Between "Extinction by Instinct" And "Paralysis by Analysis"- A Case Study on Indian Oil Industry

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Abstract:- This paper is a part of my Ph.D. research titled Human Resource Management System in Investment Perspective of Performance Appraisal of Organisation (A Case Study on Indian Oil Industry) and includes in thesis as a conclusion chapter-8. This chapter will draw on those that precede it to answer the research questions posed in the first chapter of this thesis. It will demonstrate how, through the utilisation of qualitative methods and statistical analysis, the current study has produced research that has made a valuable contribution firstly, to the decision theory and oil and gas industry literatures and secondly, to oil industry practitioners. By drawing on the insights gained through the conduct of the literature review, research interviews and data analysis stages of the current study, the chapter begins by answering each of the three research questions in turn. The main conclusions of the research are then contextualised in the decision theory and oil industry literatures. This highlights how the research has contributed to one of the current debates in these literatures by providing evidence of a link between the use of decision analysis in investment appraisal decision-making and good organisational performance. Implications of the study and recommendations to practitioners follow. The chapter concludes by identifying directions for future research.

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THE RESEARCH QUESTIONS REVISITED

In Chapter 1 the three research questions that the current study aimed to examine were proposed. Focussing on each question in turn in this section these questions and their motivation will be examined. Attention will be concentrated on how, through the utlisation of the combination of qualitative methods and statistical analysis, the research presented in this thesis can be used to answer these questions.

The first research question aimed to establish which of the decision analysis techniques presented in the decision theory and industry literatures, are the most appropriate for upstream oil and gas companies to utilise in their investment decision-making. This question was motivated by the recognition that there are many decision analysis techniques and concepts presented in the decision theory and industry literatures. Some of these have been applied to the upstream in the industry literature since the early 1960s. A few have only recently began to attract attention. Still others have yet to be considered in the context of the upstream. However, previously in the decision theory and industry literatures, authors had tended to describe the application of a single technique to either a real or hypothetical decision situation (Hammond, 1967; Swalm, 1966). Whilst such accounts provide useful insights, they also implied that using particular decision analysis technique in isolation, would provide the decision-maker with best possible perception of the risk and uncertainty associated with a decision. Yet, as indicated in Chapter 5, in reality, each tool has limitations (Lefley and Morgan, 1999), some that are inherent, others which are caused by a lack of information or specification in the literature. As such, the knowledge that the decision-maker can gain from the output of one tool is limited. Therefore, a combination of decision analysis techniques and concepts should be used. This would allow the decision-maker to gain greater insights and, hence, encourage more informed decision-making. Some writers had recognised this and presented the collection of decision analysis tools that they believed constituted those that decision-makers ought to use for investment decision-making in the oil and gas industry (for example, Newendorp, 1996). However, as indicated above, new techniques, such as option theory, have only recently been applied to the industry and clearly, these previously presented approaches required modification.

The research presented in this thesis addressed this first question by drawing on the decision theory and industry literatures to ascertain which decision analysis tools are the most appropriate for upstream oil companies to use for investment appraisal decision-making. This involved firstly,

identifying the whole range of techniques that are available and, secondly, deciding which of these are the most appropriate for upstream investment decision-making. This meant careful consideration of factors such as the business environment of the upstream and the level and type of information used for investment decision-making in the industry.

Through this process, the research identified the following decision analysis techniques as particularly useful for upstream investment decision-making: the concepts of expected monetary value and decision tree analysis, preference theory, risk analysis, portfolio theory and option theory. Then by drawing again on the decision theory and industry literatures, and also on insights gained at conferences and seminars, a 9-step investment decision-making process was presented. This provided an illustration of how these tools can be used together in the particular decision situation where an upstream company is considering whether to drill an exploration well in a virgin basin at an estimated cost of £10 million. The approach was summarised in figure 5.12 and this is reprinted here.

1. Assess the chance of success based on historic statistics and analogues of other basins and plays with similar geological characteristics.

2. Use sensitivity analysis to determine the critical reservoir parameters.

3. Conduct a probabilistic analysis of reserves using Monte Carlo techniques. If necessary, perform a further sensitivity analysis here by altering the shapes of the probability distributions assigned to the reservoir parameters and changing the nature of the dependencies between the variables.

4. Extraction from the probabilistic output of the reserves calculation of some deterministic samples –for example, p10, p50 and p90 (high, mid, low cases).

5. Use sensitivity analysis to determine the critical economic parameters.

6. Perform a probabilistic economic analysis for each deterministic reserve case using Monte Carlo techniques. If necessary, perform a further sensitivity analysis here by altering the shapes of the probability distributions assigned to the economic factors and changing the nature of the dependencies between the variables.

7. Using influence diagrams draw the decision tree.

8. For each reserve case, recombine the chance of success estimated in step 1 and the economic values generated in step 6, through a decision tree analysis to generate EMVs.

9. Use option theory via decision tree analysis and assess the impact on the EMV.

Figure 5.12: A 9 step Approach to Investment Appraisal in the Upstream Oil and Gas Industry

Variations of the approach could be used for development decisions, any production decisions and for the decision of when to abandon production and how to decommission the facilities. Versions of it could also be used in other industries with a similar business environment to the oil and gas industry, for example, the pharmaceutical or aerospace industries. In these businesses, investment decisions are similar in scale to the oil industry with the high initial investment without the prospect of revenues for a significant period and are also characterised by high risk and uncertainty.

The second research question focussed on two issues. First, it aimed to establish which of the decision analysis techniques that the researcher had identified to comprise current capability in answering the first research question, upstream oil and gas companies actually choose to use to make investment decisions. Second, it sought to understand how these tools are used in the process of organisational investment decision-making.

Previous studies into the usage of decision analysis techniques had suggested that there was a gap between

current practice and current capability (for example see studies by Arnold and Hatzopoulous, 1999; Carr and Tomkins, 1998; Schuyler, 1997; Buckley et al., 1996 Fletcher and Dromgoole, 1996; Shao and Shao, 1993; Kim, Farragher and Crick, 1984; Stanley and Block, 1983; Wicks Kelly and Philippatos, 1982; Bavishi, 1981; Oblak and Helm, 1980 and Stonehill and Nathanson, 1968). It appeared that whilst the literature described some very sophisticated investment appraisal tools, companies were choosing to use only the most simplistic. However, most of the earlier studies had tended to utilise quantitative methodologies and, as such, these works had only been able to provide an indication of how widely used a particular decision analysis technique was (for example, Schuyler, 1997). They had not provided any insights, based on behavioural decision theory, into the reasons why some techniques fail to be implemented and others succeed, and, more importantly, which techniques perform better than others do (Clemen, 1999). In adopting a qualitative methodology, the current study was able to address these issues.

Earlier qualitative research into organisational decision-making had neglected the role of decision analysis. Several studies had focussed on the existence of formalisation and rationality in decision-making (for example, Papadakis, 1998; Dean and Sharfman, 1996) but few had explicitly examined the use, and usefulness, of decision analysis in investment appraisal. Fewer again had examined cases where the decision situation is characterised by a substantial initial investment, high (absolute) risk and uncertainty throughout the life of the asset and a long payback period, features that are common in, though not unique to, the petroleum industry. Typically, where such research had been undertaken, it had usually been conducted within one company usually by an employee of that organisation (for example, Burnside, 1998) and had often not been published due to commercial sensitivity. There had been only one previous qualitative study researching the use of decision analysis in the oil industry (Fletcher and Dromgoole, 1996). However, this study had only focused on the perceptions and beliefs of, and decision analysis techniques used by, one functional area within organisations in the upstream. As such its findings could only be regarded as indicative rather than conclusive. In contrast, the current study integrated perspectives from individuals from a variety of backgrounds within organisations. In doing so, the research was able to produce a description of current practice in investment decision-making in the oil industry that was informed from the perspectives of the main participants in the process. The current study indicated that for exploration decisions, most companies use Monte Carlo simulation to generate estimates of prospect reserves. They then run their economic models on only one reserve case. Typically, Monte Carlo simulation is not used for economic analysis. In production decision-making, the majority of companies only use deterministic analysis. Option, portfolio and preference theories are hardly used at all by any firm. Comparing this approach with the 9-step approach outlined in figure 5.12 and reprinted above, confirms the suggestions of earlier empirical research, and establishes that there is a gap between current theory and current practice in the quantitative techniques used for investment appraisal in the upstream.

The research interviews were then used to provide insights into the reasons for the gap between current practice and capability. It appears that there are relationships between decision-makers' perceptions of decision analysis, company culture and the extent to which decision analysis is used for investment appraisal decision-making. In companies where managers are convinced about decision analysis, the culture is "numbers-driven" and decision analysis is used extensively. In companies where managers are unconvinced about the value of decision analysis, the company is largely "opinion-driven" and the use of decision analysis is not formalised or encouraged.

These ideas were then captured in a model of current practice. The x-axis in the model relates to the number of decision analysis techniques used for investment appraisal decisions. The y-axis of the model indicates the proportion of investment decisions that are made in each company using decision analysis techniques. Plotting the interviewed companies on the two axes then produces the model shown in figure 6.1 and reprinted here. The pattern obtained suggests that organisations begin to use decision analysis techniques on routine, operational decisions before introducing the techniques corporation-wide. Secondly, it provides evidence that as companies introduce more techniques, they tend to use the techniques on more decisions, some of which can be regarded as strategic. Thirdly, in the model there are clearly three groups of companies (each group is a different colour in the figure). This suggests that organisations are choosing not to modify which techniques they use or how they use them, preferring instead to stay within their group. Possible reasons for this include the decision-makers' perception of decision analysis, which are affected by the lack of any empirical evidence to indicate that using decision analysis is associated with good organisational performance.

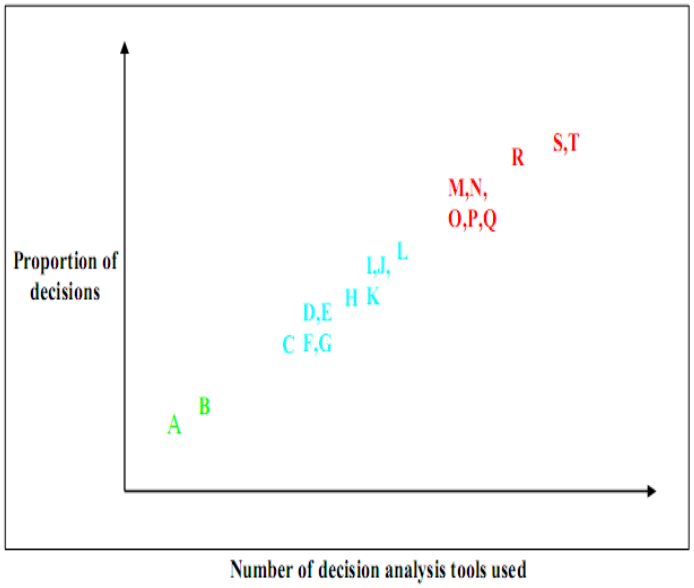

Figure 6.1: A model of current practice

This leads into the third research question that this thesis aimed to address, which was to establish if there is a link between the techniques organisations use for investment appraisal and good decision-making in the upstream oil and gas industry. This question was motivated by the recognition that despite over four decades of research undertaken on developing decision analysis methods, on understanding the behavioural aspects of decision-making, and on the application of decision analysis in practice, no previous research had been able to show conclusively what works and what does not (Clemen, 1999). Some studies in behavioural decision theory had evaluated the effectiveness of individual decision analysis techniques (for example, Aldag and Power, 1986; John et al., 1983; Humphreys and McFadden, 1980) and Clemen and Kwit (2000) had investigated the value of a decision analysis approach in Kodak, but, crucially, no earlier study had shown that use of decision analysis techniques could actually help organisations to fulfil their objectives.

Qualitative methods again were chosen as the most appropriate to evaluate the effectiveness, or otherwise, of using a decision analysis approach in organisational decision-making in the oil industry. Using the results from the second stage of the research, a ranking of the companies according to the number and sophistication of the techniques and concepts they used, was produced. The research assumed that any value added to the company from using a decision analysis approach, including "soft" benefits, would ultimately affect the bottom-line. This meant that it was possible to investigate the relationship between the ranking of organisations by their use of decision analysis generated by the qualitative study and good decision-making statistically, by using criteria that are indicative of organisational performance in the upstream. The majority of the results produced suggested that there is a positive association between the use of decision analysis in investment appraisal and good organisational performance in the upstream oil and gas industry.

This section has shown how the empirical research presented in this thesis can be used to answer the three research questions proposed in Chapter 1. The following section will examine how the work produced in this thesis contributes to the existing academic and industry literature. In section 8.4, the implications of the study for practitioners will be investigated.

THEORETICAL CONTRIBUTION

This section will demonstrate how the research presented in this thesis can be seen to have generated a robust set of findings that have contributed to the one of the current debates in the decision theory literature.

As indicated in Chapter 2, the decision theory literature is comprised of behavioural decision theory and decision analysis. Simplistically, decision analysis is the label given to a normative, axiomatic approach to decision-making under conditions of risk and uncertainty. By using any one, or a combination, of decision analysis techniques, the decision-maker is provided with an indication of what their decision ought to be based on logical argument. Conversely, the behavioural decision theory literature shows that people are not always coherent or internally consistent. They do make inconsistent patterns of choices and their inferences can be exploited (Clemen, 1999), particularly under conditions of risk and uncertainty.

There is a tendency in the decision theory literature for decision analysts and behavioural decision theorists to become embroiled in a somewhat circular argument over the use and benefits of decision analysis. Tocher (1976 and 1978 reprinted in French, 1989) and other behaviouralists argue that people do not behave in the manner suggested by decision analysis and, in particular, do not adhere to the underlying assumptions of the decision analysis approach, namely those of rationality and maximising behaviour. Harrison (1995 p90) writes:

"…the assumptions underlying maxisimising behaviour are faulty. Objectives are not fixed. The known set of alternatives is always incomplete because it is impossible to obtain perfect information and human beings cognitive

limitations preclude serious consideration of a large number of alternatives. Many of the variables that must be considered in any attempt at maximisation are not easily quantified. Therefore, a precise preference ranking of the firm's objectives or its alternatives that will maximise outcome is most unlikely."

In a special edition in 1991 of the Harvard Business Review The logic of business decision-making, Etzoni (1991 p41) commented:

"Decision-making was never as easy as rationalists would have us think. Psychologists argue compelingly that even before our present troubles began, human minds could not handle the complexities that important decisions entailed. Our brains are too limited. At best, we can focus on eight facts at a time. Our ability to calculate probabilities, especially to combine two or more probabilities – essential for most decision-making – is low… Moreover, we are all prone to let our emotions get in the way – fear for one. Since all decisions entail risks, decision-making almost inevitably evokes anxiety."

Additional limitations on maximising behaviour become apparent in considering the human predicament of decision-making. Shackle (1974 p1) eloquently articulates this in the following quote:

"If choice is originative, it can be effective, it can give thrust to the course of things intended to secure its ends. In order to secure its ends, choice must apply a knowledge of what will be the consequence of what. But the sequel of an action chosen by one man will be shaped by circumstance, and its circumstances will include the actions chosen now and actions to be chosen in time to come by other men. If, therefore, choice is effective, it is unpredictable and thus defeats, in some degree, the power of choice itself to secure exact ends. This is the human predicament…Decision is not, in its ultimate nature, calculation, but origination."

If, as Shackle indicates, decision-making is not founded on calculation, the assumptions underlying decision analysis are untenable. As such Tocher and other opponents would rather operate with no model at all than utilise a model that is in conflict with how people actually act and think:

"…any theory which is worth using predicts how people will behave, not how they should, so we can do our mathematics." (Tocher, 1976 reprinted in French, 1989 p140)

Decision analysts response to such criticisms is that they acknowledge that utility functions and subjective probability distributions do not provide valid models of decision-maker's actual preferences and beliefs (French, 1989). They argue that their intention is not to describe the decision-maker's beliefs and preferences as they are; it is to suggest what they ought to be, if the decision-maker wishes to be consistent. French urges that the "is" should not be confused with the "ought", and decision analysis only suggests how people ought to choose. Decision analysis, he argues, is normative not descriptive analysis. Keeney and Raiffa (1976 pvii) adopt a similar stance:

"…[decision analysis is a] prescriptive approach designed for normally intelligent people who want to think hard and systematically about important real problems."

Krantz et al. (1971) describe decision analysis to be:

"…normative principles defining the concept of rational behaviour rather than a description of actual behaviour". (cited by Tocher, 1978 reprinted in French, 1989 p151)

They go on to say:

"…We want to stress that subjective probabilities are means of describing rational behaviour. Nothing more! They cannot be used as estimates of the objective probability of an event or the credibility of a statement or the corroboration of a theory." (cited by Tocher, 1978 reprinted in French, 1989 p151)

But to critics such as Tocher such a defence is weak and referring to the above quote from Krantz, Tocher writes:

"This sums up my attitude to the utilitarians; I am irritated by their arrogance – they will tell me how I ought to think regardless of the evidence of how people actually think or take decisions." (Tocher, 1978 reprinted in French, 1989 p151)

Figure 8.1 shows the relationships between these two areas of the decision theory literature. Recently, researchers have realised that to unite the two seemingly diametrically opposite views, empirical research needs to establish if there is a relationship between the use of decision analysis and successful decision-making (Clemen and Kwit, 2000; Clemen, 1999). Clemen (1999 p2) believes that:

"…such research could connect the … existing areas into a truly unified body of literature"

Figure 8.1: The relationship between decision analysis and behavioural decision theory (adapted from Clemen, 1999)

However, as indicated above in section 8.2, such studies have been slow to appear, doubtless because of the threat they represent to decision analysts:

"Asking whether decision analysis works is risky. What if the answer is negative? The contribution will clearly be scientifically valuable, but many individuals – consultants, academics, instructors – with a vested interest in decision analysis could lose standing clients, or even jobs." (Clemen, 1999 pp23-24)

The research presented in this thesis then can clearly be seen to provide a useful contribution to the theoretical debate, by establishing the existence of such an association in the upstream oil and gas industry.

IMPLICATIONS OF THE STUDY FOR PRACTITIONERS

The findings presented in this thesis clearly have implications for practitioners in the oil industry. These will be analysed in this section.

By answering the first research question, the study has provided an indication of which decision analysis techniques are the most appropriate for upstream companies to use for investment appraisal and indicated how these tools can be used together. Companies can use this as a template to modify their own investment appraisal approach. The model of current practice produced by answering the second research question, showed which tools companies in the upstream use. This will allow organisations to compare their processes with the rest of the industry and make any appropriate modifications. This model also permitted the researcher to identify best practices in those companies that currently use decision analysis (summarised in figure 8.2) and these should be communicated to companies through publications in industry journals such as Journal of Petroleum Technology.

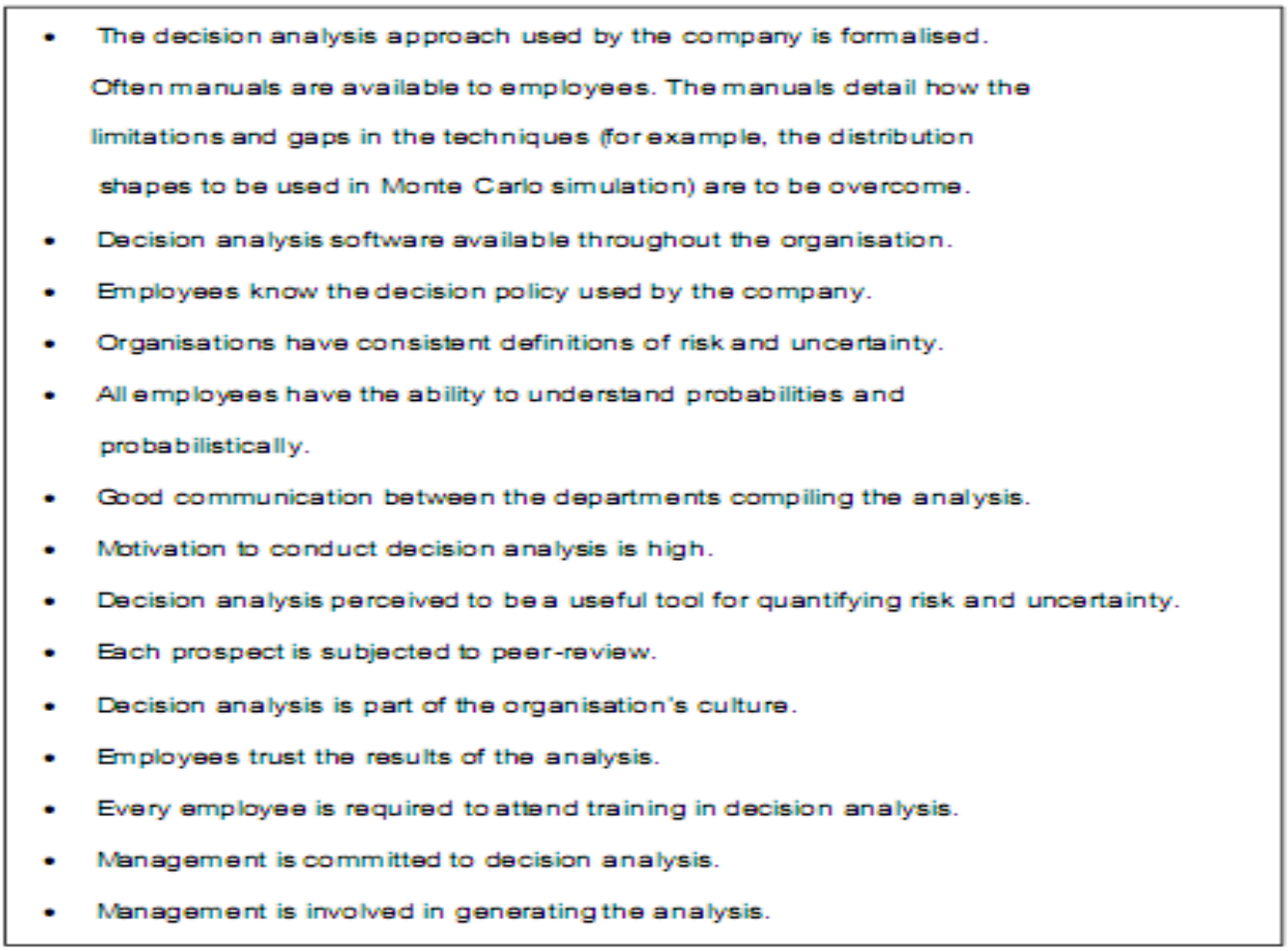

Figure 8.2: Best practices in organisations' use of decision analysis

By providing evidence that decision analysis contributes positively to organisational performance, the current study ought to promote interest in decision analysis tools and concepts. This should result in more organisations using decision analysis, and some companies using the more sophisticated decision analysis techniques and ideas. Clearly then the research presented in this thesis ought to be seen as a vehicle for narrowing the gap between current practice and current capability in the use of decision analysis by the upstream oil and gas industry. However, this will only occur if, simultaneously, decision-makers recognise that decision analysis is not a threat, that it does not dictate answers, nor does it usurp decision-makers and remove choice and neither could it ever aspire to do so. Numerous decision analysts (for example, French, 1989; Keeney and Raffia, 1976) stress that decision analysis is not a means whereby the decision-maker is replaced by an automatic procedure. Newendorp (1996 p7) observes in his book on decision analysis that:

"We will unfortunately not be able to develop a single "handy-dandy" formula which will cure all the evaluation problems relating to capital investment decisions."

The basic presumption of decision analysis is not to replace the decision-maker's intuition, to relieve him or her of the obligations in facing the problem, or to be, worst of all, a competitor to the decision-maker's personal style of analysis, but to complement, augment, and generally work alongside the decision-maker in exemplifying the nature of the problem (Bunn, 1984 p8). Keeney (1982) commented

"Decision analysis will not solve a decision problem, nor is it intended to. Its purpose is to produce insight and promote creativity to help decision-makers make better decisions." (Goodwin and Wright, 1991 p4)

Yet, currently decision-makers, in the upstream, at least, appear to fear that implementation of decision analysis, will be accompanied by a diminishing role for decision-makers. Clearly, decision-makers need to be educated in the conception of decision-analysis. Only then will organisations fully adopt decision analysis.

FUTURE RESEARCH

Whilst conducting the research underpinning this thesis, one of the most difficult tasks for the researcher was to recognise that every interesting issue uncovered could not be explored. As such, whilst contributing to the theoretical debate and providing useful advice to practitioners, the current study has also highlighted several areas for future research. These will be discussed in this section.

Firstly, as highlighted in Chapter 5, there is a need for several studies to investigate the issues surrounding Monte Carlo analysis. One study needs to establish the shape of the input distributions that ought to be used to represent the reservoir parameters, in a field of specified lithology and depth, in a Monte Carlo simulation to generate an estimate of the recoverable reserves. A further study is required to explore the nature of the dependencies between these variables. The data necessary for such a study is due to be published next year by the Geological Society in a book titled Oil and Gas fields of the United Kingdom Continental Shelf edited by Jon Gluyas et al.. The need for these studies is particularly pertinent since most companies are using Monte Carlo analysis to generate estimates of recoverable reserves at the prospect level. Similar studies also need to be conducted to investigate these issues for economic variables. However, the economic data that are necessary for such research are regarded by most companies to be strictly confidential. Consequently, such research is unlikely to be undertaken in the near future.

Further work is also needed to understand the complexities of option theory and its application to the upstream. The growing interest from the industry should ensure that this occurs. The researcher expects to see more companies using the technique on individual investment appraisal cases in the next couple of years. Software companies such as Merak are interested in integrating the technique into their existing packages and this should aid its introduction to the industry.

One of the most interesting areas that the researcher had to acknowledge was beyond the scope of this thesis were issues of tacit knowledge and the extent to which organisations and decisions are dependent upon it, and decision-makers reliance on gut feelings and experience. Firstly, understanding such issues, and secondly, researching them, requires specialist skills in areas, for example, such as organisational psychology. Following similar observations, in March 1999 the Departments of Management Studies and Economics at the University of Aberdeen identified a researcher with the appropriate background to undertake such research. This Ph.D. is due for completion in March 2002.

Future research should concentrate on further examination of the link between use of decision analysis and organisational performance. The current study focussed on those oil companies active on the ONGC, a comparative study could be undertaken in companies active in other areas. Following presentation of a paper based on Chapter 7 of this thesis at a recent Society of Petroleum Engineers conference in Japan, JNOC (Japanese National Oil Company) are considering conducting a similar study in Japan. The study could also be replicated in other industries with a similar high risk/high reward environment, such as pharmaceuticals or aeronautics. CSIRO are currently considering funding such research.

These studies could perhaps adopt longitudinal research designs. Previous research (for example, Papadakis and Lioukas, 1996; Rajagopalan et al., 1993), suggests that organisational performance is a function of a diverse collection of factors. Cause-effect relationships are, at best, tenuous and a broader conceptualisation of effectiveness that incorporates both process and performance measures, is now appropriate (Goll and Rasheed, 1997). Using longitudinal research designs, researchers would be able to gain a greater understanding of the causal relationships between the decision process and organisational performance by studying how connections between context, process and outcome unfold over time (Papadakis, 1998). This would minimise the possibility of reverse causality among the main variables (Van de Ven, 1992; Leonard-Barton, 1990). Consequently, longitudinal research methods would increase researchers' confidence in the causal interpretation of the findings (Hart and Banbury, 1994; Chakravarthy and Doz, 1992).

CONCLUSION

This thesis has highlighted that decision analysis should not be perceived to be providing a dictatorial straitjacket of rationality (French, 1989). Rather it should be seen to be a delicate, interactive, exploratory tool which seeks to introduce intuitive judgements and feelings directly into the formal analysis of a decision problem (Raiffa, 1968). The decision analysis approach is distinctive because for each decision, it requires inputs such as executive judgement, experience and attitudes, along with the "hard data". It helps

decision-makers to tread the fine line between ill-conceived and arbitrary investment decisions made without systematic study and reflection ("extinction by instinct") and a retreat into abstraction and conservatism that relies obsessively on numbers ("paralysis by analysis") (Langley, 1995). The thesis has demonstrated that such an approach contributes positively to organisational performance in the upstream oil and gas industry.

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