax and in consequence have suggested a tightening up of the system and a redesigned form. They made the suggestion that the new form could be used throughout the company, but I do not think this to be the case. The final part of the report deals briefly with the informal system of the marketing department, stressing the need to train salesmen to obtain market intelligence and the need for regular meetings of salesmen to ensure the information gathered is passed on.

GROUP B.

Group B split the problem into four parts.

1) Redesigning the formal system to avoid errors.
2) Improvement of sales analysis.
3) Lack of Market Information.
4) Lack of co-ordination of supervision.

The group thought that it would be important to rationalise the products. Superficially it appears there are three standard products (parallel tube, $4^{o}\ 20'$ cone, $9^{o}\ 15'$ cone) but when one takes all the combinations of size, colour and surface finish the number of standard products is greatly increased. The group produced a very good technical solution to this problem using an alternative colour coding method (page C.70). This approach was to produce uncoloured cones and then silk screen print the colour on the top of the cone, the only part visible when the cone is full of yarn. Such an approach will enable rationalisation of production runs, stock holding, etc. This group designed a questionnaire to be filled in by the salesmen when visiting customers. The questionnaire is quite well designed and will provide marketing management with some important information.

The group noticed the likelihood of declining markets in the traditional products and they proposed work to investigate the markets to either confirm or disprove this management feeling. If it did prove to be a declining market they suggested the investigation of other markets in the plastic injection moulding business. Although the group realised the importance of the informal information system, there is little evidence in the report of how the informal information is to be gathered. Even though this information is informal there still needs to be planning on how the information is to be gathered.

The group put forward some good ideas for the redesigning of the formal system. They stressed the importance of discussions with other departments and that the ideas being put forward are only proposals. They also realised that the bad name of the marketing department would make such discussion difficult in the short term and they saw their proposals as operating in the medium term when the name of the department had been improved. They proposed a good multipart form although it might prove to be a little overcrowded and the system to operate the forms also seems reasonable. The principal criticsm of the redesigning of the formal system is the lack of effective short term plans to stop the errors occurring in the existing system.

GROUP C.

Group C considered the following changes or additions to the existing system which they split into formal and informal. At the formal level they proposed the introduction of a sales visit report and designed a form to be completed at the end of each sales visit. This form was quite a comprehensive and reasonable form. They proposed to plan the sales areas, to give an area for each salesman and to plan the salesmen's calls. They also decided to tighten up the expense procedure and introduce additional checks in this area. Finally at the formal level they considered the sales analysis and sales data base to be inadequate therefore they proposed changes to both the analysis and data base. At the informal level the following would be considered, market surveys, technical journals, etc., contact with customers both by marketing manager and salesmen, trade associations and contact with managers in other areas of the organisation.

The problem of the possibly declining market was considered and the search for new products and their attendant information needs examined. Page C.76 contains their plan for market surveys which proposed splitting them into two parts. Part 1 would look back through past records to produce a useful sales analysis and part II would examine the market. They produced good proposed improvements to the formal system including a good set of multi-part forms. The improved card index (C.84) and stock record card (C.85) would provide good data bases to be used to produced a useful sales analysis.

GROUP D.

This group produced the most disappointing of the reports.

They identified the problem areas and produced some solutions to deal with these but they failed to extend these into a coherent plan for the future. They identified five problem areas.

1. Double Ordering:- to solve this problem they would add orders onto the card index and this would provide a check each time an order was placed that it was not a duplicate order.
2. Errors in Transposition of Information:- to cut down errors in this area they suggest that salesman quotes be verbal only and that the sales clerk send an order acknowledgement as a cross check.
3. Need to improve interdepartmental co-ordination:- part of the solution to this problem will be to hold interdepartmental management meetings.,
4. Misdirection of sales force:- to solve this problem there would be tighter control of the sales force with a greater emphasis on market information.
5. Absence of data base in marketing department:- to solve this problem they decided to create customer files, expand the card index, improve the sales analysis system and develop departmental trend analysis, etc.

This group had the ideas of what to do to solve the problems but lacked a detailed plan of how to carry out the ideas in practice. The group listed some sources of informal marketing information but again the detail tends to be missing.

GROUP E.

Group E produced the most effectively written report containing both good ideas and the detail of how to put the ideas into practice. The need for better market information was identified. This information would be required before decisions could be taken on reorganisation. The report then outlines the proposed marketing strategy which led to some of the marketing information requirements. The benefits of the information and the expected costs were also considered.

In order to solve the problems and to eliminate the errors in the existing system they would need to redesign the order flow system. The report contained detailed operations manuals dealing with the various parts of the new system. The manuals and the systems contained in them are well designed although some of the forms used might prove to be a little overcrowded in use. The group produced a good flowchart of the proposed system (C.108) and though this flow chart does not conform to normal flowchart practice it still graphically illustrates the relationship between the different parts of the new system.

The report also gives a series of external information sources, the other major market information source being the sales analysis. The sales analysis, which includes a sales activity analysis to be completed by the salesman, has been well thought out and should provide considerable and varied information to marketing management. The report also considers informal marketing information both in broad terms and the details of collection.

The report ends by listing its aims which would be achieved by improving both marketing management and the information system and are as follows.

1) Clear corporate strategy.
2) Full sales analysis.
3) A better customer service.
4) Identification of future or potential markets.
5) Planned consistent production.
6) Fully involved workforce, fully conversant with the aims of the company.

GROUP F.

Group F started their report by asking a series of questions about the products and markets. They then went on to examine the sources that were available to provide answers to the questions along with the way in which the information was collected.

This group considered the problem of reporting marketing information to the rest of the management team. They considered that there should be three types of report, monthly, quarterly and annually. The monthly report would be a comparison of orders received for each product line against forecast demand. This report would also include any specific customer's comments regarding product quality, special variants requested, etc, that have not already been circulated. The quarterly report would contain an updated forecast for the coming twelve months. This is an interesting forecasting method and provided it is linked with a reasonable forecasting model it should be a good system. The annual report would give the market potential for the coming five years and would include new product possibilities as well as existing lines. Circulation of the three reports would be to the whole management team of Plas-Tex Ltd. Group F made it clear that even though these reports would be in existance this would not prevent the immediate communication of complaints, comments, opportunities, etc. to other members of the management team as they arise.

The report of this group then goes on to give detailed procedure files for the formal system of quotations, order form, despatch/advice note, invoice, product and rep.codes, customer record files, accounts, monthly reports and customer visit form. The two principal purposes of these files are to tighten up the existing systems so as to remove the possibility of errors and to extend them in order to provide better information. There are some additional procedures for example the Customer Visit Form, which is well designed giving plenty of space for comments probably the most important part of the form.

GROUP G.

This was not a particularly good report and unfortunately the few good ideas it contained were obscured by poor organisation. Like all the other groups they redesigned the existing formal systems to eliminate errors with a fair degree of success. To get around the problem of initial shortage of clear information this group decided to take the last two years' sales invoices and to analyse these to obtain such information as sales per product per month/year and also to identify the larger customers. At the same time as this analysis was carried out the new customer card index which would be updated so that only live customers would be kept in the file. The remaining customers from the card index would be visited by salesmen to see if any could be revived.

The group decided to introduce a Failed Quotation Report (C.141) which would be filled in by a salesman if an order did not follow a quote. If the salesman could be pursuaded to fill these forms correctly then it should be possible to gain some very useful information on pricing and competitors. They decided to change the order form (C.142), providing a form on which there would be a box for every standard product. This is a good idea in principal but would fail in this example due to the variety of products so making the boxes too small to be of use. The group also produced an improved sales analysis procedure and proposed the introduction of a production analysis. To control the salesmen the group decided to introduce the

Salesman's Weekly Report. This form would also give a regular weekly communication between salesmen and the marketing manager.

The group failed to grasp the importance of informal information to the marketing department.

4.3.5. CONCLUSION FROM THE STUDY.

In common with a lot of case studies Plas-Tex Ltd. does not have one correct solution but in any solution of the case some mention of the following would be expected.

The principal difficulty of the case is the lack of hard information; there are plenty of feelings about the situation but this is all. Because of this the first function of any information system should be the provision of some market information as soon as possible to allow management to form a marketing strategy. It should also be taken into account that before any changes to the formal systems are made they should be fully discussed with all interested parties.

In any proposed solution to the Plas-Tex Ltd. case it must be recognised that the formal systems for ordering, quotation and invoicing adequately handles the majority of transactions. It would be foolish of any new marketing manager to try to change everything in the department, and it would be better in the short term to plug the gaps in the existing system. The errors in the existing system could be eliminated by ensuring a good degree of systems discipline and the use of some verification checks. In the medium term once the marketing manager has got the department working well then these formal systems could be revised and updated.

Part of the existing system that will need to be completely revised is the sales analysis. This needs to be extended to show the differences in sales between all the product types and the quantity as well as value needs to be shown. This type of analysis can be inputed into a forecasting system for both the short and long run, the forecasting being carried out in terms of the quantity sold and not value. The way the analysis is reported to the rest of management should also be considered probably monthly for sales and quarterly for updated forecasts. To overcome the problem of lack of marketing information and to give some values to initialise the forecasting systems the invoices for the past year or two could be analysed.

Some form of customer file also needs to be introduced. This could be an extended card index or possibly due to the lack of space on the cards it may need to be extended into a lateral file or the problem may be solved with a computer system. Greater control over the sales force will be required which could be provided by visits reports, weekly or monthly meetings and an improved expense form. Some type of follow-up of quotations that have not produced orders could provide some very useful market information.

Within the Plas-Tex Ltd. marketing information system there appears to be a complete lack of informal information. It is likely that the old marketing manager will have taken his informal system with him when he left, however, all the salesmen will have some form of informal information system in operation. The informal information system for the marketing manager should include contacts with salesmen, customers and other managers. Also included in the formal system will be journals, trade associations, etc.

We can now turn to see how the groups performed and the conclusions that can be drawn from their work. Some of the groups realised that there was little hard market information and only feelings and so planned to obtain market information before taking any decision. Some groups thought the feelings a sufficient basis on which to start to take some of the decisions concerning marketing strategy. When putting forward changes to systems that would effect other departments some groups stated that discussions would be needed before they would be implemented but some groups ommitted to mention this.

All groups realised the changes that needed to be made and the extra information that would be needed. All groups with one exception produced good sets of detailed plans for the obtaining of such information. The system manuals produced are generally good and in some cases very good. Most of the groups redesigned some of the forms but some fell into the trap of trying to fit too much onto one form and so having spaces too small for the figures. This is a fault managers would soon learn to correct when the complaints start to arrive from the people filling in the form.

Not surprisingly all the groups felt that sales analysis to be inadequate and produced plans for a more detailed analysis. Some of the groups linked the analysis to forecasting systems. They also introduced various visit forms to control the activities of the sales force and provided a communication link between it and the marketing manager. Most of the groups correctly considered that informal information is very important in the marketing area and all groups except one outlined the type of informal needs, most including the detail of how to collect it. Some groups listed the benefits that would be expected from the information and the resources required to produce it but on the whole this was poorly carried out.

The way in which these conclusions can be related to management in general will now be considered. This will depend partly on how representative the group of students is of management in general. This sample suffers the same shortcomings as the sample used in the personnel management study, these being the facts that all the students had taken a conscious decision to extend their knowledge of management and that all the students had the necessary qualifications to gain entrance to the D.M.S. The fact that these entrance qualifications are becoming the norm for management tends to reduce the bias from this source.

It would be difficult to pursuade managers to take part in such a study unless they would be able to extend their knowledge as a result, and therefore it would be difficult to remove this source of bias.

Some conclusions from the study can be extended to management in general but the biases in the sample should be remembered. Like the personnel management study this one shows that managers are capable of determining their information needs. The difference in this study is that the managers were from all functions within the organisations and yet they proved capable of determining information needs for the marketing function. This shows how useful groups of managers can be when determining information needs. They do not all have to be from the same function in fact it can be better if they are not. This study also shows that managers are capable of designing the detail of systems although they did have a few problems for example with form designed. The problems with the detail would probably be removed if an information analyst joined the group. The majority of managers realised the importance of discussions of all interested parties when changes are made to existing systems or new systems designed. This is not surprising as an important part of a manager's job is discussion and dealing with other people inside or outside the organisation. Like the personnel management study this study showed that even with a detailed example managers find it difficult without special training to determine information value and cost.

4.4. SMALL BUSINESS INFORMATION STUDY.

This piece of empirical work was carried out to examine the information needs at the initial stages of setting up a small business and the way in which these needs are determined.

4.4.1. TYPE OF STUDY.

The study is based on an exercise set to students as part of their residential period of study. The students were taking the Diploma in Management Studies (D.M.S.) at the Department of Management Studies, North Staffordshire Polytechnic. The D.M.S. is a national, post graduate, post experience general management course. Due to the general nature of the D.M.S. the range of students taking part in the study varied from junior to senior management with the majority being middle management and from all parts of the organisation. The following are examples of the job functions of students taking part in the study: Managing Director, Sales Manager, Production Unit Manager, Work Study Manager. The exercise was set some two months before the residential was due to take place, to give the students time to gather background information. The students were then given the majority of the residential week to organise a written and verbal presentation, the written report to be handed in by the Wednesday night, the presentation to be given on the Friday morning. The following was given to the students as part of the briefing for the project.

GROUP PROJECT.

1. The project will occupy the first three days of the residential period together with a plenary session in the final morning.

2. For the purpose of the project the participants will be arranged in groups of five or six. The structure of the groups will be announced early in the Spring Term.

3. Each group will be required to produce a written report relating to the formation of a new enterprise. That report will be submitted no later than the evening of the third day of the residential period and will contain all the data in section 7 together with any supporting commentary.

4. The reports will be presented to a panel in the plenary session on Friday morning. The panel will comprise members of staff.

5. The terms of reference, to the groups, require:-

   5.1. The outline of a policy for the formulation of a new business enterprise.

   5.2. A precis of the planned development of the enterprise for the first three years of operation.

   5.3. An outline of the policy for the expansion and development of the enterprise beyond the first three years of operation.

6. The choice of business is left to the discretion of the groups.

7. The report will, however, cover the following points:-

   7.1. Detailed description of the product(s) or service(s).

   7.2. The nature and size of market.

   7.3. An outline of marketing policy.

   7.4. A consideration of the sales organisation relative to the market.

   7.5. A consideration of the means of distribution of the product to the market.

   7.6. The location of the enterprise.

   7.7. The type of premises required and the availability of these in the area of location.

   7.8. The requirements in terms of plant.

   7.9. The layout of the plant and allied services, within the premises.

   7.10. The members and grades of personnel required.

   7.11. The capital requirements for the enterprise and the provision of these.

   7.12. The cost structure of and the profitability of the enterprise.

The above terms of reference were given to the students who were split into four groups some two months before the residential. The students were encouraged to seek any advice they require from members of the management depart - ment staff or from specialists outside. A wide range of staff members were also available at the residential centre along with representatives from the Small Firms Service, West Midlands Region and one of the larger banks.

4.4.2. METHODS EMPLOYED BY GROUPS.

All the members of each group worked well together and in fact worked well past the time allotted and into free time during the residential. They worked hard before the residential, bringing a considerable amount of background information for their project with them. All the groups chose their proposed business in an area with which at least one member of the group was familiar. The information needs were determined by the groups by first examining the business and then determining the information required to make out a case for the success of such a business. It is interesting that one of the groups brought to the residential an Apple Micro-Computer with a financial planning package to carry out all the cash flow calculations.

4.4.3. SUMMARY OF RESULTS FROM GROUPS.

The reports produced by each of the four groups have been given in Appendix D. The detailed cash flows, detailed layout drawings, etc. produced by the groups have not been included due to the amount of space that would have been taken by them. The summary of results will be given for each group in turn.

GROUP A. (COLUMN SERVICES LTD.)

This group reported details of the case for setting up a company (Column Services Ltd.) to package and repackage columns for use in high performance liquid chromatography (H.P.L.C.). The principal information required concerned the area of the available markets, the size of the total potential market for columns being determined from the total number of sets of H.P.L.C. equipment sold and then multiplying by the number of columns required per year to operate the equipment. The sale of sets of equipment is a high growth market so it is reasonable to assume that the sale and repacking of columns will also be a high growth market. The market for columns at present is being met by the manufacturers of H.P.L.C. equipment and a series of smaller service companies. The smaller service companies are all experiencing considerable growth therefore this group considered not unreasonably that there would be an opening for the formation of another small service company in this market. It is interesting to note that a considerable amount of the groups information came from informal sources because of the close proximity of some of the members of the group to the market. This case probably had the best chance of success out of the four possible businesses because of such factors as the nature of the market concerned and the competitors in this market, the relatively small amount of capital required to finance the start of business (capital not provided by outside institutions), and the close involvement of members of the group. The chief problem which is likely to be encountered by this group is the fact that the major suppliers of raw materials are all outside the U.K. thus making the proposed business vunerable to changes in exchange rates and fluctuations in supply. The detailed financial calculations produced by this group were sound but have not been included in Appendix D due to space constraints.

When the group had calculated their price for columns they carried out a telephone survey of potential customers to try and gauge whether the business could be successfully launched. This survey confirmed the high probability of a successful launch of the business and in some cases the potential customers were willing to place firm orders for columns there and then. It is likely that this small business will be launched in the near future.

GROUP B. (Brew-Ware).

This group sets out the case for setting up a pottery business in the Stoke-on-Trent area although since it would employ 56 people it is debatable whether it can be still classed as a small business. This group produced very clear precise strategies for each of the areas of operation. This is a very good indication as to the success of the business as it shows clearly that the members of the group know precisely where the business is going. The biggest problem with this case for a proposed business is the amount of capital required to set up a manufacturing operation of this size.

The members of staff appraising the various projects considered that this group produced a very well researched case for the establishment of Brew-Ware. The report contains on page D.12. a list of information and its sources used in preparing the case and is worth reproducing again in this section.

"PRODUCT INFORMATION.

a) Raw Materials and Kilns - local suppliers.

b) Buildings - Newspaper advertising.

c) Production costing - local company information.

d) Product Technical Specification - Company Information.

e) Product rates - local company information.

MARKETING INFORMATION.

a) Previous market demand - confidential documents from existing ceramic manufacturers.

b) Future market demand - confidential documents from existing ceramic manufacturers.

c) Market outlets - own research and information from existing manufacturers.

d) Product price - own research and confidential information from existing manufacturers.

FINANCIAL INFORMATION.

a) Own research and information deduced from manufacturing and marketing information." *1

The majority of this group were involved in the pottery industry. It is interesting when looking at the information used to prepare the case for the business and its sources to note the amount of which comes from the individuals' own experience and knowledge required to carry out their normal job functions. The list of information requirements produced by this group would provide a useful

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*1 APPENDIX D. (Page D.12).

check list of information requirements to anybody setting up a small manufacturing business. The group produced a detailed financial analysis which unfortunately contained a few mistakes (none of which would seriously affect the viability of the business) but due to space constraints this has not been included in Appendix D. The group also produced a mathematical model to help with sales forecasting, a detailed factory layout and job description for all its proposed employees but again due to the space constraint these have not been included.

GROUP C. (Newcastle Tyre and Exhaust).

This group set out the case for setting up a garage specialising in the replacement of tyres, exhausts systems and batteries. This case is different from the ones so far put forward in that none of the members of the group were involved in the area of the business in their normal occupations or interests. However, to get around this problem of lack of direct market knowledge themselves they consulted a friend involved in running a tyre and exhaust system outlet. Such co-operation may not have been so freely given had the prime object of the group been to set up such a business and not just the completion of an academic project.

The members of staff assessing the viability of the project considered the case put forward for this business to be well structurered and researched. However, some members of staff were a little dubious about some of the latter sales forecasts but even this reservation would not seriously affect the viability of the project. Like group B this group produced clear objectives and strategies. It is interesting that this group opted for a service business considering that there was not sufficient monetary return to be made in a manufacturing business at present. The group researched the market well producing and obtaining considerable market information. The profits produced from the project would be quite considerable and even if the latter sales estimates were considered to be optimistic and were revised the project would still return a reasonable profit. Due to space constraints the detailed financial calculations, cash flows, etc, have not been included in Appendix D.

GROUP D. (LEISURE CENTRE LTD.)

This group presented the case for setting up a leisure centre initially providing facilities for squash but later expanding to provide other leisure activities. Although none of group were employed in the leisure industry some of the group members had experience and involvement with the running of a similar enterprise as part of their leisure activities. This group put in a considerable amount of work collecting and analysing information to enable them to determine potential markets. In this particular case the search for premises is an important marketing consideration for the actual position of the leisure centre determines the potential market. During the discussion and the information collection process the group discovered informally that two other leisure organisations were looking in the same area for premises. This increases the group's confidence that the area in which they had chosen to consider the setting up of a leisure centre was a good one.

One drawback to the proposed business is that compared with the other projects it does not return very large profits although the profits returned do make it a viable proposition. The group produced a reasonably sound financial analysis. One small mistake was discovered but this did not seriously affect the viability of the project. Due to the space constraint the detailed financial analysis, cash flows, etc, have not been included in Appendix D. Also due to space consideration the detailed plans of the leisure centre and some impressive artists impressions of how the proposed leisure centre will look have not been included in Appendix D.

4.4.4. CONCLUSIONS FROM STUDY.

The work produced by these groups shows how important it is to have a good knowledge of the market when putting forward a case to start a small business. This will include information , publicity available although not necessarily free, e.g. government statistical reports, reports from market research organisation, own market research, etc, and market information that is only available because of ones' occupation which can come from the organisation's formal system or the individual's informal system. The first two groups show how important the latter type of information can be. Both the cases produced by these groups rely for a great part of their market information on information obtained by members of the group because of their direct involvement in the market concerned due to the nature of their employment. The other two groups did not have any group members directly involved in the market because of their occupation. Group C obtained a feel for the market from a friend who was directly involved. This provided the group with valuable information not directly available to the general public. Group D did not have any members involved in the market through their occupations but they did have some members who had experience in running facilities as part of their leisure activities.

How representative can the cases put forward be of the normal small business enterprise? The projects put forward by the groups may be considered by some just to be an academic exercise, but I do not believe this to be the case. Several of the small businesses put forward in the past have been started with a high degree of success, all of which are still in operation. There is also a high probability that the first of the projects put forward here will be started and should stand a very good chance of success. It could be said that such detailed analysis as produced by these groups would not be produced by the average small business. But if a small business required any external finance then such an analysis would be required before any finance would be granted. If the business was to be financed by the person/s starting the business I would again think it very foolish not to produce such a detailed analysis. The large failure rate of small businessess may in part be due to the failure to produce such a detailed analysis which if carried out would have shown them not to be a viable proposition.

To consider how representative such cases are one must examine the types of small businesses that are likely to be started.

The following list which is not meant to be exhaustive presents the most likely reasons for the setting up of small businesses. In some cases more than one may apply.

1) A manager or group of managers seeing an opportunity arising in the market they are directly concerned with or a closely associated market.
2) A person or group of people who have developed a new product and wish to market it.
3) A person or persons wishing to sell a skill that they possess.
4) A person or persons wishing to invest some money in a small business.

The different reasons for starting a business are likely to affect the probability of the business being a success. Some of the variations of success are likely to be attributed to the information available on the likely market and the detail of the analysis made as to the profitability, cash flows, etc. The cases put forward in this study can be considered to be representative of type one which because of their nature are likely to have better market information than the others and be better able to produce a financial analysis of the situation. The success rate of the businesses started as a result of this exercise is higher than would be expected which may in part be due to the better market information and the better prepared case.

Any person considering the starting of a small business would be advised to produce a report similar to the ones produced by groups in this study. Such a report should consider the likely markets open to the new business as well as a detailed financial analysis. Such a report may well eliminate a business before it starts due to lack of markets, profitability, etc, but this is better than starting the business and failing later. The production of such a report will not guarantee success for a small business but if such a report shows the business to be viable then this is likely to be the case. The check-list given to the students before the start of the study will be of use to the small business man in the production of such a report.

4.5. CONCORD INSULATORS LTD.

Concord Insulators Ltd. is a case study constructed around a decision analysis problem. It is based on a real situation concerning the hiring or buying of vehicles for a transport fleet. In the case study this has been changed to the hiring or buying of production machinery. The full case study being given in Appendix E. There are two main points that the case study has been produced to illustrate.

First the case study shows a method of producing a value of the piece of information itself. In valuing the information it is best to consider the whole of the information and knowledge that goes into the production of the best decision. If there was no information or knowledge available then the only option open to management would be to take random decisions at each decision point (each decision path having an equal probability of being chosen). The expected return from such random decision taking is £33,895·75. The expected return from the best decision using the tree is £38,656. The value of information is therefore the difference between the two.

VALUE OF INFORMATION = 38656 - 33895·75
(All information and
Knowledge) = £4760·25

In addition the range of values can be determined. If the best decision was chosen at random then the value of the information would be £0, the lower limit. The upper value of the information is given by the difference of the two extremes of returns i.e. £7,871.

VALUE OF INFORMATION = £4760·25

within the range £0 to £7871.

This value should be considered in the context of the basic concepts in the economic appraisal of management information (see section 3.2.). This is discussed at length in the case study (pages E13 to E17).

The second point the case study has been produced to illustrate is the size to which a decision analysis can grow. The majority of examples used in texts and papers on decision analysis are greatly oversimplified. This produces trees that are small and so not realistic in terms of practical examples. Concord Insulators is an attempt to produce a decision problem of realistic size. The size of the tree is shown in the appendix with a main decision tree and two sub-trees. In order to obtain a value of the information a random tree is also required thus further increasing the amount of work involved.

Further information on the case study can be found in Appendix E where the case is produced in full.

4.6. ROBERT LIVESEY AND SONS LTD.

Robert Livesey and Sons Ltd., is a case study concerned with the implementation of a cost control system. It is based on a real situation and only the company name has been changed. The manuals, memos, forms, etc., have been reproduced from the originals. The full case study is given in Appendix F.

This case study concerns the implementation of a cost control system and is typical of the situation that can arise when a specialist system (cost control, production control, forecasting, etc.) is implemented. There are two basic problems that can occur either together or separately. These are the lack of understanding by managers of the information produced and the lack of credibility of the information to the managers that do understand. In the case outlined in Robert Livesey and Sons Ltd., both problems occurred. Such problems can be greatly reduced and possibly eliminated by correct implementation and ensuring the following two rules are followed.

1) The system should be verified and validated. The first stage the verification checks the mechanics of the system ensuring that it behaves in the manner that the system designer requires. This stage is usually carried out reasonably well but the next stage is sometimes omitted. The second stage, validation, checks how the system under test relates to other systems and the environment.

Data is put into the system and the resulting information is checked for consistency. The second stage can delay the time when managers receive information for the first time but it greatly increases the chance it will be correct information. It is difficult and takes a long time for a system to live down a reputation for producing bad information.

2) Knowledge should be provided before information. To provide information and then at a later stage try to provide the knowledge to understand it can create many problems and build barriers to understanding. Worse still is the case where the manager is given specialist information and expected to understand it. It saves problems and significantly reduces the chance of mental barriers being produced if the knowledge is provided before the information. Care should be taken to avoid specialist jargon and abbreviations as these are not easily understood by the layman.

Further information on the case study can be found in Appendix F where the case is produced in full.

CHAPTER 5. CONCLUSIONS.

The aim of the study was to produce a methodology for an economic appraisal of management information. It is not claimed that the methodology will work for every piece of information but it is considered it will work for the greatest majority. The first part of the thesis, Chapter 3 covers the analytical background to the construction of such a methodology.

The methodology can be divided into four main sections these being:-

1) Determination of management's information needs.
2) Determination of management information value.
3) Determination of management information cost.
4) Cost benefit analysis of management information.

It is possible that in some cases stage three will be carried out before stage two.

STAGE 1. Determination of Management's Information Needs. This first stage is to produce a list of management's information needs. This list will be produced at two levels at least, management's present information needs and management's potential information needs, and will include both formal and informal information.

The information the manager is receiving at present can be determined by using interviews, questionnaires, observations and record inspection. These techniques will be reasonably successful in identifying the information managers receive at present. The diary technique and communication analysis are expecially useful to record the information managers use when taking unprogrammed decisions. It must be remembered though that the information the manager receives at present does not represent the manager's present information needs. The manager may not 'need' (or be able to use) some of the information he receives and may not be getting some information he considers he may need. To extend this list into management's present information needs discussions must be undertaken with the manager or managers concerned. When the information analyst opens discussion with managers questions like 'what information do you need?' should be avoided because they will usually bring unhelpful response like 'I don't know', 'What I get now' or 'all the information you can give me'. It would be wrong of the analyst to assume from these replies that the manager does not know his information requirements, the problem lies in the question. The approach must be first to determine in detail the managers job and then to examine the information needed to carry out each part of the job. Such detail seems to help the manager to successfully determine his information requirements. The first four of the empirical studies showed that managers were capable of producing reasonable lists of present information needs. The lists will not be the perfect information to carry out the job they will be the information that the manager can understand and use at present. It is interesting to note that the Marketing Information Study (Section 4.3.) showed that managers were capable of giving inputs to groups examining information needs outside their normal area of operations. If information systems are to be designed that are flexible enough to be capable of extensions as managers develop then the manager's potential information needs require to be estimated. It should be remembered that as this list of potential information needs is concerned with the future which is uncertain, such information needs can only be estimated. These needs can be estimated by specialists inside and/or outside the organisation. The analyst should avoid the temptation to produce systems that go directly to the potential information needs. This is what happened in the case study Richard Livesey and Sons Ltd. (Section 4.6. and Appendix F.). Here managers were presented with information they were unable to either understand or use. It would be better to present managers with simpler information and gradually increase its complexity as the managers' understanding grows. Knowledge should be provided before information. To provide information and then at a later stage try to provide the knowledge to understand it can create many problems and build barriers to understanding. Worse still is the case where the manager is given specialist information and expected to understand it.

The Richard Livesey Case and part of the Company Information Study (Section 4.1. and Appendix A) emphasise the need when designing systems to verify and validate such a system. The first stage the verification checks the mechanics of the system ensuring that it behaves in the manner that the system designer requires. This stage is usually carried out reasonably well but the next stage is sometimes omitted. The second stage, validation, checks how the system under test relates to other systems and the environment. Data is put into the system and the resulting information is checked for consistency and management understanding. The second stage can delay the time when managers receive information for the first time, but it greatly increases the probability that it will be correct and usable information. It is difficult and takes a long time for a system to live down a reputation for producing bad information or information that is difficult to understand.

The list of information needs produced at this stage will include both formal and informal information, also information about the internal and external environments. The analyst should be concerned not only with the formal information about the internal and external envirionments but should use his expertise to help the manager develop his informal information system. It would be wrong of the analyst to try to formalise the manager's informal information. Such an approach will be doomed to failure because of the nature of the informal system, but assistance to the manager to develop his own information system would be of value.

If management functions are shared by a number of managers then the information analyst will himself be dealing with groups of managers to determine the information needs of the shared function. The group approach may also be of use even when dealing with individual manager's information requirements as they may introduce the manager to fresh ideas. This point was amplified in the Marketing Information Study where managers from various functions within the organisation successfully identified marketing information needs. Fresh ideas may also come from the analyst or specialists in fields such as accounting, production control, etc.

In order to determine management's information needs the analyst will require two extra skills in addition to his information skills. First he will need a knowledge of the processes involved in management, both at a management system and a behavioral level. This will be essential if he is to communicate effectively with managers and to discuss with them in detail their job and the information needed to perform them. The second additional skill will be behavioral. The analyst will need to know how to act as a catalyst to get the best out of individual managers or groups of managers in terms of the determination of information needs.

The result of the analysis so far will be a list of management's present information needs. If systems to produce some of this information are to be designed they should be flexible enough to allow for the development of managers' information needs. To build in this flexibility a list of managers' potential information needs will be required. It must be remembered that as these potential needs are concerned with the future they will be subject to error.

STAGE 2. Determination of Management Information Value. Stage two of the methodology takes the information produced in stage one and values it. The methods of valuation have been dealt with in detail elsewhere in the thesis and so only the general approach will be considered here. The empirical studies carried out showed that on the whole managers are not very successfull at valuing information. They could order the information needs in value terms but had problems in setting numerical values to the information.

Stage one produced a list of management information needs and the first part of this stage orders them in importance to the manager (i.e. value), this ordered list being called the information needs framework. Although this framework contains some form of valuation each piece of information from it now needs to be valued individually. The logical time to value such information is before it has been collected or analysed so that if it proves not to be economic it need not be collected. The technique that is most effective at valuing information before it has been collected is the estimation heuristic approach, but unfortunately this technique only really works well when a valuing framework is already in existence. To initialise the valuation framework, decision analysis and the accounting approach should be used on a number of representative pieces of information from the information needs framework. The problem with valuing information in this way is that the information has to be collected before it can be valued (with the exception of some Bayesian analysis) and this stage is a little late to decide that the information is not worth collecting. Nevertheless this method remains the best way to initialise the valuation process. The quantified values of the information will provide the skeleton for the information value framework. This partial framework along with some form of training provided by simulations, case studies, examples and training packages will enable the estimation heuristics to be carried out successfully on the remaining information in the needs framework. (The provision of training packages will be the direction followed for the extension of this research, such packages will probably be based on programmed learning and using micro-computers as the teaching vehicle). This will then complete the initialisation of the information value framework, with a technique that allows the information not to be collected if it proves uneconomical. When the values are recorded it should be shown which are quantified and which are estimated values. The two frameworks, needs and values, should be checked together to ensure consistency between the needs and valuing processes. Any inconsistencies should be investigated with the aim of removing them.

Given the dynamic nature of business and the fact that managers will develop with time, the information needs will change. When new information needs are added to the list, the first valuation will be made by using estimation heuristics to decide if the information is economic. The framework may also need to be updated. This may be a total update for example to take account of inflation or it may be an update on a particular piece of information whose importance has changed. Consistency in estimation can be maintained by carrying out the quantification techniques on a sample of the information collected. The lower the accuracy of estimates the greater the sample size needs to be. Such a problem of inaccurate estimates may be overcome by improved training for the information value setter. The inaccurate estimates may of course be due to high variability within the business concerned.

The use of groups may improve the estimates and the help of a group may improve the estimation abilities of individuals. Also to supplement the information value framework and to keep it up to date it may be necessary to carry out attitude surveys on existing ongoing information to ensure it is maintaining the value associated with it. This total process of valuation will work well for the majority of management information.

For some information, managers will not estimate a value or they may not feel confident of estimates made. In such cases a list of benefits accruing from the information should be made in place of the valuation.

STAGE 3. Determination of Management Information Cost. The next stage in the methodology is to determine the cost of the management information. In some cases this stage may be carried out before stage two, the valuation. This will be when the cost is required at the initialisation stage of the estimation heuristics. The detail of costing management information has been dealt with elsewhere and so only the general approach will be considered here. The cost of the information can be determined in the following way.

a) List all the resources required to produce the information.
b) Cost the resources using cost accountancy principles using either full costs or marginal costs depending on the case.
c) Determine 'an opportunity cost' if applicable. This cost will be a surplus in value of an alternative piece of information not already produced that could be produced with the resources being considered i.e. that more attractive opportunity foregone.
d) To arrive at a Total Cost the cost calculated in b) should be added to an opportunity cost if there is one.
e) If the Total Cost will be incurred over quite a long time scale then the costs should be discounted to bring them into line with returns and values used elsewhere.

The cost of information can be used to produce a separate list or better still the costs can be added to the information value framework making it an information value and cost framework. Before leaving cost of information it is worth noting that because of technological change (especially the silicon chip) automated information processing costs are falling and look set to continue falling. This fall is occuring in both actual and real terms. Such a fall in costs will affect the work of costing in that it will make opportunity costs more important. If more and more information becomes economic to produce it becomes very important to ensure that the information with the greatest value is collected, produced and used first. Opportunity cost will show whether this is being carried out.

STAGE 4. Cost Benefit Analysis of Management Information. There will be three parts to the cost benefit analysis of management information although two of these parts will have been carried out within stages two and three. The parts are:

a) Determine the cost. The cost of the management information will have already been determined within stage three.

b) Determine the value. A numeric value for the value of the majority of management information will have been produced in stage two. In the case where information does not have a very precise value or where management are reluctant to set a value on it, a list of benefits will have been produced during stage two.

c) Compare cost and value. The previously determined cost and value will be compared and provided the value is greater than or equal to the cost then information will be considered worth producing. In the cases of information with an estimate of value which is considered imprecise or where management are reluctant to place a value on it, (i.e. the information which at stage two had a list of benefits produced for it), the list of benefits will be considered in relation to the cost. Provided that management considers the benefits will exceed the cost the information will be considered worth producing.

It must be remembered that the procedure for management information cost-benefit analysis does not automatically take the decision as to whether a piece of information should be produced. This decision must rest with the manager or managers requiring the information, and therefore it must be possible to override the procedure so that managers can take account of non-quantifiable factors affecting the decision to produce the information or not.

Whichever method of setting a value for information is used one or more of the following six factors needs to be taken into account.

1) TIME:- the speed at which the information can be obtained and is required.
2) KNOWLEDGE:- the knowledge level of the recipient/s of the information.
3) PRIOR INFORMATION:- the amount and type of other

information that is available to assist with the decision the piece of information is to be used for.

4) ACCURACY:- the accuracy of the information (this may be subjective dependent on personality).

5) QUANTITY:- the size of the piece of information or the amount of information available for a particular decision.

6) POWER:- information can be closely linked to power and as a result this may enhance the value of the information to the individual but not necessarily to the organisation.

Along with these six factors the information analyst and manager should be aware of the following pitfalls which should be avoided. The empirical studies carried out emphasise the need to avoid some of these pitfalls.

1. Information systems are not solely concerned with computers.
2. There is a significant difference between data and information.
3. More data in reports does not mean more information for managers.
4. Where possible all information should be cost-justified which requires a value and cost to be attributed to it.
5. Any increase in the speed at which information is provided needs to be justified.

6. Absolute accuracy is not essential in every case (it is impossible when the base data itself is not accurate). However, the degree of inaccuracy in any information should be given along with that information.
7. More frequent reporting does mean more information. Again any increase in the frequency of reporting must be justified.
8. The total integration into one corporate data base should not be the aim of system designers. Integration and the formation of data bases should be used only when they will be of advantage. This will usually mean only partial integration, at varying levels within the organisation and a series of data bases.
9. The information needs of managers are very difficult to determine by interviewing due to the fact that the majority of managers do not appear to know their information requirements. It is really dangerous for systems designers to decide managers' information needs themselves as few have experience of management. However, with a combination of various techniques and a reasonable approach a realistic estimate can be made to determine the information needs of the manager.
10. The provision of 'correct' information is not necessarily going to produce good management. The manager's managerial skills and abilities may need to be developed so he can take full advantage of

the information provided. It is however arguable that information should not be provided until the manager has been trained to use it.

11. The provision of communication mechanisms does not by itself mean that communications within an organisation will improve. The behavioral problems will also have to be dealt with.
12. The managers who are receiving information from an information system should have sufficient knowledge of the system to be in control. The information system should be run to serve the organisation and not vice-versa. This statement assumes a high level of competence on the part of individual managers and in many organisations considerable staff development would be necessary to achieve this.

I would not presume to suggest that the methodology given in this study will solve all the problems associated with the economic appraisal of management information. However, I do believe that most of the major problems in such an appraisal have been considered and solutions put forward. This work should be considered a beginning since there is still work to be carried out in certain areas. For example the author intends to extend the research into the area of the production of training packages based on programmed learning and taking advantage of micro-computer technology to develop the skills of management in the estimation of information value.

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