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Towards a Model for Exploring the Relationship between Managerial Decision Problems and Decision Support Opportunities

Thesis Submitted for the Degree of Doctor of Philosophy in the National University of Ireland

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Declaration

The Author hereby declares that, except where duly acknowledged, this thesis is entirely her own work and has not been submitted for any degree in the National University of Ireland, or any other University.

Signed:

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Abstract

The organisational decision making environment is complex, and decision makers must deal with uncertainty and ambiguity on a continuous basis. Managing and handling decision problems and implementing a solution, requires an understanding of the complexity of the decision domain to the point where the problem and its complexity, as well as the requirements for supporting decision makers, can be described. Research in the Decision Support Systems domain has been extensive over the last thirty years with an emphasis on the development of further technology and better applications on the one hand, and on the other hand, a social approach focusing on understanding what decision making is about and how developers and users should interact.

This research project considers a combined approach that endeavours to understand the thinking behind managers' decision making, as well as their informational and decisional guidance and decision support requirements. This research utilises a cognitive framework, developed in 1985 by Humphreys and Berkeley that juxtaposes the mental processes and ideas of decision problem definition and problem solution that are developed in tandem through cognitive refinement of the problem, based on the analysis and judgement of the decision maker. The framework facilitates the separation of what is essentially a continuous process, into five distinct levels of abstraction of manager's thinking, and suggests a structure for the underlying cognitive activities. Alter (2004) argues that decision support provides a richer basis than decision support systems, in both practice and research. The models and information that are available to the decision maker are critical, as inadequate or inaccurate information and incorrect models will have a negative effect of the decision outcome. Therefore, the level and nature of decision support that is available to managerial decision makers is significant at all levels of the framework.

This study employed an exploratory approach and firstly, established the applicability of the Humphreys and Berkeley (1985) framework to understand the complexity of organisational decision making, in a pilot study. The pilot study indicated that leveraging the Humphreys and Berkeley (1985) framework had

significant merit, because it facilitated an understanding of the decision problem characteristics at each of the levels of the framework, and highlighted the fundamentally different activities which were identified at each level. Thus, the pilot study enabled a clarification of the presentation of the framework, which eased the research process in the main study. The main study examined a global organisation in the financial services industry. Specific categories of key decision problems were identified which had passed through the different levels of the framework over time. This in turn allowed the recognition of the decision support requirements at each of the levels of the framework. The nature and the extent of the decision support currently availability was then identified, and its relationship with the concept of decision support maturity investigated.

The constituent literature on decision support, especially in regard to modern high profile systems, including Business Intelligence and Business analytics, can give the impression that all 'smart' organisations utilise decision support and data analytics capabilities for all of their key decision making activities. However this empirical investigation indicates a very different reality. The results suggest a low level of decision support maturity in the organisation, with an over-reliance on expert human analysts.

Chapter 1. Introduction

Decision making has been identified as a fundamental characteristic of managerial activity in organisations (Simon, 1955; 1956; Simon and Newell, 1958; Mintzberg, 1973; 1975; Mintzberg, Raisinghani and Theoret, 1976; Simon, 1977; 1979; 1987; Drucker, 1992; March and Simon, 1993; Mintzberg, 1994; Simon, 1997; Drucker, 1999). Moreover, decision making capability is recognised as the intrinsic difference between successful organisations, those who continue to grow and to gain competitive advantage, and those organisations who do not survive (Drucker, 1988; 1999; Kahneman, 2003; Davenport, 2006; Davenport, 2009; Davenport, Harris and Morison, 2010; Kahneman, 2011).

1.1. Decision Support for Decision Makers: an overview of the research motivation for this study

Computer systems, and in particular Decision Support Systems and the more recently developed Business Intelligence Systems, are perceived as providing the necessary decision support which will facilitate a better decision making environment, thus augmenting decision making quality. More specifically, it is the impression that organisational decision making has reached this level of maturity which allows decision makers to operate with perfect information and automated decision making tools, which in turn provides transparency and ease of reconciliation across the whole organisation. However, an analysis of basic decision support mechanisms reveals that this ideal is not a reality. The widely reported Business Intelligence and Business Analytics successes are characterised as having a very narrow remit, focusing on specific applications of Business intelligence and Business Analytics within particular business areas, rather than on enterprise-wide endeavours (Kohavi, Rothleder and Simoudis, 2002; Carte, Schwarzkopf, Shaft and Zmud, 2005; Piccoli and Watson, 2008). Moreover, most applications are of a descriptive reporting nature, rather than of a predictive or prescriptive guidance nature (Wixom and Watson, 2010; Shanks and Bekmamedova, 2012).

Currently, the organisational environment is characterised by radical change and increasingly complex and wicked problems (Courtney, 2001; Malhotra, 2001). Complex and wicked problems are problems that are unstructured and their formulation **is** the problem. They are also characterised as changing significantly in response to a solution; by the fact that they may not have a single right answer; that they may have many interrelated causative forces; may have no (or few) precedents; and may have many stakeholders (Rittel and Webber, 1973; Bennet and Bennet, 2010). They have been referred to as "messes" by (Ackoff, 1979). Messes produce conditions where one knows a problem exists, but the specifics of that problem itself are not clear. It is impossible to make a single decision with which to determine action regarding a complex problem, because there is no single action that will produce a total solution. Realising a desired solution requires a continuing process which must be incorporated into a decision solution strategy that will plan for a sequence of actions (Bennet and Bennet, 2010). Although wicked problems are not new to managers, social, environmental and economic conditions are increasing both the volume and the variety of the wicked problems confronting decision makers (Courtney, 2001). Since solutions to wicked problems are not true or false, but good or bad, values inherently form a large part of the problem, and the values employed vary among decision makers; ultimately, they depend on human cognitive ability. Problems of this nature occur on a regular basis, and not just within the context of a crisis situation.

Providing decision support has been a major concern for organisations over time, and it has been the subject of an extensive body of Information Systems academic literature, since Gorry and Scott Morton coined the phrase 'decision support systems' or 'DSS' in 1971. Alter (2004) argued in the abstract of his paper in *Decision Support Systems* (p. 319) that "*the initially revolutionary DSS agenda is now ancient history*", and he proposed that " '***decision support***'[1]

[1] Emphasis based on the original Alter (2004) work

provides a richer basis than 'DSS' in both practice and research". The basis for his argument is both understandable and compelling, because, providing the right information at the right time and via the right representation is a fundamental element of supporting human decision making (Holsapple and Joshi, 2003). This fairly basic objective demands a necessary challenge in order to avoid the pitfalls which have at times plagued DSS research: techno-hype, domination of software vendors' rhetoric and failure to understand the underlying problems which decision makers encounter. An understanding of what decisions are made, as well as an understanding of the information and the decision support applications that will satisfy the requirements of the decision maker, has not been clearly established for the full range of organisational decisions. Providing decision support acknowledges that support can come in many different forms, and not only in the form of technical artefacts. This has been echoed in Murphy's earlier work, when he stated that based on his empirical studies, an overly technical orientation was evident in much of the research on DSS. He also observed that "*the difference between successful and unsuccessful decision support is most likely to be influenced by the actions of the staff rather than any technological platform*" (Murphy, 1994, p. 106). These are now referred to as "expert human analysts" in the Business Intelligence and Business Analytics literature (Kohavi *et al.*, 2002).

The emphasis on enabling and on improving human decision making has subsequently been re-stated by Arnott (2006), who argues that *"Decision Support Systems (DSS) is the area of Information Systems (IS) devoted to supporting and improving human decision-making"* (Arnott, 2006, p.56). Decision Support Systems "*represent a variety of techniques and technologies usually borrowed from a range of disciplines, which aim at improving access to necessary information for more effective decision making*" (Burstein and Widmeyer, 2007). In the intervening time since 1971, many system types have been considered as providers of the necessary information. These include Executive Information Systems (EIS); Knowledge Management Systems (KM); as well as Decision Support Systems and Business Intelligence systems (Forgionne and Kohli, 2000;

Clark, Jones and Armstrong, 2007), all of which have expanded the decision support domain. More recently, new terms, such as Business Analytics and Business Intelligence, have been presented as a means to deliver effective real time decision making information (Dover, 2004; Gitlow, 2005; Davenport, 2006; Burstein and Widmeyer, 2007; Davenport *et al.*, 2010).

The interactive and adaptive process of the development and use of Decision Support Systems, described by Keen (1980) identifies Decision Support Systems as primarily 'support systems', but with the caveat that the final system must emerge through an adaptive process of design and use that incorporates the interaction of the decision maker, the systems designer and the decision support system itself. This process facilitates the decision maker's ability to take full advantage of their decision support enablers, by facilitating the decision maker to maximise the value of Decision Support Systems through continuous use and enhancement. The resulting improved decision support capability will satisfy the business requirements of greater flexibility and agility which are perceived as necessary requirements in today's business environment (Watson and Wixom, 2007).

This research investigates the decision making process from the perspective of a cognitive understanding of managers' thinking. A framework developed in 1985 by Patrick Humphreys and Dina Berkeley provides the theoretical instrument for the analysis. The Humphreys and Berkeley's framework, first presented in 1985 within the psychology research domain of that time, presents a cognitive representation of managers' thinking across five levels, which correspond to levels of understanding of a decision problem, which managers gain as additional insights during the problem solving process. The evolution of the different levels of understanding of the decision problem is characterised by activities engaged in by a number of different organisational actors, at different hierarchical positions, within the organisation. The decision support and guidance needs are different for each of the decision making levels, in each of the activities associated with gaining an understanding of the problem, as well as gaining an understanding of a preferred solution. The research

therefore, investigates how the development and enhancement of future decision support can be influenced by an understanding of these cognitive processes, because it can help us identify the requirements for manager's decision support. The research questions associated with investigating and understanding decision support in this context are presented in the next section and are discussed in more detail in section 3.1 of Chapter Three.

1.2. Research objective and research questions

The aim of this research is to study the nature and the extent of decision support which is available to organisational decision makers at all levels of the organisation, as well as the nature of the decision problems that are supported. The attributes of particular interest, for the research model employed in this dissertation, are twofold. On the one hand, complex decision problems which occur continuously in organisations, and on the other hand, decision support. Decision support will define the level of support available to decision makers so that the decision solutions are devised based on quality information that is easily accessible, and is of relevance to the decision maker. The research objective for this study is stated as follows:

> *An investigation into organisational decision support for decision makers, through the application of a cognitive framework that characterises decision problems based on their level of abstraction of problem representation and on their level of formalisation of the proposed solution.*

In order to achieve the research objective, the following research questions were formulated:

Research Question One: *How can complex decision problems, which managers encounter, be represented and analysed from a decision support viewpoint, by using the Humphreys and Berkeley (1985) framework?*

The first construct for understanding Decision Support involves understanding the organisational decision problems from a cognitive representation perspective. A cognitive representation perspective reflects the evolution of managers' thinking as they go through the decision making process, and it is characterised by the degree of abstraction of the managers' representation of the decision problem, and by their level of understanding of the evolving problem solution. The Humphreys and Berkeley (1985) framework facilitates the separation of what is essentially a continuous process into five qualitatively different representations of a decision problem, from the point where assessment and expression of the problem is problematic to the point where implementation of agreed routines and procedures that will resolve the problem can be specified. The representations are characterised by the degree of abstract cognitive thought on the part of the decision maker, and it provides a mechanism that enables the researcher to apply structure to decision makers' thinking. Four propositions which are put forward in section 2.3.7, underpin the operability of Research Question One.

Research Question Two: *What level of decision support and decisional guidance is available to decision makers, individually and in groups, within the organisational decision environment, with respect to the different category of problems facing managers?*

This question is explanatory in nature as it seeks to explain the extent of the availability of the formal and informal decision support tools available to decision makers. By 'tools' the researcher means systems, routines, procedures and other forms of discussion and information dissemination that can be observed in an organisation (Simon, 1977). The review of the literature in Chapter Two reveals that there is an abundance of research on Decision Support Systems. However, Alter (1992, 2004) advocates that the focus of research should be on helping human agents to make better decisions, rather than just focus on decision support systems, because '*decision support provides a richer*

basis than DSS' for further research as well as for use in practice. Therefore, the purpose of this research question is to ascertain the extent and the nature of decision support availability and its application by decision makers. Three propositions are put forward in section 2.6.4 which will underpin the achievement of Research Question Two.

Research Question Three: *How does the level of availability of a decision support portfolio to match the decision support needs of managers, reflect the decision support maturity of an organisation?*

The answer to Research Question Three is exploratory in nature, and it aims to identify the factors which impact decision support maturity. Chapter two concludes that the literature on what constitutes decision support maturity is highly ambiguous. Achieving decision support maturity implies an evolutionary process from an initial state of minimal and ad-hoc support to a desired end-state, where decision makers gain insights and decisional guidance through their use of the available decision support tool set. The focus of RQ3 is to understand the extent of decision support at each of the representation levels where decision problems have been identified. Thus, the relationship between the supply of decision support and the demand of the decision problem formulation is being examined. Therefore, RQ3 is a synthesis of the findings in relation to the first two research questions, which gives the researcher the opportunity to discuss the scope and quality of decision support provided in the organisation at each of the cognitive representation levels. The next section details the research plan pursued to answer the research question posed in order to fulfil the research objective.

1.3. Plan of Research

In **Chapter Two**, a review of the constituent Decision Making and Decision Support literature is presented. The aim of this chapter is twofold: firstly, it is to present the complexity of organisational decision making and

conversely, it is to present the wide range of decision support which is available to decision makers. The chapter argues that a cognitive framework, which reflects on decision problem definition and problem solution that are developed in tandem through a cognitive refinement of the decision problem, is an appropriate mechanism to enable an understanding of the requirements of decision makers. The cognitive refinement is based on the analysis and judgement of the decision maker during the different stages of problem definition clarification and problem solution realisation. The identification of the decision makers' requirements will facilitate an understanding of the applications and models that should be developed. A number of propositions are proposed which will facilitate the operationalisation of the empirical study.

Chapter Three presents the research strategy that is deemed appropriate for this research study. Following from the conclusions generated in Chapter Two, the research problem is defined, and a number of research questions are formulated. The two key paradigms considered in IS are presented with a view to choosing an approach most applicable to this particular study. The shortage of empirical evidence and the complexity of phenomena surrounding a cognitive representation of decision making provide the researcher with the opportunity to generate theory from this research study. In pursuing this course of action, the researcher follows a case study approach collecting data through semi-structured interviews. The case study approach is chosen as an appropriate research method, as it provides the necessary richness and depth required to satisfy the research problem and questions, given the exploratory nature of this research study. The data gathering techniques used in this study are presented and the methods of data analysis are discussed. Data analysis displays are considered as a significant feature of this research project in view of the nature of this study. The researcher leveraged the use of qualitative analysis coding techniques to produce analytical memos which facilitated data reduction, and in turn, the case write-up in Chapter Five. The chapter concludes with a presentation of the research protocol for this research project.

Chapter Four presents the case analysis for an exploratory study conducted prior to undertaking the main case. The exploratory case allowed the researcher an opportunity to investigate the appropriateness and usefulness of a cognitive framework to illustrate different stages of thinking associated with problem definition and with problem solution evolution. This exploratory study describes the decision making activity of managers across ten organisations, and illustrates how these decisions were mapped to the cognitive representation levels of the framework. It also portrays the degree of decision support in the form of applications, models and information availability for each of the organisations. These mini cases represent an instrumental case, in that the actual detail of the organisational decision making outlined, is of less importance than the process being studied, i.e. the suitability of the Humphreys and Berkeley (1985) framework to an assessment of organisational decision making.

Chapter Five presents the case analysis for BigBank. A single extended case was completed as a means of identifying and refining the most effective way to display and answer the research questions posed for this study. Research Question One illustrates the cognitive representation of decision problem formulation and subsequent clarification by fourteen executives and managers at BigBank. Research Question Two identifies the extent and the nature of the availability of the formal and informal decision support, in terms of their distribution and total number of instances at the time of this study. In addition, Research Question Three deals with the degree and nature of decision support across the decision problem representation levels so that a model of decision support maturity can be proposed.

Finally **Chapter Six** presents the overall conclusions of the research study. The theoretical contribution of this research is discussed. This research study investigates organisational decision support for decision makers. A theoretical model is proposed that recognises the decision problem focus for the five cognitive levels of abstraction, and identifies the decision support requirements at each level. The chapter concludes with recommendations for further research.

1.4. Publications based on this research

Published Papers:

Daly, M., Adam, F. (2011). Understanding Organisational Decision Support Maturity: Case Studies of Irish Organisations. *International Journal of Decision Support System Technology (IJDSST)* Vol. 3(2) pp.57-78.

Conference papers:

Daly, M., Adam, F., (2014). Decision Support and Decision Guidance: A Case Study in the Financial Services – DSS2.0 is Still Far Away. *IFIP TC8/WG8.3 Working Conference. International Conference on DSS2.0: Supporting Decision making with New technologies.*

Daly, M., Adam, F., (2014). Understanding the Decision Landscape of Organisations as a Blueprint for delivering high impact IS. *La 19ème édition du Colloque de l´Association Information et Management (AIM 2014)*

Daly, M., Adam, F., Pomerol, J. (2008). Analysing the true Contribution of Decision Support Tools to Decision Making – Case Studies in Irish Organisations. *IFIP TC8/WG8.3 Working Conference. International Conference on Collaborative Decision Making.*

Chapter 2. Investigating Organisational Decision Making and Decision Support in Organisational Literature

2.1. Introduction

In this chapter, the state of current knowledge within the study of executive decision making in organisations is considered. In particular, the role of senior executives and managers as decision makers in organisations, where there is complexity and high levels of uncertainty on a day-to-day basis, is investigated (Hambrick and Snow, 1977; Hambrick and Mason, 1984; Hambrick, 2007). Organisational decision making is an extremely important aspect of the workings of an organisation as it impacts on all of the current activities of managers and executives who are acting on behalf of the organisation (Ackoff, 1974; Pennings, 1985). While we refer to organisational decision making, the practicality of organisational decision making is manifested by managers and executives who work to achieve organisational objectives in an environment that is constantly changing and becoming more complex, and where it is harder to anticipate environmental context and direction (Huber and McDaniel, 1986; Eisenhardt, 1989; Morgan, 1997; Brashers, 2001). However, complexity cannot be avoided, and when working in such an environment many of the strategic problems identified are significant and are of major importance to the organisation.

Fundamental questions with which strategic management must be concerned include how managers understand, describe and communicate strategic problems, which occur daily, and how these managers are supported in the decision process, such that the optimal solution can be realised. Problem detection and recognition is of paramount importance (Pounds, 1969; Mintzberg *et al.*, 1976; Pomerol, 1997; Weick and Sutcliffe, 2001; Davenport, 2006), as failure in this area will lead to the wrong problem being solved and poor outcomes from the decision process realised. Organisations of the past have also struggled with issues such as managing large volumes of information (Huber, 1982; Huber and Daft, 1987), their ability to react to external environmental

uncertainty (Earl and Hopwood, 1980; Daft and Lengel, 1986; Huber and McDaniel, 1986) and advances in technology (Huber and McDaniel, 1986; Mentzas, 1994). There is an abundance of literature pertaining to the many dimensions of organisational decision making within the organisation science, management science and decision theory domains, as well as within Information Technology and the Information Systems domain. The focus of this research is on behavioural decision making and the relevant decision support make available primarily, through the use of Information Technology and Information Systems.

Section 2.2 provides an overview of some of the constituent theories in relation to organisations and organisational decision making, that is: organisational strategy and the associated types and structures of organisations, and how these in turn impact upon the decision making environment. The nature of managerial work and the role of the manager as decision maker are discussed in section 2.3, as ultimately, organisational decision making is a function of organisational managers. The research focus of this study is on the behavioural and the cognitive theory of decision making. Literature relating to decision making models is discussed, as well as the use of these models by decision makers when engaged in the daily managerial role. The limitations inherent in a human being's capacity to solve problems and to make decisions are considered. Essentially, human beings struggle with complexity, while simultaneously the decision problems facing organisations become increasingly complex, all due to the fact that the decision environment is volatile, and because the availability and nature of information remains inconsistent.

The support available for decision makers is the subject of Section 2.4, and in particular, how decision makers are supported through the provision of Information and Information Systems. The evolution of Information Systems which have been designed with decision making in mind, namely Decision Support Systems, is considered in Section 2.5, providing an understanding of the use of information and of Decision Support Systems by decision makers. Finally, in Section 2.6, we consider how Decision Support Systems have been evaluated in the extant literature.

2.2. Organisational Decision Making

The constituent literature pertaining to our view of organisations, the types and structure of organisations, and how these subsequently affect the decision making environment, provides a rich background for this research (Barnard, 1938; Pettigrew and Pettigrew, 1973; Miles, Snow, Meyer and Coleman Jr, 1978; Mintzberg, 1979; Berkeley and Humphreys, 1982; March and Simon, 1993; Cocks, 2010; Johnson, Whittington, Scholes and Pyle, 2011). Organisational decisions are decisions made by entities within the organisation on behalf of an organisation (Huber, 1981). The decision making entity may be an individual, for example an executive or a manager, or may be a group of actors within the organisation, where the decisions do not relate to personal purposes but to organisational purposes, and are made to fulfil organisational needs (Barnard, 1938; Huber, 1981). The purpose of this section is to consider aspects of organisational strategy and structure that shape the organisational decision making environment. Organisational strategy and structure are interdependent, determining the activities the organisation pursues and the appropriate application of the necessary coordinating mechanisms. Strategic management accentuates those strategies and section 2.2.3 argues for a strategic visionary style of leadership that incorporates imagination, inspiration, insight, foresight and sagacity, because this is essential for organisational decision making in a complex and uncertain environment. This research considers a behavioural decision making perspective and is informed by the seminal body of literature of Herbert Simon (1955; 1956; 1957; 1977; 1997), March and Simon (1958, 1993) and Cyert and March (1963).

2.2.1. Images of Organisations

Many researchers present images of organisations as metaphors, as a way of describing and of furthering an understanding of organisational characteristics and their interrelatedness. Using metaphors implies "*a way of thinking and a way of seeing….. which exerts a formative influence on our*

language, and on how we think,… on how we express ourselves" (Morgan, 1997, p.4). While a metaphor allows the reader, and indeed the researcher, to identify and highlight similarities in a non-complex and insightful way, the metaphor may also present an image which is "*incomplete, biased and potentially misleading*" (Morgan, 1997, p.5).

Morgan (1997) presented organisations as any one of eight metaphors: organisations as machines; organisations as organisms; organisations as brains; organisations as cultures; organisations as political systems; organisations as psychic prisons; organisations as flux and transformation; and organisations as instruments of domination. The use of so many metaphors illustrates the difficulty when researchers endeavour to describe and analyse 'organisations' in a comprehensive manner. However each metaphor brings an added dimension to our understanding of the constituents of what an organisation is, the structure which facilitates the activities engaged in, the associated processes and procedures, the internal and external influences, to name but a few of the constituents of organisational theory. The focus of this research is on organisational decision making and therefore the consideration of organisational theory is limited to providing an overview of those aspects of organisational theory which have a direct effect on organisational decision making.

2.2.2. Organisational Strategy and Structure

There is an abundance of existing research literature on organisational strategy. Strategy may be broadly conceived of as a course of action for achieving an organisation's purpose (DeWit and Meyer, 2004) and is generally associated with the long-term goals and objectives of an organisation, as well as the necessary activities and resources required to achieve those stated goals and objectives. The current core activities as well as the possible and emergent activities which will be realised and enabled in the future are included in strategy (Johnson *et al.*, 2011).

Within an organisation, strategy is generally considered at three organisational levels: corporate, business and functional, with a hierarchical

relationship among these strategy levels. As one moves from corporate level strategy to business level strategy to functional level strategy, one moves 'downwards' in terms of organisational hierarchy. The need to link the corporate, business and functional levels of strategy underlies the importance of coordination and integration across the levels so that interdependent units or departments can achieve "*a unity of effort*" (Lawrence and Lorsch, 1967, p.4). The level of integration indicates the level of coordination and collaboration that exists between departments when interdepartmental processes are required to achieve organisational objectives. They identify integration mechanisms including rules and regulations, formal plans and the organisational authority hierarchy, and postulate that a turbulent and complex environment requires a highly integrated strategy process which will ensure that the subunits or departments will not proceed in different directions, and instead work as a cohesive team towards achieving organisational goals. Ansoff (1968) recognises 'strategy' as "*decision rules and guidelines*" required by an organisation for its "*orderly and profitable growth*", while acknowledging that a stable environment is required when implementing such a strategy. However Mintzberg (1994) concludes that "*strategic planning is actually incompatible with serious strategy making*" as strategic planning determines a perceived known future based on a known past. For the most part, an organisation's strategy is designed to evolve the organisation in an advantageous manner more rapidly than their competitors can (Brown and Eisenhardt, 1997).

The different levels of strategy and the type of integration that is dealt with at each level are identified by Schendel and Hofer (1979) as presented in Table 2.1. This representation indicates a downward communication and strategy setting scenario.

Strategy level	Issues addressed	Integration level
Enterprise	Governmental and regulatory impact	Total organisation
Corporate	What business should we be in? How should different business units be integrated?	Business and Corporate Portfolio
Business	How should the firm compete in a given business?	Functions and Business
Functional	Resource deployment and achievement of objectives?	Sub functional and Function

Table 2.1. Different levels of strategy (Schendel and Hofer 1979)

Decisions made at an organisational level constrain strategic options at every other level, especially those below it. Constraints setting is one of the themes of Humphreys (1989) research, which points out that during the decision making process, options discarded by executive level management are rarely re-visited, as the only option presented to the lower level management is focused on the outcomes of decisions already made by the higher levels of management. Clearly, strategy happens because people do things. "*Organisational Structure gives people formally defined roles, responsibilities and lines of reporting with regard to strategy. Systems support and control people as they carry out structurally defined roles and responsibilities*" (Johnson *et al.*, 2011, p. 431)

The structure of an organisation can be regarded as the way an organisation divides its labour into distinct tasks, and then achieves coordination amongst them (Mintzberg, 1979). The structure can also be viewed from the perspective of authority pertaining to the chain of command inherent within an organisation. The chain of command will normally evolve from the strategic apex, reflecting a hierarchical view of organisational structure, which determines the bargaining subgroups within the organisation (Pettigrew and Pettigrew, 1973). Coordinating systems include standardisation of work practices and supervisory procedures, which are influenced by the structure and functions of a particular organisation. "*Coordination is the process through which people arrange actions in ways that they believe will enable them to accomplish their goals"* (Quinn and Dutton, 2005, p. 36).

Metaphors are regularly used to describe different structures for organisations. Mintzberg (1979) described five types of organisation structure, each unique, with its own characteristics, environment, needs and resources. These are: a simple structure; a machine bureaucracy; a professional bureaucracy; a divisionalised form; and an adhocracy. While different structures are associated with different situations, for example a simple structure is appropriate for a small organisation; effective organisations achieve internal consistency due to the coordinating systems applied, regardless of structure type. The coordinating systems are determined by the primary driving force that sets the organisational direction (Mintzberg, 1979).

Miles *et al.* (1978) consider organisational structure from the perspective of organisational function and of a coordination mechanism. They classify organisations, within a given industry type, as one of four distinct types: a prospector type, where success is achieved through finding and exploiting new product and market opportunities; a defender type, where stability is achieved through excellence in a niche area; an analyst type, where achieving a balance between the inherent risk of pursuing prospector type opportunities and the defender type caution, is aspired to; and a reactor type, which is a 'residual' strategy when none of the other three strategies is followed, and is, in effect, an ad-hoc organisational response. Each organisation type responds according to type when reacting to problems associated with its internal and external environment. Interestingly, while all four types occur within each industry type, individual organisations choose unique strategies to adapt to their external environment, which defines the organisations product-market domain and strategy. This in turn will influence not just the organisation's structure but also its choice of technology and process adoption that is employed for production and distribution standardisation, as well as its administrative processes (Miles *et al.*, 1978).

Other researchers have viewed organisational structure through a different lens and from a different focus of organisational activity. Organisational decision making is considered a key organisational activity, and Huber and

McDaniel (1986) advocate that organisations should be designed to facilitate organisational decision making, since "*effective organisations are those whose decisions are of high quality*", especially when the organisational environment is "*hostile, complex and turbulent*" (p. 573). Greater levels of turbulence indicate a demand for more frequent and faster organisational decision making and organisational structure can influence its effectiveness. Equally a greater level of complexity and hostility in the organisational environment heightens the demand for higher quality decisions. The organisational environment is defined as "*the totality of physical and social factors that are taken directly into consideration in the decision making behaviour of individuals in the organisation*" (Duncan, 1972, p.155). Huber (1981, p.3,4) presented four organisation types as conceptual models for portraying and interpreting organisational decision making. The four conceptual models are: 1) the Rational model: organisational decisions are consequences of organisational units using information in an intentionally rational manner to make choices on behalf of the organisation; 2) the Political / Competitive model: organisational decisions are made as with the Rational model, but with a political and competitive influence due to the interpretation of organisational goals and associated reward systems; 3) the Garbage Can model: organisational decisions are consequences of intersections of problems looking for solutions, solutions looking for problems, and opportunities for making decisions (Cohen, March and Olsen, 1972), emphasising aspects of chance and timing; and 4) the Program model: organisational decision making is affected by standard operating processes and procedures, structure and norms. Huber (1981) categorised the four models to provide a framework for interpreting organisational decision making, and in particular, as a way of interpreting and articulating the organisational aspects of the environment thus, providing an understanding of the decision maker's organisational setting and environment. However most organisations have aspects of all four models, suggesting the difficulty in establishing a specific organisational decision making model regardless of organisational structure.

Organisations are complex and multifaceted (Morgan, 1997) and the study of organisations is the study of cooperative systems of human activity, where the individual's actions are coordinated to facilitate the joint survival of the organisation and its members, "*these contributions to survival are accomplished .. [primarily]… through control over information, identities, stories and incentives*" (March and Simon, 1993, p.2). While organisational strategy reflects the activities engaged in by the organisation, structure reflects the functional aspects of organisational activities and processes. The organisational systems provide the coordination and control mechanisms through which the organisational activities and processes are realised.

Strategy, structure and systems are interdependent, and all three should support each other in a circular process of mutual reinforcement, which is referred to as the organisational configuration (Mintzberg, 1979; Johnson *et al.*, 2011). Therefore the activities that managers engage in, and the policies and procedures followed, largely depend on the kind of organisation they are in, the nature of its primary driving configuration and the sources of organisational power (Drucker, 1967; Mintzberg, 1979). While organisations have different structures and follow different strategies, each has to be structured and managed to ensure that the prevailing configuration of the particular organisation is consistent with the primary coordinating mechanisms, and any inherent contradictions are realigned so that they may fit together cohesively and comprehensively.

2.2.3. Strategic Management

In a similar vein of 'strategy and structure' a separate body of research has been written about strategic management (Simon, 1957; Schendel and Hofer, 1979; Pennings, 1985; Westley and Mintzberg, 1989; Eisenhardt and Zbaracki, 1992; Eisenhardt, 2002). Strategic management is the mechanism that develops and utilises the organisational strategy to guide the organisational direction, emphasising strategies which will enable organisational renewal (Schendel and Hofer, 1979). In the classical conceptual idea of managerial work,

strategy making is **the**[2] job of top management (Mintzberg, 1973). Strategy making had been depicted as a deliberate process until Mintzberg (1987) urged managers to endeavour to be creative when developing strategy and he championed the idea of "*emergent strategy*" as opposed to "*deliberate strategy*". Emergent strategy is formulated as a kind of continuous process in which many people take part and is a half-deliberate, half subconscious process that adjusts itself to changing needs and environments. Deliberate strategy is formulated by senior and remote teams of strategists. Mintzberg (1987) speaks of "*crafting strategy*", as a kind of intuitive design when management is essentially creating strategy and implementing strategy simultaneously in a continuous process, whereby the design and the execution are intermingled. Craft, in turn, evokes the notions of traditional skills requiring dedication and perfection through the mastery of detail. *"It is not so much thinking and reasoning that spring to mind as involvement, a feeling of intimacy and harmony with the materials at hand, developed through long experience and commitment"* (Matheson, 2009, p.26). The goals and objectives of strategy making are synonymous with determining 'what' is to be achieved and 'when', but not 'how' the results are to be achieved.

2.2.3.1. The role of the strategic visionary

The concepts of strategy and leadership have been combined into that of "*strategic vision*", with an emphasis on the person as the "*strategic visionary*" (Westley and Mintzberg, 1989). They use the analogy of a drama production to provide a model for visionary leadership in action and to convey the dynamic nature of visionary leadership. The many rehearsals, the performance itself and the audience are all required to deliver the production. The repetition of the rehearsals allows the development of an intimacy with the subject at hand, and in a similar manner, the repetition of dealing with strategy as 'craft' facilitates

[2] Emphasis based on the original Mintzberg work

learning the 'craft' of strategising. This idea is embodied in the model presented in Figure 2.1.

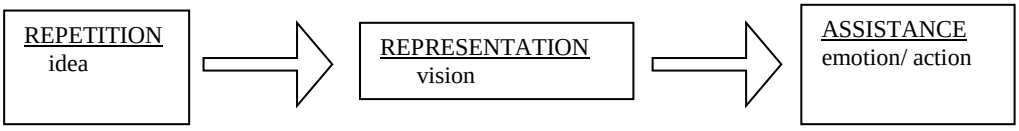

Figure 2.1. Using drama to describe visionary leadership (Westley and Mintzberg, 1989)

The visionary leader will exercise influence with the objective of goal achievement (Mumford, Zaccaro, Harding, Jacobs and Fleishman, 2000). Strategic visionaries use their familiarity and their experience of the business and of the organisation's products and markets to add value by building new perceptions to replace old practices, and thus develop more strategic perceptions for the future direction of the business (Westley and Mintzberg, 1989). In the 'drama' analogy, action and communication occur simultaneously, often through the use of improvisation. The production is the vision articulated, "*the vision represented and communicated, in words and in action*" (Westley and Mintzberg, 1989). The strategic visionary influences and entices their followers to understand and embrace the communicated idea. Finally an audience is needed, but not a passive audience, because the audience provides 'assistance' with feedback. While improvisation is generally considered a characteristic of the performing arts genre, the extent of improvisation is still carefully managed. In the organisational context, the visionary leader will drive through the desired strategy by involving the main players (the managers) as well as the other organisational actors. Therefore, organisations need to cautiously change to match new environments while maintaining their stability and structure (Zack, 2000).

Visionary styles, as depicted in Table 2.2, are symbolised by five visionary leadership style types identified in a study by Westley and Mintzberg (1989). A visionary leadership style may vary from leader to leader, but some important "*management capacities*" have been characterised across all styles such as imagination, inspiration, insight, foresight and sagacity. Strategic vision can be

derived from a combination of these capacities, with some capacities more prominent than others according to the individual leadership style. Each leadership style reacts in a different way to other organisational actors. Both the creator style and the idealist style are less dependent on other actors, depending instead on sudden moments of introspective imagination and inspiration, whereas the proselytizer is dependent on others and current situations to stimulate their vision resulting in a more emergent vision for the future.

Characteristic style	Salient capacities (personal)	Process	Organisational content
Creator	Inspiration, imagination, foresight	Sudden, holistic, introspective, deliberate	Start-up, entrepreneurial
Proselytizer	Foresight, imagination	Emergent, shifting focus, interactive, holistic	Start-up, entrepreneurial
Idealist	Imagination, sagacity	Deliberate, deductive, introspective, incremental	Turnaround, public bureaucracy
Bricoleur	Sagacity, foresight, insight	Emergent, inductive, interactive, incremental	Revitalization, turnaround, private and public bureaucracy
Diviner	Insight, sagacity, inspiration	Incremental, sudden crystallization, interactive	Revitalization, bureaucracy

Table 2.2: Variations Of Leadership Style, adopted from Westley and Mintzberg, (1989)

The term "*bricoleur*" refers to a common figure in France, a man who frequents junkyards and there, picks up stray bits and pieces, which he then puts together in a do-it-yourself fashion, to make new objects. In an organisational context the bricoleur is someone who can create order from chaos, using the local context and leveraging the world as defined by the situation (Ciborra, 2002). The bricoleur and the diviner styles refer to visionary leadership within bureaucracies. Insight and sagacity are common capabilities identified as necessary to understand and deal with people in a politicised environment. While a characteristic or prominent style may be indicative of organisational type according to Westley and Mintzberg (1989), the overlap of the characteristics associated with those referred to in the Table 2.2 under the headings of "*salient capacities*" and "*processes*" indicate that the decision maker must surely bring

aspects of many visionary styles into play, while making decisions when working in a day-to-day operational context (Westley and Mintzberg, 1989).

2.2.3.2. The need for strategic leadership

The connection between organisational outcomes – strategies and effectiveness, and the characteristic style of top management is the subject of the Hambrick and Mason (1984) paper, as very often the "*organisational outcomes – strategic choices and performance levels – are partially predicted by managerial background characteristics*" (Hambrick and Mason, 1984, p.197). Additionally, Hambrick, Cannella and Pettigrew (2001) emphasise that strategic leadership theory refers to the study of the people who are the executives in the organisation and are referred to as the 'upper echelons' by Hambrick and Mason (1984). Executives exercise positional power and influence to achieve their goal objectives (Mumford *et al.*, 2000), but the level of discretion and latitude of action that the executive is afforded will determine the scope and the timing of their decisions (Hambrick and Finkelstein, 1987). The central idea of the 'upper echelons' theory reflects the same emphasis on the personalised style of top management and its influence on the organisation, which is compounded when the "*top management team's collective cognitions, capabilities and interactions*" are taken into account. Cognition involves the acquisition and interpretation of information, the storage and retrieval of memory, the formation of judgement and choices and the motivation involved (Hambrick and Mason, 1984, pp. 334-343). The 'upper echelons' theory was revisited by Hambrick in 2007, and the influence of top management over the fate and form of their organisations was again emphasised as "*executives' experience, values and personalities greatly influence their interpretation of the situations they face and, in turn, affect their choices*" (Hambrick, 2007, p.334). Therefore understanding the role of executives and managers is fundamental to understanding the decision choices made by them, when endeavouring to interpret and resolve the decision problems encountered in organisations.

An alternative view based on organisational theory (Pettigrew and Pettigrew, 1973; DiMaggio and Powell, 1983) indicates that executives have very little influence and effect because of the normative, regulative and societal forces at play in organisations which constrain executives by a multitude of conventions and norms or environmental and inertial forces (Lieberson and O'Connor, 1972). However Cohen et al (1972) consider the organisational theory view of decision making as a description of what 'ought' to be done, while the behavioural view of decision making is more consistent with 'actual' decision making processes (Cohen *et al.*, 1972). The behavioural view also acknowledges the seminal body of literature on decision making attributed to Herbert Simon (Simon, 1955; 1956; 1957; 1977; 1997), March and Simon (1958, 1993) and Cyert and March (1963). The behavioural decision making view informs this thesis and is consistent with the research domain under discussion.

2.2.4. The nature of strategic problems and decisions

Organisational decision making is formally defined as the process of identifying and solving problems (Daft, 1998) Organisational decisions are strategic if they have profound implications for the organisation, and are often "*significant, unstructured, complex, collective and consequential*" (Ackoff, 1974; Pennings, 1985). The importance of strategic management decision making is central to the Mintzberg *et al.* (1976, p.246) definition of 'strategic' as "*simply meaning important, in terms of the actions taken, the resources committed or the precedents set; and a decision as a specific commitment to action*". This definition is the basis for Eisenhardt and Zbaracki's (1992) paper looking at those infrequent decisions made by top management in an organisation that "*critically affect organisational health and survival*" (p.17). However, the need to make decision choices happens on a day-to-day basis and the responsibility for these choices "*normally falls within the purview of top management*" (Hambrick and Snow, 1977, p.109).

Strategic problems have frequently been referred to as 'messes' (Ackoff, 1979) and 'wicked' (Rittel and Webber, 1973) and are considered as: significant;

complex in themselves, and having independencies with other complex problems; ill-defined with no single way of explaining discrepancies; difficult to clearly understand; difficult to formulate the exact nature of the problem and the interdependencies; and are often not replicable (Mason and Mitroff, 1973; Rittel and Webber, 1973; Ackoff, 1979). Lyles and Mitroff (1980) found that ninety per cent of strategic problems reported by managers of large U.S. companies could be classified as ill-structured, meaning that there is generally more than one way to both formulate and solve a given problem. Keeney (1982) identified complex decision problems as having the following characteristics:

- High Stakes : Multiple objectives such that the perceived desirability between alternatives is difficult to differentiate;
- Complicated structure, whereby numerous features make it extremely difficult to appraise alternatives in a thorough and responsible manner;
- Not having an overall expert with sole decision making responsibility, but having many individuals who have expertise which must be incorporated in the decision process;
- Decisions must be justified, not just with organisational superiors, but with regulatory bodies and with many other stakeholders.

Therefore, it can be suggested that complexity cannot be avoided; it is part of the decision problem and therefore must be incorporated when realising the decision solution. Managers make strategic decisions on a continuous basis, often motivated by an immediate need for action based on the external competitive environment. Strategic decisions can be a response to environmental change and their effectiveness may be influenced by environmental conditions, such as environmental turbulence and uncertainty (Huber and Glick, 1993). The context of the strategic decision is affected by the environmental stimuli which range from opportunity decisions to crisis decisions and which may change over time. Problems decisions that are imposed on an organisation, as, for example, government regulations, can often be identified as ‘well structured’. However when the environment becomes more uncertain and

more complex it is harder to anticipate external environmental events, and therefore the problems associated with incorporating government regulations, become both more complex and unstructured (Lyles and Mitroff, 1980). Drucker (1999) points to the need for systematic innovation in the exploitation of the unexpected and unplanned for successes as a result of external environmental influences.

It may be contended that strategic decisions are considered as potentially having a significant impact on the organisation's current or future strategy, and as such will demand the attention of the organisation's decision makers. In many decision scenarios, the organisational context adds a complexity beyond that inherent in the decision scenario itself. Within this context, the role of the decision maker in the decision process is discussed in the next section.

2.3. The Manager as Decision Maker

The role of the manager as significant in an organisation has been recognised in a hundred years of Operational and Organisational research. In the early days of Operational research, the roles of entrepreneur and manager were categorised as being very different. The role of entrepreneur was interpreted as that of a leader, an innovator and owner and often as an heroic figure (Schumpeter, 1934), while the role of manager was perceived as the rational decision maker without decisional discretion, who acts to simply maximise profit (Mintzberg, 1990). However, more recent management science thinking recognises the combined requirements of leadership and management, as management without leadership encourages an uninspired style, and leadership without management encourages a disconnected style (Gosling and Mintzberg, 2003). This combined requirement reflects the complexity of contemporary management (Rowley, 2006). This section considers the role of managers in an organisational setting and in particular their role as decision maker. Decision making is inherently a human activity, and the focus in this research is the influence of human cognitive behaviour on decision making activities and decision outcomes. The decision making environment is extremely complex and

decision makers utilise models and frameworks that enable them to simplify and contextualise their decision environment. A number of such models and frameworks are discussed and in particular, a 1985 framework by Humphreys and Berkeley (1985) is considered in some detail as a mechanism to represent and thereby understand the cognitive evolution of complex decision problems.

2.3.1. The role of the manager

Managerial work had been identified as 'difficult to define' over many years of research in the area (Carlson, 1951; Mintzberg, 1973; Stewart, 1982). A body of literature exists which considers managers as rational beings, whose work on a day to day basis is taken up with 'classic' managerial tasks such as planning, organising, controlling, coordinating and commanding; terms introduced by the French industrialist Henri Fayol in 1916. These terms describe the distinctive characteristics in the process of management, and continue to be used by writers today, even if some of the terms have a variation on the term, reflecting the changing behavioural preferences over time. For example the term 'motivate' began to be used in the 1970s, in preference to 'control' (Stewart, 1982). A number of studies originated from Sune Carlson in 1951 who studied managerial behaviour and sought to analyse management activity, where the actual time usage of managers was recorded, and which found that most of top management time was taken up with the demands of others. This highlights the fragmented nature of managerial work. Over twenty years later Mintzberg's study recognised how senior executives spent considerable time as '*ad hoc respondents to unforeseen situations*', on a variety of activities which resulted in managers being very busy, frequently interrupted and having little control over their time, and where action is more important than reflection (Mintzberg, 1973). Mintzberg noted, that of many of the various tasks performed daily by the CEO, half took less than ten minutes to complete, while only ten per cent took more than one hour to complete. Most activities incorporate several roles, with potential for either role conflict or role ambiguity. Managers are always under pressure, always 'firefighting', always working to find, not necessarily the best

solution to a given problem or solution, but the solution that may be implemented given the time and resources available, which is referred to as a "*satisficing*" solution (Simon, 1957) .

Mintzberg's (1973) study of top managers suggests that managers perform ten major roles that can be classified into three major categories: interpersonal, informational and decisional. Interpersonal roles are those associated with communication as a figurehead, as a leader and liaison officer. Informational roles include the monitoring, acquisition, understanding and disseminating of information, while decisional roles consider the decision making aspects of the manager's job at the different levels within the organisation. However the three roles are not easily separated, and need to be considered as an "*integrated whole*" (Mintzberg, 1973). The authority bestowed, and the privileged information position held by managers, enables them to make decisions within the organisation. Floyd and Wooldridge (1996) focus on the key roles of middle managers, who synthesise information, and who facilitate a more adaptable approach towards the implementation of strategic decisions. The differences in the decision making focus between that of the CEO, and middle level managers, is also highlighted by King (1985), as the role of the CEO should incorporate an understanding of both the internal and the external business environment and its complexities, while the role of middle managers or analysts includes actually '*performing'* the analysis (King, 1985; Drucker, 1995).

Barnard in 1938, contended that organisational decision making was more logical than personal, because organisational goals are explicitly stated and therefore provide specific objectives and organisational direction. Barnard defines 'decisions' as the "*acts of individuals which are the result of deliberation, calculation and thought*" and he considers decision making as a logical process of discrimination, analysis and choice, which is fundamental to the functions with which executives engage (Barnard, 1938, p.185). Decision making as pertaining to organisational objectives and direction is fundamental to Kotter's (1982) study of effective general managers, who identified two broad categories of activity: (i) "*agenda setting*" which is developing loosely connected goals and plans that

address their long, medium and short-term responsibilities, and (ii) "*Network building*" which is developing a network of cooperative relationships both internal and external to the organisation. The network includes people who may be relied upon to have information about particular areas of the business. Information is obtained on a continuous basis through discussion, both formal and informal via different network members.

The importance of decision making is emphasised as a key managerial function of senior executives (Barnard, 1938; Simon, 1957; Drucker, 1967; 2006). Senior executives are those in positions of responsibility, decision making and authority: *To make decisions is the* ***specific***[3] *executive task.... Effective executives do not make a great many decisions. They concentrate on the important ones. They try to think through what is strategic and generic, rather than 'solve problems'. They make a few important decisions on the highest level of conceptual understanding* (Drucker, 1967, p.95). From Herbert Simon's perspective, *management* is equivalent to *decision-making*, and strategic decision making is considered crucial to ensuring organisational advantage , as decision making is "*the central activity in which the organisation is engaged*" (Simon, 1973, p.270). Making clear-cut decisions when needed is considered one of the key constituents of what makes a good manager. Many of these decisions may trigger many other decision problems at other levels in the organisation, as well as action requirements throughout the organisation.

2.3.2. The role of the decision maker

Decision making is inherently a human activity, as defining a human attribute as language itself (Damasio, 1994). Traditionally, Information Systems researchers have started from the assumption that any decision has its origin in a dissatisfaction (Pounds, 1969). Typically, the dissatisfaction arises from the difference between the current state of affairs (as perceived by the decision

[3] Emphasis in original Drucker text.

maker), and another, not yet existing, more desirable state of affairs. This difference can be called *"the decision problem"* (Pomerol, 1997, p. 4), and it is illustrated in Figure 2.2.

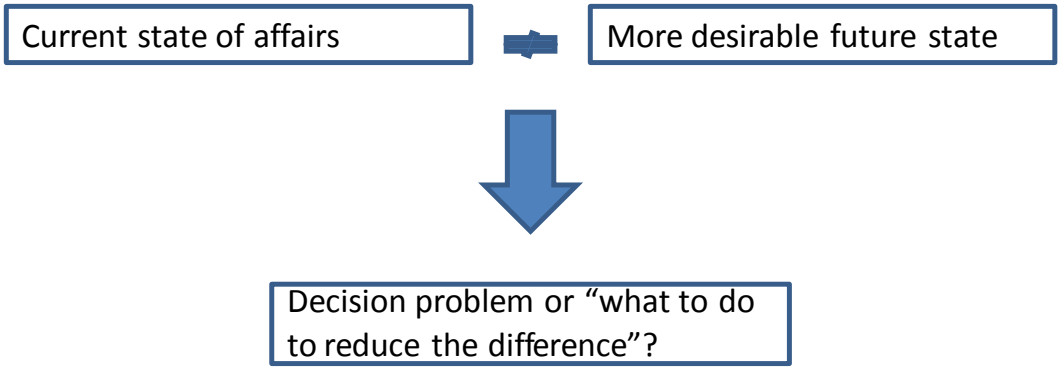

Figure 2.2. The decision problem (Pomerol, 1997)

Any imaginable course of action may be considered at this stage of the decision process. The model depicted in Figure 2.2 highlights the individual dimension of decision making in that, what is wanted by one person may not be desirable for another. Identifying what problems to solve is a key part of a manager's job, and is often based on past trends or on projected trends. The present shapes the future, and is shaped by the past, and in particular the recent past experience of the decision maker (Pounds, 1969). Before making a decision, managers must first recognise the current state by searching within *the "problem space"* (Newell and Simon, 1972). Problem formulation requires the manager or decision maker to frame the context of the current state, and is much more difficult than understanding the techniques that may solve it. Management frequently report the formulation of the problem as their greatest difficulty (Pounds, 1969). However, managers can evaluate the current state, and are able to make comparisons regarding the current state, based on their experiences to date (Pomerol, 1997).

Managers build up experience over time, and the assessment of the current state is conditioned by, and contains information about the past and the

future. In many situations, redundant information is retained by the manager because redundant information is an automatic 'mistake-catcher' (Miller, 1953). In other words, managers know a part of what happened before the present and have their own perception of what may occur in the near future. Then, bearing in mind their perception of the current state, managers try to identify it with reference to their experience. The many recorded situations or states they have already met or have learnt about are called 'recorded states' (Pomerol, 1997). The first phase of decision making then, consists of finding one or several recorded states close to the perceived current state. This operation is labelled 'diagnosis' (Pomerol, 1997) and, depending on the context and complexity of the recorded states, it may be more or less certain. An accurate diagnosis is more certain in circumstances that are very similar to those already encountered, and less certain in circumstances that are substantially different from previously encountered situations. The decision process as suggested by Pomerol (1997) is depicted in Figure 2.3 below.

Diagnosis is not straightforward, as problems "*do not present themselves to the decision maker in convenient ways*" (Mintzberg *et al.*, 1976, p.253) and, as Keen and Scott Morton (1978) noted, never come "*neatly packaged"*. Instead of discreet decisions, decision makers face "*problems and messes*" made up of multiple, interrelated problems (Ackoff, 1994, pp. 184,185). Matching appropriate action to recognised situations is considered an important aspect of the intuitive type of behaviour of experienced decision makers and experts (March and Simon, 1993).

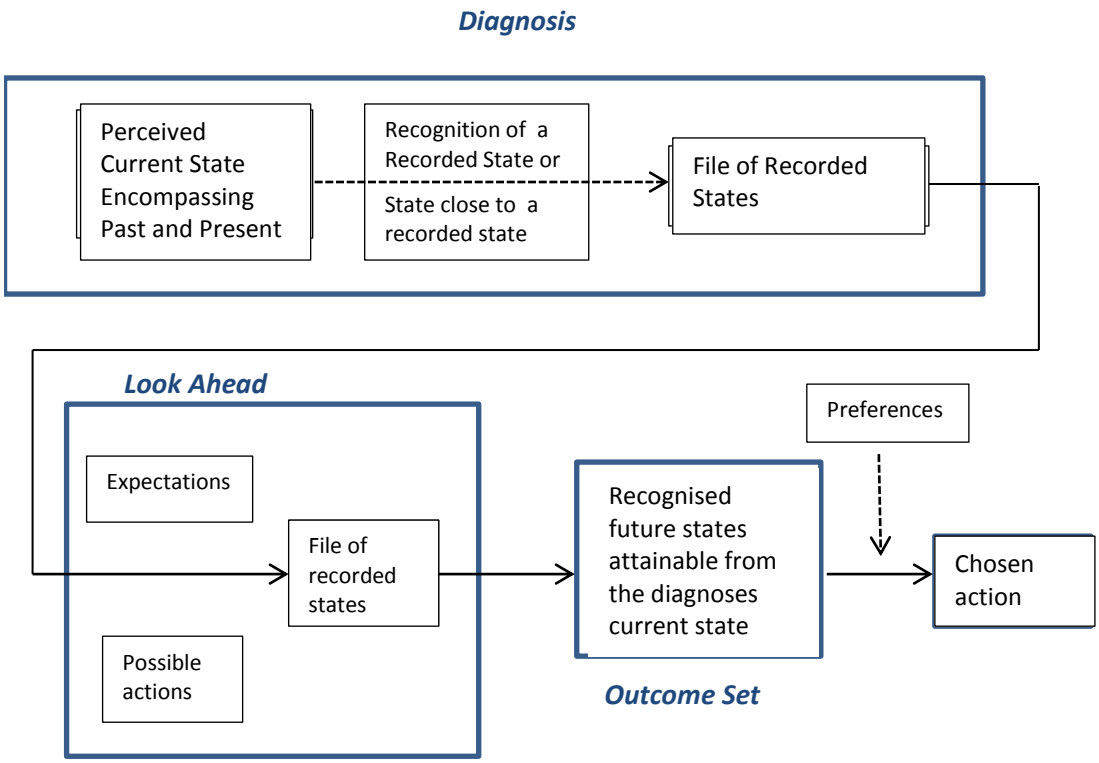

Figure 2.3: Modelling the Decision Problem (Pomerol 1997)

Diagnosis emphasises the roles of interpretation and of judgment, which are inherent elements of the decision maker's endeavours to comprehend an issue, and which implicitly determines the subsequent course of action in decision making (Dutton, Fahey and Narayanan, 1983). Managers will have some experience from the past, and will use the learning gained from that 'prior' experience to identify with the perceived current state, and where possible, will 'pattern match' or 'diagnose' and find one or more past experiences that can then be matched with the current problem (Pomerol, 1997). Diagnosis is therefore dependent on the decision maker's own reservoir of recorded actions, events and situations (based on past experience), as well as their interpretation of these within the current problem context. There are times when the 'file of recorded states' will be an accurate diagnosis of the current situation, but there are also times when the diagnosis is uncertain because the recorded states may be inaccurate. While the decision maker may have previously experienced some similar situations, it is difficult to remember precisely what happened, as well as

to understand exactly the context of the current decision problem. Moreover superficial similarities between the past experience and the present scenario may mask deeper differences (Weick and Sutcliffe, 2001).

The Pomerol (1997) decision process model (Figure 2.3) differentiates between the decision maker's understanding of the current decision problem based on the set of recorded states, and their understanding of the decision problem based of their expectation and their analysis of the future expectation of the outcome. These two elements are referred to as '*diagnosis'* and '*look ahead'*. '*Look ahead'* is concerned with behaviour after the decision problem diagnosis. After diagnosis, many states are attainable with different probabilities that depend on the various expectations and preferences of the decision maker. Indeed, in the world of managers, the decision problems being considered very often result in much uncertainty, and consequently, difficulties emerge because future states are not known with any degree of certainty. Expectations may be influenced by preferences, and the set of 'recorded states' under consideration can be modulated by the feasibility of the possible actions. In 'look-ahead' mode, the decision maker's imagination is once more influenced by their own file of 'recorded states', which further influences expectations and preferences.

The set of the "*recognized future states attainable from the diagnosed current state*" may be viewed as the 'outcome set' of the decision process. Once again, the preferences of the decision maker may also be applied to this outcome set, and the preferred outcome defines the action chosen by an individual i.e. their decision or decision strategy. Thus, the elements of the outcome set incorporate the possible goals (or objectives) of the decision maker, based on what is thought to be attainable or not attainable, from among the attainable states. Pomerol (1997, p. 6) considers "*a goal is the outcome that the decision maker wants to attain …. and is the result of a complex alchemy, combining possible actions, recorded experiences, expectations and preferences*".

For the most part, the separation of 'diagnosis' and 'look ahead' does not happen in reality, where the current state is normally recognised with a greater degree of certainty, and future states are not known with certainty. In an

uncertain setting, it may happen that many states are attainable with different probabilities, and the chosen action is determined by the evaluations of the decision maker. March and Simon (1993) describe two possible 'logics of action' to differentiate the reasons certain actions are chosen. They refer to the decision maker's preferences as a "*logic of consequences*" (p.10), whereby decision makers assess the expected subjective value of alternative courses of action, and choose their preferred 'outcome set' based on their heuristic search and a satisficing rationality. The second logic considers a matching of rules to situations based on what is attainable or not attainable, and is a "*logic of appropriateness*" (p.10), which is "*linked to conceptions of experiences, roles, intuitions and experiential knowledge*" (p. 8). This is influenced by the recorded experiences and the expert knowledge of the decision maker, who is familiar with the situation, as well as, by their expectations and preferences which will facilitate the need to purposefully and explicitly rationalise their actions (Lederman and Johnston, 2011).

2.3.2.2. Cognition

It is evident that decision makers learn from experience when the outcome from previous encounters is known, and switching between elements of both judgement and analysis is inherent in decision behaviour (Payne, 1982; March and Simon, 1993), and is influenced by cognitive style. Mason and Mitroff (1973) suggest that every person exhibits a particular specific psychological cognitive style and that each style utilises information in different ways. A number of intellectual processes are subsumed within the term cognitive style. These concern the way in which information is acquired or formulated, analysed and interpreted. Cognitive style includes such human activities as information filtering and pattern recognition (Sage, 1981), which are fundamental to the formulation and diagnosis of the decision problem.

Mintzberg, in the retrospective commentary of the 1975 HBR article, reprinted in 1990, noted that "[a] *renewed interest in strategic vision, in culture, and in the roles of intuition and insight is necessary, ... as managing insightfully*

depends on the direct experience and personal knowledge that come from intimate contact" (p.171). March and Simon (1993) also consider intuition an important component of the experienced decision maker's skill set, especially those with domain expertise who have become familiar with complex scenarios through past experience, as intuition is considered as an unconscious process of making decisions on the basis of experience and accumulated knowledge. Accordingly intuition should be viewed as a valuable weapon to be used to counteract an overreliance on a purely sequential or analytical practice (Paprika, 2008). Klein (1993) argues that very little rational decision making takes place when an expert recognises a situation as of a kind previously encountered. Instead the expert retrieves a cognitive schema that provides the basis for a solution in a process which Klein terms "*recognition-primed decision making*". The process involves some explicit reasoning, but the significant action is the automatic retrieval process (Evans, 2008).

However, March and Simon (1993) contrasts the attitude to intuition whereby, on the one hand, the concept of intuition can be glorified as 'insight' or 'creativity' when successful outcomes occurs; and on the other hand, deemed as 'blind-spots' and 'jumping to conclusions' when decision outcomes are less than optimal. The distinction between intuition and deliberate thought processes has been considered within a dual process perspective in recent years (Stanovich and West, 2000; Kahneman, 2003; Dane and Pratt, 2007; Evans, 2008; Kahneman, 2011). A neutral notation, devised by Stanovich and West (2000), refers to the two processes as *System 1* and *System 2*, and this notation has been adopted by many other researchers (Kahneman, 2003; Dane and Pratt, 2007; Evans, 2008; Kahneman, 2011). The System 1 process represents fast thinking, and denotes intuition as being "*more influential that experience tells you"*, with no sense of voluntary control (Kahneman, 2011). System 1 processes are considered relatively effortless (Dane and Pratt, 2007), are non-conscious (Hogarth, 2001), experiential (Epstein, 1998; 2008), natural (Tversky and Kahneman, 1983), and associative (Sloman, 1996). Decision makers *make holistic associations* when they form impressions and intuitions, based on the

recognition of patterns or of structures, and then they match them to environmental stimuli (Dane and Pratt, 2007, p. 37).

The System 2 process represents slower and more reasoned thinking which allows ideas to develop in a deliberate and analytical manner (Hogarth, 2001; Kahneman, 2003; Dane and Pratt, 2007; Evans, 2008; Kahneman, 2011). Rational decision making processes are part of the System 2 processes (Epstein, 2002), and are often, rule based (Sloman, 1996). The impressions and intuitions which are formed by System 1 processes become beliefs and judgements, and require System 2 process intervention. Kahneman (2003), emphasises that judgements are always intentional and explicit, even when they are not overtly expressed, whether the judgement originates from impressions and intuitions or from deliberate reasoning.

While a function of the System 2 process is to monitor the quality of decisions, Kahneman and Frederick (2002) suggest that the monitoring is quite lenient, allowing many intuitive judgements to be expressed, some of which are ignored and some of which are erroneous. While the need for intuition is greatest when the external environment is most turbulent, cognition and experience will have a lesser influence when either some or all of the information sources, the problem characteristics and the manager's goals are changing rapidly and unpredictably (Khatri and Ng, 2000; Dane and Pratt, 2007). Therefore, it is reasonable to acknowledge that many decisions are compromised and the decision outcomes do not achieve the intended benefit for the decision maker or for the organisation, despite many intelligent decision makers using all the analytical and intuitive know-how acquired through years of training and experience, as well as guidance derived from the organisational rule-based structure. Some of the decision process models and routines which have been prescribed as best-practice for decision making are discussed in the next section.

2.3.3. Decision making process models

A number of researchers have contributed a variety of models of the decision making process, at each of the levels in the organisation - corporate,

business and functional, each with the objective of improving the decision outcome. Models provide a structure which when followed will reduce uncertainty by increasing structure.

March and Simon (1993) have claimed that organisations use programmed responses to routine situations, and decision process models normally comprise of variations based on three primary routines, which include i) formulation of the issue, ii) analysis of the issue, and iii) interpretation of the issue. There are many examples of such programmed responses in organisational literature over the last century. As early as 1910, Dewey (1910) put forward five phases of reflective thought, which could facilitate the decision process: i) suggestion (of a possible solution), ii) intellectualisation of the difficulty, iii) development of hypotheses, iv) reasoning or mental elaboration of the hypotheses and v) testing of the hypotheses. In the 1920's, Wallas (1926) identified four steps within 'creative discovery', namely: i) preparation, ii) incubation, during which the unconscious mind mulls over the issue, iii) illumination and iv) verification. The best known and most widely used stage-model was developed by Simon (1960, 1977), who described three stages in the overall decision making process: i) intelligence, ii) design and iii) choice. In the model, intelligence is concerned with the search for and subsequent identification of problems; design involves the development of alternatives and choice and includes the analysis of the alternatives and the selection of one alternative for implementation. A review stage was subsequently added in 1977, to monitor the outcome of the three-stage model. These linear and programmed approaches are recognised as effective when the decision problem is structured and repeatable. However, in reality, very few decisions present themselves in such a manner.

Unstructured decisions are decision scenarios with high levels of uncertainty, or with low frequency of repetition, and involve decision problems that have not been encountered in quite the same form before "*and for which no predetermined and explicit set of ordered responses exists in the organisation*" (Mintzberg *et al.*, 1976, p.246). They propose a three stage model of i)

identification, ii) development and iii) selection. However, recognising the additional complexity associated with unstructured decisions, they separate the elements of 'identification' as comprising 'decision recognition', which determines how opportunities and problems are recognised, and 'diagnosis', which determines how the environmental stimuli are comprehended. Identification is a crucial phase in strategic decision making because diagnosis determines all of the subsequent courses of action in decision making. Simon (1977) indicates that each decision making scenario is a complexity of interrelated decisions and contexts. Each phase or stage in itself can be a complex decision making process, and subsequently implementing the decision is regarded as a part of the decision making process, as essentially all managerial activity may be considered as decision making. Their research indicates that the decision maker, when faced with complex and unknown problems will seek to break down the decision at hand into sub-decisions, to which some general purpose set of known procedures or routines will apply. This enabled Mintzberg *et al.* (1976) to consider that

decisions processes are programmable even if they are not in fact programmed (...) there is strong evidence that a basic logic or structure underlies what the decision maker does and that this structure can be described by systematic study of his behaviour (Mintzberg *et al.*, 1976, p.247).

Nutt (1984) considered all of these models as normative, enabling action-making and ensuring the decision making proceeds through a series of analytical steps to determine needs, develop ideas and assess the merits of the ideas. This normative approach was considered in conjunction with an evaluation of the purpose of each stage or step, and a five-stage approach was developed. The five-stage model includes i) formulation, ii) concept development, iii) detailing of viable alternatives, iv) evaluation and v) implementation (Nutt, 1984). While all of the models discussed have a degree of commonality in their approach to a process, designed to arrive at good decisions, in general there are three main processes, namely formulation of the issue, analysis of the issue and interpretation of the alternatives (Sage, 1981). Each of these main processes has

a number of sub-processes. The five stage model proposed by Nutt (1984) would indicate a more comprehensive and granular approach to the individual stages of the decision processes, as in indicated in Table 2.3., where the models are compared.

Sage 1981	Dewey 1910	Wallace 1920	Simon 1960, 1977	Mintzberg et al. 1976	Nutt 1984
Formulation	Suggestion (of a possible solution)	Preparation	Intelligence	Identification	Formulation of problem
Analysis	Intellectual-isation of the difficulty,	Incubation - unconscious mind mulls over the issue	Design	Development	Concept development
	Reasoning or mental elaboration	Illumination			Detailing of viable alternatives
Interpretation	Testing of the hypotheses	Verification	Choice	Selection	Evaluate merits of alternatives
			Review		Implementation

Table 2.3: Normative models of the decision process

It should be noted, that the main functions of formulation, analysis and interpretation are not discreet activities, and some analysis is performed during the final stages of formulation, and in general, interpretation begins before analysis finishes (Janis and Mann, 1977). Moreover, in empirical research, Nutt (1984) reported that managers do not use the normative methods to any great extent, that not alone are steps not taken in sequence, but managers regularly skip many of the stages which are prescribed within the models for a 'good' decision making process. The "*convergent, insightful* and *interwoven*" models as described by Langley, Mintzberg, Pitcher, Posada and Saint-Macary (1995), present the decision process in a more integrative manner whereby the convergence of decision problem does not happen in a steady and gradual manner, at a moment in time, but instead, progresses "*through occasional*

insights, which are inspired and in turn inspire others" (P. 269). Decision making is complicated and is affected by the intrinsic complexity of organisations.

It is important to recognise that the initial stage of problem formulation has been identified as one of the most critical stages in the decision making process (Mintzberg *et al.*, 1976; March and Simon, 1993; Pomerol, 1997). Problem formulation includes the identification of possible opportunities for the organisation, and the associated problems and threats (Klein and Myers, 1995) and can include very complex problems (Courtney, 2001). Failure to recognise opportunities at this stage may result in lost opportunities (Hall and Paradice, 2005).

However, there is a threshold to the accumulation and interpretation of stimuli which can be absorbed, and once this threshold is reached managers will recognise a given situation as problematic and, subsequently, initiate a decision process (Mintzberg *et al.*, 1976). Moreover, Cowan et al (1986) identified 'important decision makers' as those with the least energy and time to devote to internal decision making, and those who attend to fewer 'choices' of greater significance. Determining the manager's preferences may often be considered of greater significance than following through the prescribed steps of the decision analysis process (Keeney, 1982). Clearly, research indicates that best practice is not followed at each stage of the decision process, and it sometimes describes the process as chaotic. There is ample evidence of good decision outcomes which are attributed to opportunistic or serendipitous circumstances (Nutt, 2001).

The largely linear models described in this section treat 'diagnosis' as an implicit part of problem formulation, and the linear models have been criticised as typically taking '*a given set of options or alternatives*' as a starting point (Dutton *et al.*, 1983). As discussed in section 2.3.2, 'diagnosis', which determines all future options or alternatives considered at a later stage, is a complex process, due to the inherent level of judgement and analysis required on the part of the decision maker. Furthermore the outcomes from diagnosis are complex and varied. Understanding how organisational decision makers make decisions and understanding why decision makers do not adhere to normative practice

requires consideration of the limitations of the decision maker. These limitations include limited time and incomplete information, as well as their limited cognitive and computational ability. These limitations are discussed in the following sections.

2.3.4. Decision maker's limitations: Impact of 'Bounded Rationality'

It is clear that the role of the decision maker is complex, and many of the problem decisions faced by managers are unstructured in nature and require the use of reasoning and human judgment at an individual level. The various models of decision making derived from economic theory present the decision process in a very ordered, logical and rational manner. However many researchers of organisational and individual decision making processes have raised doubts regarding the degree to which human decision making can be analysed as being 'rational', and as reflecting a set of predictable objectives which managers seek to achieve (March and Simon, 1958; Cyert and March, 1963; March and Simon, 1993). Therefore the nature of decision problems faced by managers, as well as the inherent limitations of the decision making capabilities of the managers themselves, indicates that decision making is regularly compromised and consequently the decision outcomes are compromised. Human rationality and rational behaviour in general, has been an important topic of study at least since the classical writings of the Greek philosophers, when rationality was associated with the process of reasoning. Bounded rationality is simply the idea that when people make decisions or choices, there are many factors inherent is human decision making which influence both the process of reasoning undertaken, as well as the outcomes chosen. These factors include the knowledge that decision makers have and do not have; their ability to reason or rationalise that knowledge; their understanding of the consequences of their decision; their understanding of the probabilities of the occurrence of the consequences; to name but a few. Rationality is bounded because of the limitations of human cognitive capability (Simon, 1955).

Prior to Simon's research on organisational decision making and bounded rationality, researchers had used the comfortable hypothesis that in accordance with economic theories, individuals and organisations select the alternative which leads to the preferred outcome of their decisions, which in turn will maximise their utility or their profit (Von Neumann and Morgenstern, 1944). Simon (1957) recognised that a model of 'bounded rationality' was required in situations involving decision making under uncertainty and imperfect competition, and suggested that decision makers construct simplified mental models of reality, when dealing with complex problems. However, while decision makers behave rationally within the confines of their mental model, the model is not always well adapted to the requirements of the real world.

The theory of bounded rationality has as its basis concepts of 'certainty' with regard to complete and accurate knowledge of all consequences of the decision; 'uncertainty' in so far that the consequences of each choice cannot be specifically or emphatically defined; and 'risk' regarding the probability distribution of the occurrence and consequence of each of the alternatives. One of the key mitigating factors, with respect to the limitations inherent in the concept of bounded rationality, is that of 'satisficing', or the alternative of choice meeting the decision makers aspiration as to how good an alternative should be found (Simon, 1957). The choice outcome in a satisficing scenario is normally exercised with respect to a limited, approximate and simplified model of the real situation, for which a finite set of alternatives exist, which may not be known to the decision maker at that time. The idea of limited consequential rationality has become more or less accepted as standard in behavioural decision making theory, and is recognised widely as an accurate portrayal of human judgement and choice during the decision making process.

The alternatives generated and the way they are evaluated are a function of the decision makers' definition of the situation (March and Simon, 1993). The selection is based on the decision maker's set of 'givens', which reflect the decision maker's cognitive base as well as their set of values: principles for coordinating and prioritising consequences or alternatives according to their

preference (March and Simon, 1958; Hambrick and Mason, 1984). Even though the 'givens' are always being updated as new information is acquired, decision makers continue to filter and subsequently distort their perception of a situation. Hambrick and Snow (1977) summarise the process, taking a sequential view as represented in Figure 2.4, where a strategic decision problem is complex and made up of far more phenomena than a person can possibly comprehend.

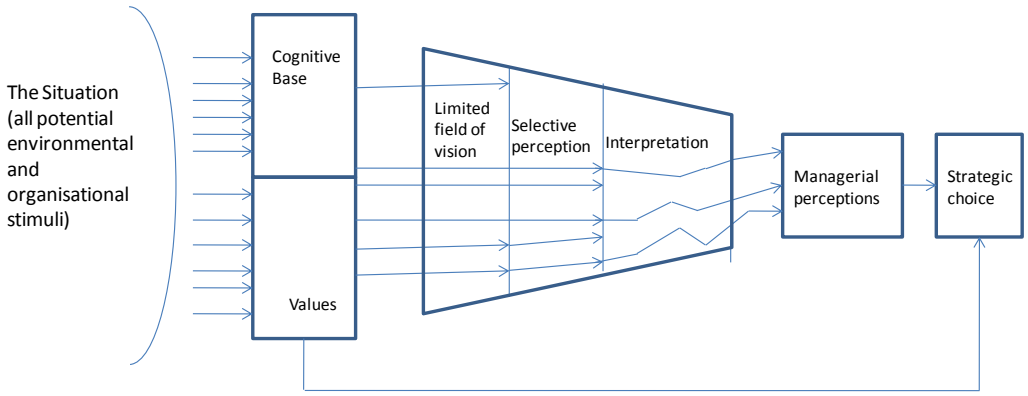

Figure 2.4. Strategic choice under conditions of Bounded Rationality (Hambrick and Snow, 1977)

The manager's 'field of vision' is limited due to the bounded rationality phenomenon. Therefore the manager's perceptions are limited, as individuals selectively perceive only some of the possibilities of the field of vision. Finally, the 'interpretation' of the available information is further filtered through one's cognitive base and value set. Decision makers only use a subset of the information they receive, due to their cognitive limitations. Values may affect perception as well as the choice of alternative, which further influences the interpretation process and therefore the outcome (Hambrick and Mason, 1984). Therefore the concepts, beliefs, assumptions and 'cause-and-effect' understandings of the decision maker determine how the problem will be framed (Dutton *et al.*, 1983). The model (Figure 2.4) presents the flow of information affecting the different cognitive stages, in one direction only, suggesting that it is by successive analysis of the sensory inputs, that a response

is determined. However, there is also an appreciation of the importance of information flowing in the other direction. The process of judgement and choice is comprised of several sub-processes namely: information acquisition, evaluation, action and feedback / learning; all of which interact and influence the next strategic choice in a continuously changing environment, where both the environment and the mind fuse in a continuous fashion (Einhorn and Hogarth, 1981; Hogarth, 1981). Compounding this problem is the fact that when environmental complexity increases, people tend to narrow their focus to familiar environmental cues and information that may blind and mislead the decision maker's interpretation (Weick, 1995), especially when weak signals present themselves in a disjointed fashion and are underestimated.

One of the criticisms of the 'satisficing' concept is that it largely ignores organisational conflict and March and Simon have been accused of considering decision making only where organisational harmony and continuity prevail (Pettigrew, 1973). On the other hand, Cyert and March (1963) regard conflict as a 'normal' part of organisations and acknowledge that "*most organisations most of the time exist and thrive with considerable latent conflict of goals*" (Cyert and March, 1963, p.117). March and Simon (1958, 1993) consider individual conflict within the decision process as arising in three ways: unacceptability; incomparability; and uncertainty; all of which contribute to an inability to reach agreement on a preferred alternative. Unacceptability and incomparability are aspects of the decision makers' perception of the available alternatives and therefore a cause of dissatisfaction with the choice alternatives. Uncertainty influences all the cognitive inputs for the decision maker as well as the perceptions of the available alternatives, and will be considered in greater detail in the following section.

2.3.5. Decision maker's limitations: Influence of uncertainty and complexity

Uncertainty in the context of decision making, has been discussed in research literature over many years and is a characteristic of decisions of the

non-routine kind that individual decision makers in organisations have to make (Eisenhardt, 1989; Sethi, Pant and Sethi, 2003; Elbanna and Child, 2007). Essentially uncertainty exists when the details of a situation are complex, unpredictable or probabilistic, when information is available but inconsistent, or when people feel insecure in their own state of knowledge (Brashers, 2001). Uncertainty is considered as having a negative influence on the decision making process as it "*blocks or delays action*" (Lipshitz and Strauss, 1997, p.150). Conceptualising uncertainty as a sense of doubt that blocks or delays action has three essential characteristics: (1) it is subjective (different individuals may experience different doubts in identical situations), (2) it is inclusive (no particular form of doubt, e.g., ignorance of future outcomes, is specified), and (3) it conceptualises uncertainty in terms of its effects on action (hesitancy, indecisiveness, and procrastination) (Lipshitz and Strauss, 1997). The effect of uncertainty is considered in terms of 'lack of control' over decisions and the associated actions required for the achievement of organisational goals, which results in the inability to act deterministically (Thompson, 1967). Uncertainty reduces effective control because it reduces transparency and predictability with regard to current events and to future events, as well as to their likely occurrence (Milliken, 1987). Drucker (1967, p.92) considers all decision making as a "*risk-taking judgement*".

2.3.5.1. Types of work-related uncertainty

Tushman and Nadler (1978) consider three sources of work-related uncertainty: task characteristics, task environment (internal and external) and task interdependencies. The characteristics of tasks differ in their amount of predictability and thus in the amount of uncertainty which must be dealt with during task execution. The task environment is generally seen as a source of uncertainty, since areas outside the organisation are not under the direct control of the actors in the organisation and are potentially unstable, but exert considerable influence on the internal environment (Weick, 1979). The third source of work-related uncertainty identified by Tushman and Nadler (1978) is

inter-unit task interdependence, which refers to the amount of task interdependence between differentiated functions (sub-units) in an organisation, and is associated with the need for greater and more effective coordination across the functions. The interdependence may involve joint problem solving and decision making, and the resulting additional uncertainty must be dealt with by the respective functions. In such a situation, managers are faced with multiple and conflicting objectives and must make trade-offs in pursuit of their own function's objectives. The resulting conflict is unavoidable as each function is established to ensure that specific functional objectives are realised effectively and efficiently (Thompson, 1967). Similarly, March and Simon (1993) indicate that differences in goals and in perceptions of reality can be a condition for intergroup conflict. The optimal decision problem solution must meet the objectives of all functions or sub-units that are involved. Task interdependencies are an important cause of uncertainty, when a decision maker is not provided with adequate measurement information when endeavouring to manage task interdependencies when roles and responsibilities are ambiguous. Interdependencies will always exist between organisational functions when an organisation is functionally structured. Retaining a significant level of informality of organisational structure will mitigate some of the conflict potential of task interdependence because, the necessary integration and coordination mechanisms will be facilitated more easily (Macintosh and Daft, 1987).

Task complexity and cross function task interdependence are each present as sources of uncertainty and therefore, in need of improved information processing requirements (March and Simon, 1993). As work-related uncertainty increases so does the need for increased amounts of information and thus the need for increased information processing capacity (Tushman and Nadler, 1978), which will enable decision makers decide on how best to deal with the decision problem. Uncertainty is a permanent characteristic of our environment, and managers can be seen to make efforts during the decision process to 'cope' with the unpredictable nature of uncertainty (Thompson, 1967). Environmental uncertainty has been defined as the inability to assign

probabilities to the likelihood of future events (Pennings, 1981), or the inability to understand or predict the future consequences of decisions (Taylor, 1984). Organisations link with their environment, and can influence and shape their environment (Pennings, 1981), which is why environmental uncertainty is an important consideration for managers (Milliken, 1987). Specifically Tushman and Nadler (1978, p.614) note that: "*since organizations are dependent on inputs from the larger environment, and since this environment is at least potentially unstable, the organization must be able to track and cope with environmental-based uncertainty".* Duncan (1972) describes a static / dynamic dimension as an important contributor to perceived environmental uncertainty: the more dynamic or changing the environment, the greater the uncertainty faced by the actors in an organisation. Therefore it is important to develop an understanding of the environmental through continually scanning the environmental and Milliken (1987) differentiated between three perceptual aspects of environmental uncertainty: state uncertainty, effect uncertainty and response uncertainty. 'State' uncertainty, which is also referred to as 'situational' uncertainty means that decision makers do not understand how components of the environment might be changing. This may result in an inability to predict competitors' responses to an unpredictable and changing competitive environment, as well as misinterpreting the external and internal consequences of governmental and regulatory bodies' decisions.

The other two types of environmental uncertainty, discussed by Milliken are consequential to state uncertainty. 'Effect' uncertainty considers the impact of environmental events on the organisation and the organisation's reaction to these events. This includes the implications and consequences for the organisation in terms of the organisation's ability to function in that future state. 'Response' uncertainty is experienced in the context of a need to make an immediate decision when there is a perceived lack of understanding with regard to the range of strategic responses available, and to the relative utility of the possible options. In general there are three sources of response uncertainty:

incomplete information, inadequate understanding of available but ambiguous information, and undifferentiated alternatives.

2.3.5.2. Mitigating the effects of uncertainty

Decision makers at all levels of the organisation are affected by uncertainty. High level executives, in their role as strategic decision makers, and operational personnel making decisions in the course of their day-to-day work processes, are impacted by their individual 'perceptual' existence of uncertainty (Milliken, 1987), when they function in environments where volatility and complexity make their environment less predictable. Therefore, dynamic and complex environments necessitate a movement from the old paradigm of predicting changes to our environments and then reacting to the changes when they happen, to anticipating the environmental changes and increasing the speed by which we create actionable knowledge.

The use of heuristics in decision making when all possibilities cannot be fully explored has been researched extensible (Tversky and Kahneman, 1971; 1974; 1981). Their research highlights the impact of cognitive biases when heuristic judgement is required, often resulting in severe errors of judgement. Sage (1981) lists twenty seven cognitive biases, any and all of which may affect information formulation and acquisition as well as information analysis and interpretation. His analysis is based on previous research on cognitive biases by Cowen, Einhorn, Hogarth, Kahneman, Tversky, Slovic and Wright, over many years. Many of the biases listed can be collectively labelled "*biases due to the inability to interpret the results of statistical analysis*" and occur during the earliest stage of problem formulation (Paradice and Courtney Jr, 1988). Decision makers regularly utilise models and frameworks in an effort to compensate for their cognitive biases and limitations. Moreover, biases such as representiveness, availability, adjustment and anchoring may sometimes be useful in heuristic search when decision makers rely on them to reduce complex tasks associated with assessing probabilities and predicting outcome sets, to simpler judgemental options. Cognitive biases have a significant impact on the decision making

process, especially on the formulation of the decision problem (Kahneman, 2011).

2.3.5.3. Berkeley and Humphreys classification of uncertainty

Berkeley and Humphreys (1982) classify uncertainty across seven types which are summarised in Table 2.4. This table also includes other researchers' references who have discussed the particular uncertainty domain.

	Seven types of uncertainty (Berkeley and Humphreys, 1982)	**Other Authors who discussed theme**
i	Uncertainty about the probabilities of outcomes of subsequent events, conditional on what has preceded them in the act-event sequence between immediate acts and consequences.	Kahneman & Tversky 1982, Daft & Weick 1984, Daft & Lengel 1984, 1986
ii	Uncertainty about the probabilities of subsequent events, conditional on the occurrence of other events extraneous to the sequences in i.	Thompson 1967, Kahneman & Tversky 1982 Galbraith 1973, 1977 Milliken 1987
iii	Uncertainty about how to incorporate prior information in determining the probabilities of a subsequent event.	Einhorn & Hogarth 1981 Galbraith 1973, 1977
iv	Uncertainty about how to conceptualise the worth of consequences: assessing a consequence's utility requires the generation of a single number describing its holistic (and entire) "moral worth". When more than one criterion of "worth" is involved uncertainty can arise about how to combine these criteria.	Tversky & Kahneman 1974, Keeney & Raiffa 1976, Mintzberg et al, 1976, Keeny 1982 Daft & Lengel 1984, 1986
v	Procedural uncertainty which Hogarth et al. (1980) describe as 'uncertainty concerning means to handle or process the decision'.	Hogarth et al. 1980 Dosi & Egidi 1991
vi	Uncertainty about how the decision maker will feel, and wish to act having arrived at a subsequent act (choice point) *after* intervening events have unfolded 'for real'.	Milliken 1987
vii	Uncertainty about the extent one possesses agency for inducing changes in the probabilities of subsequent events (conditional on acts yet to be taken, as in i above) through being able to alter relations between states of the world (Savage, 1954).	Savage 1954, Milliken 1987 Lipshitz & Strauss 1997

Table 2.4. Types of Uncertainty (Berkeley & Humphreys, 1982)

All of these types of uncertainty are usually present in ill-structured decisions and they occur during each phase of the decision making process. Each type of uncertainty is considered within the decision process, especially in relation to the accumulative effect of the different types. For example, when trying to reduce the effects of uncertainty type four, (uncertainty about the worth of consequences) if there is more than one criterion of 'worth' involved, then any

or all of the other six types can be increased in a corresponding manner. This in turn may compromise the overall value of the decision made.

The subjective nature of uncertainty has already been identified and Duncan (1972, p. 327) recognises the significance of the decision maker's perception of the conditions which cause the uncertainty. Lipshitz and Strauss (1997) conducted an empirical study which investigates the subjective nature of uncertainty and considers how uncertainty is conceptualised and handled in decision making instances where uncertainty prevails. Their findings include: 1) in two-thirds of the instances, decision makers are uncertain about their role or situation, which is equivalent to type seven uncertainty in Table 2.4, while the remaining one-third of instances concerns the potential outcomes of the decisions taken, which is equivalent to elements of uncertainty types one and two in Table 2.4; and 2) three conceptualisations of uncertainty are identifiable which relate to inadequate understanding, undifferentiated alternatives and lack of information. While 'undifferentiated alternatives' equates to type four uncertainty in Table 2.4, 'inadequate understanding' and 'lack of information' can be aligned with all of types one to seven inclusive, in Table 2.4. Thus, the Berkeley and Humphreys (1982) representation of uncertainty will be applied as an accurate conceptual model of decision making uncertainties, and will be utilised as a lens through which efforts at accommodating the uncertainties can be applied, and is discussed in the following section.

2.3.6. Humphreys and Berkeley's Representation Model

This research has considered many different decision making models which have been employed by decision makers when endeavouring to cope with uncertainty, as has been described in section 2.3.3. However the influence of bounded rationality on the decision maker's thinking, and the levels of uncertainty inherent in all but the most structured of decision making, has meant that decision makers continue to use strategies which attempt to 'bring order' into their information processing activities when confronted with excess information or the lack of sufficient information (Simon, 1981; Payne, 1982;

Taylor, 1984). These strategies include: reducing the uncertainty by delaying action and gathering more thorough information; reducing the decision into sub-decisions; suppressing the uncertainty by ignoring it and acting on intuition; or assessing the consequences and associated probabilities based on similar previous experience (Tversky and Kahneman, 1974; Mintzberg *et al.*, 1976; Janis and Mann, 1977; Lipshitz and Strauss, 1997).

A different approach for handling uncertainty is presented by Humphreys and Berkeley (1985) in which decision problems can be conceptualised on five qualitatively different levels of abstraction, which are taken into account when handling the seven types of uncertainty listed in Table 2.4. The five representation levels theorise on the evolution of managers' thinking as they learn about the reality that surrounds them, based on: (1) the degree of abstraction of the representation they have of the problems to be tackled and (2) the degree of formalisation of the representations of the proposed solutions. The Levels of Representation framework (Humphreys and Berkeley, 1985) illustrates a theoretical characterisation of the evolution of managers' thinking on five levels, which is presented in Table 2.5.

Cognitive Level	Representations of Managerial thinking	Abstraction level
5	Representations are mainly cultural and psychological; managers are more or less aware of what problems may involve, but their expression is beyond language. Problems are shaped at this level.	Maximum
4	Representations become explicit and problems can be broken into sub-problems, some of them formalised. The structuration of problems is still partial and managers refer to 'the marketing function' or 'the marketing process'.	
3	Decision makers are able to define the structure of the problems to be solved. They are able to put forward and discuss models for investigating alternatives solutions.	
2	Decision makers perform sensitivity analysis with the models they have already defined so as to determine suitable alternative solutions and implementation implications	
1	Managers decide upon the most suitable values and the representation of the problems is stable and fully operational.	Minimum

Table 2.5. Representation of Manager's thinking at cognitive levels (after Humphreys and Berkeley 1985)

The process described by Humphreys and Berkeley (1985) is a top-down process whereby the structuration of the concepts investigated is refined from one level to the next, mediated by time and by knowledge acquired from previous experience. The levels framework permits integration across levels, and outcomes from decisions at a higher level define the constraints at a lower level, whereby problem solving is viewed as a development process passing through five representation levels, from more to less abstract. Therefore, this process facilitates a tighter link between ideas and associated actions as decisions are not made after gathering all the facts, but rather constructed through an incremental process of successive refinement which evolves while gathering the facts.

A decision maker's ability to understand and represent a problem at a level is developed from experience and knowledge gained as a result of their own problem-structuring experience at the level below, and from their ability to understand the problem from an increased degree of cognitive abstraction developed through the use of problem structuring language as well as imaginative thought processes, to encompass the highest levels of abstraction. The juxtaposition of the interconnectedness and the differentiation of the process of problem formulation and the process of conceiving of a solution is important, as "*every specification of the problem is a specification of the direction in which a treatment is considered*" (Hall and Paradice, 2005). There is always the danger of a solution-mindedness approach at the earliest possibility, at the expense of firstly, clearly and unequivocally defining the problem. Humphreys (1989) emphasises three major formal principles associated with the 1985 framework, namely: what is qualitatively different at each level are the cognitive operations carried out by the decision maker in developing the problem representation; the results of decisions which have been implemented at a particular level constrain the way operations are carried out at all lower levels; and any decision problem is represented at all levels, and handled at each level in turn.

Level 5 in Table 2.5 is particularly important in that, at this early stage, the decision maker has total freedom to decide on a direction to follow. The only factors limiting the horizon of the decision maker are either psychological (unconscious) or cultural (e.g.: his or her educational background or experience). In the literature on human decision making, this initial step appears under the term 'problem definition' or 'setting the agenda' (Simon, 1997), or problem recognition (Mintzberg *et al.*, 1976) or awareness of the problem (Lyles and Mitroff, 1980). This stage is important because it conditions the outcome of the decision making process as avenues not considered at this stage are less likely to ever be considered. This early phase of problem setting can be considered "*thinking done in anticipation*", to shape and frame the problem in an approximate, incomplete and simplified way (Tversky and Kahneman, 1981) and the decision maker "*must make sense of an uncertain situation that initially makes no sense*" (Schon, 1983, p.40) as problems emerge.

Even when the problem representation becomes explicit at level 4, it is discussed at a substantive manner rather than at an analytical manner, or before any level of calculation is possible (Bernard 1938). As noted by Levine and Pomerol (1995), levels 5 and 4 are generally considered as strategic levels of reflection handled by top executives (problem defining), whereas the remaining three levels correspond to more operational and tactical levels of problem setting or problem solving by developing the structure of the problem within a frame, or building a conceptual model (Checkland, 1981). During level 3, sufficient discourse and coherence is reached where it is possible to describe the structure developed, which is subsequently tested at Level 2. At this point, sensitivity analysis or robustness analysis may be performed to understand the impact of changing one element within the structure, for example, enabling the realisation of a greater level of congruence of the actions implemented at Level 1, and the ideas structured at Level 3. At Level 1, sufficient constraints have been set and the only remaining task is to make a best assessment of the 'most likely value', which will describe the operational solution requirements. The managers who define the implementation criteria, based on best assessment, typically

consider the implications of uncertainty relating to inadequate understanding about the outcomes of a situation and the underlying cause and effect relationship (effect uncertainty), or a lack of information about response outcomes (response uncertainty).

While the Humphreys and Berkeley (1985) framework does not represent a linear model of thinking, the natural progression across the levels of the framework is one that goes from level 5 to level 1, and rarely back to a previous stage unless a strong stimulus forces a change of mind about the situation. This representation of managers' handling of decision problems and information needs is a simplification, in that it separates what is essentially a continuous process into separate ones. Although, all levels of management span the five cognitive levels, it is clear that lower levels of management are more likely to be given problems already well formulated to work on, such that their thinking is mostly geared towards levels 1 and 2 and possibly 3 of the framework. A more formulated representation is part of the organisational internal communication system which is designed to prevent an overload on the cognitive capabilities of the individuals (Daft and Huber, 1987), and will facilitate the lower level manager utilising their own heuristic investigation and 'best assessment' criterion specification.

Moreover, the nature of decisions tends to change across the executive hierarchy spectrum. At the upper levels, decisions regarding organisational purpose or goals receive major attention and those relating to means are secondary. This proposition tends to shift and reverse itself at the lower levels of the hierarchy of the organisation. Even though the substantive content of the decision problem changes, the cognitive representation process, as outlined in the framework, is relevant for all decision makers. Humphreys and Jones (2006) have noted that the process is also characterised by the decrease in discretion that is inherent in the increase in the set of constraints which are imposed on the representation of problems, until the *truth*, as constructed by managers, emerges and the implementation of solutions becomes logical, such that it may be delegated to lower level management. The use of the word *truth* is

purposefully provocative in the sense that the model and the solutions it yields are constructed by participants, but it could be a requisite decision model. A requisite decision model is defined as *"a model whose form and content are sufficient to solve a particular problem"* (Phillips, 1984, p. 29). Complex problems don't have objective solutions and only the process described by Humphreys and Berkeley (1985) and Humphreys (1989), can deliver a negotiated outcome, whereby participants will agree to be realistic, viable and acceptable, such that "*although no person in the group would necessarily agree with all the judgements, the model expresses a social reality that is evolving as the group works through the resolution. This social reality is not an ideal, merely the current working agreement among the members"* (Phillips, 1984, p. 32). Phillips recognises that a decision model that is requisite at one level of an organisation will typically not be requisite at a different level, which is indicated in the Humphreys and Berkeley (1985) framework as the qualitatively different nature of the decision required at the different levels, replicating the differences of both form and content at each level of the framework.

Nutt (2001) investigated problem formulation in thirty three organisations, and he observed the ineffectiveness of the problem formulation process. In seventy per cent of the instances researched, the problem formulation process was revisited, and in many instances this was necessary post an attempted implementation of the solution. Humphreys (2008) discusses the concept of revisiting decisions made at an upper level of the framework when information which is communicated from a lower level may influence the normal problem formulation process in organisations. So from one perspective communication is presented as a top-down phenomena, and at another level, communication is presented as a bottom-up phenomena, implying top-down thinking and decision making with bottom-up information gathering taking place. Furthermore the integration across levels is the result of decisions made at a higher level which have defined the constraints at a lower level, thereby influencing the 'starting point' for the next decision maker.

Humphreys and Jones (2008) advocate that part of the decision making process is in determining what uncertainties to consider, and how each is handled in a more holistic fashion with all options under consideration. It is useful at this stage to consider the link between types of uncertainty and representation levels as identified by Humphreys and Berkeley (1985). The Table 2.6 provides an overview of possible uncertainty mitigating activity, which decision makers engage in at each of the representation levels.

Cognitive Level	Representations Levels activities	Uncertainty types	Mitigating activity
5	Exploring what needs to be thought about within a 'small world'.	vi, vii	Reality testing of the scenarios explored, thereby ensuring a more holistic agenda being set.
4	Problem expressing of what to include and not include, through argument and persuasion.	v, vi, vii	Articulating the principles and constraints relevant for Level 3 actions.
3	Structure of the problem solution alternatives developed. Trade-offs are agreed.	iv, v, vi, vii	Developing the structure of the problem until sufficient coherence is achieved to allow the handling of each uncertainty type.
2	Decision makers perform sensitivity analysis to understand the impact of changing elements of the assessment criterion.	i, ii, iii	Performing 'What-if' hypothesis by varying the value assessed and investigating the impact.
1	Managers decide upon the most suitable values and the representation of the problems is stable and fully operational.	i, ii, iii	Sufficient constraints in place, ensuring only the 'best assessment' alternative choice is achieved.

Table 2.6. Linking Representation Level's activities (after Humphreys (1998)*) and suggested mitigating activities for uncertainty types.*

A fundamental task facing decision makers is how to resolve the constraints and uncertainties concerning the development of a 'prescription for action' and have it implemented (Humphreys, 1998). The activities carried out at each representation level are efforts which concurrently inform and constrain, but essentially form the basis for the content elements of the next representative level, and this content is then manipulated within the problem structuring engaged in at the next lower level. At level 5, representation of the problem is through exploration of possible associations and ideas, as in a dream

or imagination (Humphreys and Berkeley, 1985) which may often be motivated by the decision maker's desire to avoid outcomes "*which will yield only anxiety and regret*" (Humphreys, 1989), which is often identified as 'concern and unease' (Smith, 1988) with regard to possibilities within the 'small worlds' of the decision maker and their exploration. The results of this exploration form the basis for the content elements of the problem representation at level 4. At level 4, an explicit or implicit representation of the problem can be stated within problem structuring, i.e. an interpretation of the problem (Daft and Weick, 1984), achieved through pattern-matching when the current status is recognised or diagnosed in the event of more complex scenarios.

The constituent literature on decision uncertainty provides some mitigating scenarios and activities which may be taken into account in an effort to lessen the impact of uncertainty on decision making. For example, developing the structure of the problem, which is a mitigating activity realised at level 3 of the Humphreys and Berkeley (1985) framework, advocates the development of the structure until 'what-if' scenarios can be clearly described and subsequently tested at level 2. The activities and discourse engaged in will enable the decision structuring and the testing of the alternatives and consequences, based on the preferences which prevail at level 3, that are, in turn, influenced by the knowledge of the actors engaged in the Level 2 testing and evaluation. This implies, that the content manipulated at each level is qualitatively different to the content at another level, and the conceptualisations which become available to a person, provide the means to enable a progressively more precise description of the problem.

Procedural uncertainty is described as uncertainty concerning the means to handle or process the decision, due to the limitation of the computational and cognitive capability of the agents, when it is unclear what information to seek, or how to invent or evaluate alternatives and their consequences, when pursuing the organisational objectives unambiguously (Hogarth, Michaud and Mery, 1980; Dosi and Egidi, 1991). While associated with decision rules, procedural uncertainty invariably leads to delayed decisions with regard to unstructured

decisions, and Hogarth *et al.* (1980) link the delay with the "*state of psychological regret*" associated with making an incorrect decision. Procedural uncertainty is represented in the Humphreys and Berkeley (1985) framework as a level 4 representation, and resolving it requires the development of a problem solution that will translate generalised possibilities into an actual problem representation and which may be resolved through the development of specific scenarios. When the scenario can evolve into a rule, then the rule in effect represents a policy, which will constrain further action and effectively prohibits non-compliance which in turn, ensures adherence to organisational objectives. Essentially, the decisions made are used to resolve the procedural uncertainty, by putting in place a structure which can be standardised. The standard can then become part of the regulatory framework and when the organisation can exert sufficient influence on its industry sector, the standard will, in turn, generate a higher degree of global order.

2.3.7. Conclusion: Propositions in relation to decision making

In the context of the constituent literature on organisational decision making, which incorporates organisational theory with regard to 'strategy and structure', strategic management, strategic decisions and decision making, the underlying message is that each organisation has a structure, a controlling mechanism and a strategy crafting process that requires coordination, integration and prioritisation. Within any organisation, strategic decisions are complex and are made up of far more phenomena than a decision maker can comprehend. The consequences of limited and bounded rationality, uncertainty and environmental complexity may result in inaccurate diagnosis of the decision problem in many situations. While decision making is regularly regarded as a linear and repeatable process the empirical research would point to the contrary (Nutt, 1984). While the role of the manager in the decision making process is not clearly delineated, it is evident that the individual decision maker plays a central role in the decision making process at all organisational levels (March and Simon, 1993; Pomerol, 1997; Weick and Sutcliffe, 2001).

In this research, the Humphreys and Berkeley's (1985) framework of representation levels is used to analyse the process whereby decision problems are tackled by managers at various level in organisations, from the stage where they exist only as roughly conceived and almost imagined problems in top managers' minds and relying on intuition (Dane and Pratt, 2007), to the stage where they are properly identified as bounded problems with agreed upon matching solutions attached to them. This process is characterised by the emergence of a shared understanding amongst participants that gives rise to a pseudo consensus, from which a requisite decision support model can be developed which will satisfy the decision maker's requirements (Phillips, 1984). This has often been studied as a once-off process, reliant on a decision conference for instance (Vari and Vecsenyi, 1992), or on special strategic groups (Bourgeois and Eisenhardt, 1988). Although, this is a useful way to study decision making processes, it has clear limitations, because in most organisations the decision process is not a discrete process, but a continuous one which occurs over long periods (Pomerol, 1997). Thus, in this research study, events relating to the emergence of the models underlying decision aids as a *process* are studied, whereby shared understanding and consensus emerge over time, upon which models for decision support are developed.

Using the Humphreys and Berkeley's (1985) framework to represent managers' handling of decision problems and their support needs is itself a simplification, in that it separates what is essentially a continuous process into separate ones. However, from the point of view of a researcher studying management decision making and decision support, this framework has the merit of clarifying the requirements for the support and guidance of decision makers, as well as proposing design avenues which can be pursued to develop applications appropriate to the five qualitatively different levels of the framework. In this research some key elements of the principles underpinning the framework, are identified in the shape of the following propositions, which will be validated in the empirical section of this thesis.

Proposition 1: *the problems facing managers in an organisation can be identified based on the descriptions by the managers themselves, as being representative of one of the levels of the Humphreys and Berkeley (1985) framework.*

Proposition 2: *the landscape of decision making processes of the firm is a dynamic one where managers' understanding of problems emerges over time towards greater formalisation of each problem and the identification of an agreed upon set of solutions, as hypothesised in Humphreys and Berkeley (1985) and in Humphreys (1989).*

Proposition 3: *managers at different hierarchical levels specialise on the emergence of decision making processes at certain levels of the framework, such that top management is concerned with the more abstract levels and lower level managers focus on implementation and execution.*

Proposition 4: *the level of constraint and specificity present at different levels provides a platform for the development of increasingly specific decision support, as problems migrate towards the lower levels of the framework.*

The objective of this research project is to understand the decision problems which decision makers encounter on a continuous basis, and the basic decision making process of the organisation, so that the necessary decision support requirement is understood. Essentially, these four propositions amount to an empirical validation of the Humphreys and Berkeley's (1985) cognitive representation framework, which is used to capture and analyse the process whereby decision problems are encountered and tackled by managers and decision makers.

The next section will consider decision support for decision makers, which includes availability of information and Information Systems (IS) which are necessary for effective decision making.

2.4. Supporting Decision Makers

Section 2.2 discussed aspects of organisational structure and strategy which impact upon the organisational decision making environment, and section 2.3 considered some of the behavioural aspects of organisational decision makers which compound and complicate their decision making efforts. This section discusses the support available for organisational decision makers, in particular, support in the form of information available to the decision maker, as well as the tools and technologies available, which provide and synthesise information. Decision Support Systems have been used in organisations since the 1960's and have evolved considerably since then. In fact, the term 'Decision Support System' or DSS is used as an 'umbrella term' to describe any computerised system that supports decision making in an organisation (Turban, Aronson, Liang and Sharda, 2007).

In recent years there has been a suggestion that 'decision support' requires a more comprehensive and a more integrated offering than is provided by Decision Support Systems. Alter (1992, p. 319) proposes that "*decision support, provides a richer basis than Decision Support Systems*" for further research as well as for use in practice, because improving decision making is fundamental in organisations and therefore, is of importance to managers and to decision makers. The basis for his argument is that the pitfalls that have at times, plagued DSSs research namely: techno-hype; domination of software vendors' rhetoric; and failure to understand the underlying problems which decision makers are facing (Arnott and Pervan, 2008), must be avoided if high impact decision support is to be delivered to decision makers in organisations.

There is a rich body of literature in existence on the subject of 'Decision Support', which is discussed in this section, which will frame further discussion on the aspects of the information and the DSSs which have evolved as most relevant towards the support of organisational decision makers.

2.4.1. Decision support for organisational decision makers

As already discussed in section 2.3.5, uncertainty is inherent in almost all decision problems and all decision situations. Lack of, or, imperfect information is a fundamental cause of uncertainty and it is pervasive in most decision making contexts. Supporting decision makers implicitly means addressing the sources of uncertainty which arise as part of the decision problem, so that decision makers can foresee the consequences of a choice taken during the multiple phases of the decision making process, as discussed in Section 2.3.3 and Table 2.3. Information systems and in particular, DSSs have been developed to facilitate and to support human decision making, by improving access to necessary information. However in the 21st century, effective decision support "*requires a multidisciplinary approach…. to provide support for participants to reach common understanding rather than a forced consensus on a course of action*" (Burstein and Widmeyer, 2007, p.1647).

When Huber (1981) developed the conceptual model for portraying and interpreting organisational decision making, he provided an insight into the information and decision aides that could be useful in different types of organisations, and which could facilitate the design of a DSS, when these organisational specifics are taken into account. For example, in relation to the Garbage Can Model of organisation (Cohen *et al.*, 1972), the essence of Decision Support is identified as a facilitator to enable managers to build a "*mental model*" of their environment, which could help in "*efficient environmental scanning*" (Huber, 1981, p.7), and which recognises that "*a good part of the information the manager collects, arrives in verbal form*" (Mintzberg, 1975, p.7). The Garbage Can model of organisation is representative of organisations that operate in complex and fast-changing environments. However, most organisations incorporate aspects of the Rational model, are Political in nature, take on board chance and risk, and exhibit the unexpected behaviour of the Garbage Can model, as well as deploying aspects of the Program model. Therefore, providing decision support which facilitates all of the Huber models

requires an extensive portfolio of decision support tools of both a computer and non-computer variety (Huber, 1981).

External sources of information are used much more frequently than internal sources of information by senior executives who rely on personal contacts and personal relationships for the acquisition of such information. These trusted sources of strategic information are decoupled from the organisation's IS suite (El Sawy, 1985). Mentzas (1994) highlighted the lack of systems that provide support across all processes in an organisation, and in particular, he acknowledged the many different systems required to support the decision processes in an organisation at individual, group and organisational levels. In effect, this indicates a lack of integration or 'total systems approach' of the Management information systems in organisations which prevails in current times just as much as it did in the 1980's and in the 1990's.

As well as information from multiple sources, other aspects of decision support can be included when endeavouring to consider avenues for improvement. Decision support exists in many different forms, and not only in the form of technical artefacts, as recognised by Murphy, who pointed out, based on his empirical research, that the difference between successful and unsuccessful decision support is most likely to be influenced by the actions of staff, rather than by any technological platform (Murphy, 1994). Adam and Pomerol (2008) advocate the consideration of the 'process' of decision making as a useful model in relation to technology support for decision making, because understanding and improving the decision process can move DSSs into the realm of support for complex decision problem situations, which are problems with different characteristics when viewed from different perspectives (Paradice, 2007).

While Alter (1992, p. 319) acknowledges the successful adoption of DSSs across all organisations, he now proposes "*decision support*" in the broadest context is a requirement to support organisational decision making. Decision support does not only relate to tools per se, but rather it concerns enabling and facilitating better decisions within organisations (Alter, 2004). Decision support

in an organisation allows the incorporation of wider elements under consideration when supporting decision making (Alter, 2004), which focusses on the decision makers' specific problem solving tasks, and ensures the output is packaged in a way that makes it easy for managers to use (Silver, 1991). Alter (2004) argues that organisations view Information Systems as systems designed to support their 'work systems' and not necessarily as systems that support information. A 'work system' incorporates all aspects of a "*system in which human participants and/or machines perform a business process using information, technology and other resources to produce specific products and/or services for specific internal or external customers*" (Alter, 2004, p. 321). A work system involves the internal and external organisational environment; the internal operational processes; the external and internal stakeholder communication processes; resource allocation including information, technology and people resources; the organisation's strategy and structure and integration mechanisms and systems; product and service offerings, and customers. Providing decision support is therefore a much more holistic support for decision makers than merely providing information from the available DSSs and their outputs. But it is also apparent the DSSs are providing information within a work system in organisations.

Since Ackoff's (1967) seminal and provocative paper, researchers have sought to propose concepts, systems and methodologies to achieve the goal of providing managers with information that they need to make 'proper' decisions under a variety of names, some of which are, at times, suggested by vendors of technology rather than the academic community. Throughout this time, it has remained consistently true, however, that basic and generic tools such as spread sheets, have formed the bulk of computer-based decision support (Fahy and Murphy, 1996), although spread sheets are inherently error-prone (Panko, 2006). The following section differentiates between data, information and knowledge. The complexity regarding the integration of data, the value of information, DSSs, the decision maker and the business environment is then discussed.

2.4.2. The Data, Information and Knowledge continuum

While existing research (Davenport and Prusak, 1998; Alavi and Leidner, 1999) contests the 'which comes first argument'; i.e. data, information, or knowledge, the more commonly held belief is that data remains at the lower end of the hierarchical structure; information is derived from data, and knowledge is information validated through experience, judgement or context. For the purpose of clarity, this section of the thesis briefly considers each of these phenomena in terms of their chronology and relative importance to the literature.

Data is "*a set of discrete, objective facts about events*" (Davenport and Prusak, 1998, P. 5). Thus, data is perceived as a series of isolated facts. While data exists in the form of numbers, text, images and sound, the form itself is not directly meaningful. It is the context within which the data is used that generates meaning: for example data is meaningful when used in the form of a message (Zack, 1999). According to Davenport and Prusak (1998), from an organisational perspective data may be described as "*structured records of transactions*". Mintzberg (1975) defined hard data as figures, documents and formulae, whereas he believed soft data encompassed judgments and opinions.

Information is generally considered to differ from data, because unlike data, it holds meaning for specific organisational actors. Information is created when isolated facts are put into context, and combined within a structure (Davenport and Prusak, 1998). Consequently, the activity of extracting information from data constitutes an interpretation of the data. Tushman and Nadler (1978, p. 614) differentiate information as "*data which are relevant, accurate, timely and concise. Information must effect a change in knowledge, data may or may not be information*." Daft and Macintosh (1981, p.210) suggest that information is consequential, "*to qualify as information, the data must effect a change in the individual's understanding of reality*". Knowledge is normally considered as information which has been internalised and is personal to the individual, and it is referred to as 'know-how' by Huber (1981). In a similar notion of knowledge as an enabler, Alavi and Leidner (1999, p. 5) define

knowledge as *"a justified personal belief that increases an individual's capacity to take effective action", and* Courtney (2001, p. 23) suggests "*knowledge is information with guidance for action, that is, knowing how to act given the information*".

As is evident from the research outlined above, the distinctions and boundaries between the constructs of data, information and knowledge are not explicit. According to Davenport and Prusak (1998, p. 147) "*the distinction between knowledge and information is seen as more of a continuum than a sharp dichotomy*". The correlative relationship of the two terms is discussed by Alavi and Leidner (2001, p. 109), who posit that "*information is converted to knowledge once it is processed in the minds of individuals*" while "*knowledge becomes information once it is articulated and presented in the form of text, graphics, words or other symbolic forms*".

While the terms information and knowledge are regularly used interchangeably in research, for the purpose of this thesis, the following interpretation is adopted: outputs from computer assisted information processing systems are considered to be data, and information is data interpreted and thereby, endowed with relevance and purpose. The conversion of data into information requires specialised knowledge, which evolves through the synchrony of many specialists and specialties in the organisation (Drucker, 1988; Laudon and Laudon, 2010), and that knowledge may be a company's greatest competitive advantage (Davenport and Prusak, 1998) as knowledge is considered the only "*meaningful economic resource*" (Drucker, 1992).

2.4.2.1. Effective information transmission and communication

The interpretation of data can be mediated by the communication media experienced. Different communication media possesses different degrees of a property called 'richness' (Daft and Lengel, 1986; Lee, 1994; Dennis and Kinney, 1998), and the level of 'richness' is an indicator of the degree effectiveness when transmitting or conveying information. Media richness research indicates that face-to-face communication provides a better communication mechanism for

reducing equivocality (Lengel and Daft, 1988). This assertion is based on the concept of 'richness' being equivalent to an ability to carry 'non-verbal cues' which provide rapid feedback and a greater degree of context to enable the recipient of the information to acquire a shared understanding of what the information means within the context of the scenario under review (Daft and Lengel, 1986). In particular, managers indicate a strong preference for verbal media, such as face-to-face meetings and telephone conversations, rather than technological system derived reports. Daft and Lengel (1986) argue that the amount of richness in the information processes and in communication media, must equate with the level of task uncertainty. Equivocality can be defined as multiple and conflicting interpretations about an organisational situation (Daft and Macintosh, 1981; Daft and Lengel, 1986). While equivocality is often connected with uncertainty, uncertainty is associated with lack of information, and equivocality is associated with a lack of understanding of the information available (Daft and Lengel, 1986). A decision maker may possess the required information, but not clearly understand what it means or how to use it.

However, different formats of presentation may influence the usefulness and acceptability of computer generated reports. A study by Russo (1977) demonstrated how tabular formats of price lists effect decision strategy, in that display formats influence the cognitive demands on memory and attention when decision makers acquire information, as well as when they evaluate information (Einhorn and Hogarth, 1981). Specifically, changes in a presentation format may lead to changes in decision strategies used, and in particular, the way graphical information is arranged on a display may affect the order in which information is acquired (Jarvenpaa, 1989). The order in which information is acquired may influence the decision maker due to an anchoring bias, as discussed in section 2.3.5. Despite this, there are no generally accepted guidelines describing the most optimal way to display information, and instead, the effectiveness of a specific presentation format depends on the task complexity (Speier, 2006). This topic will be considered in further detail in section 2.5.3 when the role of the DSS's designer is discussed.

While empirical research regularly reminds us of the preference of verbal forms of information communication, especially by management, the availability of information from computer generated systems still continues to grow. As more information becomes available, more alternatives can be identified and explored. One of the main challenges for the decision maker is to derive value from the available information, which is discussed in the next section.

2.4.3. The value of information in the decision making process

Information, and more specifically, its circulation and use within societal groups, has always been one of the foundations of society. Information Technology (IT) has been instrumental in making information availability an expected and a taken-for-granted resource within organisations, with endless opportunities to capture and to store almost limitless volumes of same. In 1978, Mason maintained the "*production and dissemination of information as being of greater importance than the production and distribution of good and services"* (Mason, 1978, p 219). Over the years, it is generally recognised that Information Technology is an enabler of strategic renewal, strategic innovation and competitive advantage (Karimi, Gupta and Somers, 1996; Weill and Broadbent, 1998; Earl and Feeny, 2000; Melville, Kraemer and Gurbaxani, 2004; Davenport, 2006). While 'IT infrastructure' provides the baseline foundation, the significance of the management of information is apparent, as organisations leverage their 'IT Infrastructure' to provide accurate, timely and reliable information (Mithas, Ramasubbu and Sambamurthy, 2011). They define 'Information management capability' as "*the ability to provide data and information to users with the appropriate level of accuracy, timeliness, reliability, security, confidentially, connectivity and access, and the ability to tailor these in response to changing business needs and directions*". Their focus is on the provision of information for management activities, and in particular, the enablement of higher-order business capability which in turn influences firm performance (Sambamurthy, Bharadwaj and Grover, 2003; Kohli and Grover, 2008). Earl and Feeny (2000) contend that "*IT is a first-order factor of strategy making*", implying that it

directly impacts organisational performance (Pavlou and El Sawy, 2010) and that it should be recognised as an important tool for strategic transformation within an organisation. While it is recognised that Information Technology, of itself, is not a direct source of value, 'first-order thinking' acknowledges that Information Technology capability will allow an organisation to compete differently, providing new possibilities for competitive behaviour when Information Technology is deployed "*in-tandem*" with business initiatives (Earl and Feeny, 2000).

Churchman (1971) describes knowledge from three different perspectives; knowledge as a collection; knowledge as an activity; knowledge as a potential. His conceptualisation of knowledge as an activity and as a potential implies the value of knowledge when someone knows how to do something correctly, as well as their ability (knowledge) to learn as their circumstances change (Courtney, 2001). Churchman's (1971) conceptualisation of knowledge as a collection and his statement that "*knowledge resides in the user and not in the collection of information… it is how the user reacts to a collection of information that matters*" (Churchman, 1971, p. 10), points to the personalised nature of knowledge. In the organisational environment of the twenty first century, when information is abundant and always available, it is interesting to realise that "*only that information which is actively processed in the mind of an individual through a process of reflection, enlightenment and learning, can be useful"* (Alavi and Leidner, 1999, p. 6). Moreover, if one's knowledge is to be useful to another individual, it must be communicated in such a manner as to be interpretable and accessible to the other individual. Porter and Miller (1985) recognise information availability as a strategic tool to create competitive advantage by providing organisations with new ways to outperform their rivals. However "*the importance of information in organisations has been both overrated and underrated by management*" (Drucker, 1995, p.54), and numerous research studies conclude that organisations have not yet mastered value creation from their information resources, despite much improved methods of coordinating, gathering, organising, selecting, synthesising and distributing information (Rayport and Sviokla, 1995, p.76).

In 1971, C. West Churchman released his seminal work "*The design of Inquiring Systems: Basic concepts of Systems and Organization"*. The original IS was conceived as an *Inquiring System*. Inquiring systems are teleological (goal seeking) systems whereby a set of activities are developed to produce information and knowledge. An inquiring system uses observable data to produce knowledge. Churchman (1971) discusses five inquiring systems based on the works of philosophers Locke, Leibniz, Kant and Hegel, and his own doctoral advisor Singer, each of whom viewed knowledge acquisition through a different inquiring system's lens. Therefore each of Churchman's inquiring systems constitutes different approaches to the acquisition of knowledge, through considering the inputs, processes and outputs of each inquiring system (Mason and Mitroff, 1973). A critical component of an Inquiring System is known as the *guarantor*. The guarantor ensures the cohesiveness of each of the inquiring systems by specifying the type of input, the transformation process invoked and the form of output that is regarded as knowledge. Each of the five inquiring systems is briefly discussed with reference to their methods of knowledge acquisition as well as their primary decision making influence.

The Lockean Inquiring System is based on the writings of John Locke (1632 – 1704). The theory of knowledge acquisition in a Lockean Inquiring System is based on experience, especially sensory perception in the formation of ideas. Empirical information is gathered from external observations (Churchman, 1971). The Lockean Inquiring System is a data-based system (Sage, 1981) and is considered typical of knowledge acquisition in association with solving well-structured decision problems for which there is a strong consensual problem solution. The information output is inductively derived based on empirical data (Mason and Mitroff, 1973).

A Leibnizian inquiring system is based on the work of Gottfried Wilhelm von Leibniz (1646 – 1716). It is represented as a closed system without access to the external environment, with a set of build-in elementary axioms that are used along with formal logic to generate more general facts or tautologies (Churchman, 1971). Since it is a closed system, the only information and

knowledge accessed is that which is internally generated. Model based systems are employed which encourage the use of rationalisation and reason. These models facilitate a representation of reality from which knowledge and justification may be derived. A typical example would include knowledge acquisition in association with solving well-structured decision problems for which there is an analytical formulation with a solution (Mason and Mitroff, 1973). Both Lockean and Leibnizian inquiring systems are suitable for stable and predictable organisational environments, but they are capable of providing "*only one view of the problem*", and hence, they are not suitable for discontinuously changing environments (Mason and Mitroff, 1973, p. 481).

Kantian inquiring systems are based on the works of Immanuel Kant (1873 - 1945) and are a mixture of Lockean and Leibnizian approaches, containing both theoretical and empirical knowledge acquisition methods (Churchman, 1971). The Kantian inquiring system recognises that there are many different perspectives to a problem, and many different ways of modelling the problem. Determining complimentary models which will provide the best representations of the perceived perspectives is part of the problem solution. Kantian inquiring systems are suitable for problems of moderate complexity or moderately ill-structured problems (Mason and Mitroff, 1973; Mitroff and Linstone, 1993). However the multiple views are uncontested and provide only one view of the problem, and as such can be afflicted by complacency in the decision making style of the decision maker (Malhotra, 2001).

Hegelian inquiring systems are based on the works of Georg Wilhelm Friedrich Hegel (1770 – 1831), and consider multiple points of view based on different interests and views held by people (Churchman, 1971). Knowledge acquisition is based on the synthesis of multiple completely antithetical representations that are characterised by intense conflict because of contrary underlying assumptions (Malhotra, 2001). The information being acquired and interpreted represents many perspectives, and specifically relies on the two most diametrically opposing perspectives. The decision is forged from the many points of view that are expressed and evaluated through decomposing the

problem and then solving it (Parrish Jr and Courtney Jr, 2008). The dialectic discussion of the data facilitates the emergence of the underlying assumptions during the debate. The information output is based on the interpretation of the data, as well as the interpretation of the discussion narrative, which is achieved through a process of "*creative synthesis*" of the opposing views (Mason, 1969). Hegelian inquiring systems can be applied to wickedly ill-structured problems, as multiple and contradictory interpretations of the focal information is facilitated (Malhotra, 2001).

Singerian inquiring systems are based on the works of Edger A. Singer (1873 – 1945) and are model based systems designed to incorporate aspects of learning and feedback. Two basic premises guide Singerian inquiring systems: a system of measures; and the strategy of agreement (Churchman, 1971, p. 189-191). The system of measures specifies steps to be followed when resolving disagreements among members of the group. The strategy of agreement principle specifies that new variables are 'swept in' and included in the inquiring models. The objective of 'sweeping in' of the additional variables, often from outside of the current domain is to provide a better explanation of the phenomenon by providing guidance and by overcoming inconsistencies. Complacency is avoided by continuously challenging system knowledge (Courtney, Croasdell and Paradice, 1998).

Churchman's (1971) seminal work has been used extensively in organisational theory research. Mitroff and Linstone (1993) refer to Lockean and Leibnizian inquiry as 'old thinking', and Singerian inquiry as 'new thinking'. They espouse 'unbounded systems thinking', which is very similar to the Singerian inquiring model (Courtney, 2001). The focus of this researcher's interest in Churchman's work is the area of information and knowledge and their value within the decision making process. A summary of the attributes of the five inquiring systems is presented in Table 2.7. The table attributes pertain to knowledge acquisition and decision making style, as well as a general overview of the philosophical foundations of each inquiring system as discussed. While each of information perspectives requires a different approach for collection, the

interdependencies and the interconnectedness of the perspectives should be understood so that an inclusive and holistic version of information is achieved (Mitroff and Linstone, 1993).

Inquiring system	Lockean	Leibnizian	Kantian	Hegelian	Singerian
Philosopher	John Locke	Leibniz	Emanuel Kant	Hegel	Edgar Singer
Era	1632 - 1704	1646 - 1716	1724 - 1804	1770 - 1831	1873 - 1945
Philosophy	Empiricism	Rationalism	Mixture of Lockean and Leibnizian	Dialectic	Pragmatism
Knowledge acquisition method	Experience Sensory perception	Reasoning Rational deduction	Both theoretical and empirical.	Synthesis of both thesis and antithesis	Interdisciplinary Multiple perspectives
System characteristic	Data-based	Model-based	Multiple model-based	Conflicting model-based	Learning system based
Decision making style	Group oriented and open Inductive	Formal, bureaucratic, by-the-book Deductive	Multiple interpretations encouraged Analytical	Conflict based	Teleological
Information failure result (Ding 2013)	Lack of alignment with reality Inconsistent information	Lack of validity of assumptions Wrong assumptions	One view of the problem causes lack of perspective	Lack of alternative views can cause disinformation	Lack of useful information & low usage of system
Suggested System example	Accounting. Statistics	Expert systems	Traditional DSS. Forecasting system	Contract negotiation support	Document management

Table 2.7: Churchman's (1971) Inquiring Systems

Each of Churchman's inquiring systems provides for a different representation of decision problems and each produces a different kind of information for coping with a decision problem. Mason and Mitroff (1973) note that most, if not nearly all, MIS has been undertaken from the standpoint of Leibnizian and Lockean inquiring system's basis which can handle well-defined structured problems, while Kantian, Hegelian and Singerian inquiring systems had been almost totally neglected. Information required for structured decision situations is derived primarily from sources internal to the organisation, such as information in relation to the day-to-day transactional activity which focuses on intra-organisational issues. When semi-structured or unstructured decision situations are being resolved, human judgement is required, and information

from outside of the organisation is as relevant as internal transaction-based information (Gorry and Scott-Morton, 1971).

Earl and Hopwood (1980) analysed the role of information in organisations and developed a framework which distinguished between different modes of information processing: (1) official versus unofficial and (2) routine versus non-routine, all of which co-exist in organisations. At that time, the authors questioned the crucial relationship between information and decision making, and claimed that the relationship had been presumed, rather than described or analysed accurately:

"We have tended to presume, for example, that the specification and analysis of information precedes decision-making, that the roles played by information in decision making are invariate across a multitude of different decision situations " (Earl and Hopwood, 1980, p.7).

Information that is meaningful to the recipient is of real or perceived value in current or prospective decision making activities. Over the last decade, Information Systems, including: enterprise resource planning (ERP) systems; supply chain management (SCM) systems; customer relationship management (CRM) systems; and e-mail; have created vast repositories of data. Nevertheless, current understanding proposes that merely having information is not sufficient, and that it is the use of this information which can be the 'game changer', to provide the revolutionary capability to which organisations have long aspired. Information for the sake of information has not provided the predicted advantages, and only such organisations that can create value from their information will gain benefits from the deluge of information now available. In such latter organisations, information is recognised as a key organisational resource, and the management of the use of information is a critical organisational differentiator.

2.4.4. Information Processing Capability

Organisational Information Processing Theory (Galbraith, 1974) emerged as a result of an increased awareness and understanding among organisational

researchers that information is perhaps the most critical contingency faced by the modern organisation (Galbraith, 1973; Tushman and Nadler, 1978; Fairbank, Labianca, Steensma and Metters, 2006). Information processing in organisations is generally defined as including the gathering of data, the transformation of data into information and the storage and communication of data. Information processing theory suggests that the most effective organisational strategies are those that recognise an appropriate 'fit' or 'match' between an organisation's ability to handle information and the type of information that is required (Galbraith, 1973; 1977; Tushman and Nadler, 1978). Tushman and Nadler (1978) also note that different organisational structures have different capacities for processing information, such that organisations or sub-units within organisations, are likely to be more effective when there is an alignment between the information requirements of an organisation, and the information processing capacity of an organisation. The conformity between organisational strategy and information technology is also an important contributor to organisational effectiveness and it demonstrates senior executives' understanding of how strategy, organisation and technology interrelate, so that a higher return on technology investment is achieved (Sauer and Willcocks, 2002).

Information Processing Theory was first introduced by Galbraith in 1973, and it explicitly states that organisations are structured around information and information flows, in an effort to reduce uncertainty (Fairbank *et al.*, 2006). In general, Information Processing Theory suggests that the most effective organisational design strategies are those that recognise an appropriate 'fit' between an organisation's ability to handle information and the amount of information that is available or required (Thompson, 1967; Galbraith, 1973; 1974; 1977). The key variables in the organisational design are information, information flows and information processing (Knight and McDaniel, 1979), and achieving a fit between the information processing requirements and the information processing capabilities (Galbraith, 1977; Tushman and Nadler, 1978; Daft and Lengel, 1986). Galbraith (1973; 1974; 1977) argues that organisations

must adopt at least one of four information processing designs to improve performance. Two of these processing designs are intended to reduce the need for information processing, essentially by managing the decision environment, and by creating self-contained tasks. The other two information processing designs involve creating processes and mechanisms that increase the organisation's capacity to acquire and to process information, namely: investing in vertical information systems and creating lateral relations. The four designs are not mutually exclusive, and Galbraith suggests that an organisation could choose one or more combinations of the four processing designs which could facilitate the reduction of uncertainty through its information processing capability. The decision environment includes both internal and external factors. Internal factors relate to people and organisational structure, while external factors include external stakeholders such as customers, suppliers and competitors, as well as technological, socio-political and economic issues (Duncan, 1972; Power, 2002).

Uncertainty is perceived as the absence of information i.e. the difference between the amount of information required to perform a task and the amount of information already in the possession of the organisation. Moreover, the greater the level of uncertainty, the greater the amount of information required in order to achieve a given level of performance during task execution. Einhorn and Hogarth (1981) differentiate between the handling of information in the sub-processes associated with acquisition, evaluation and action. Simple tasks primarily involve information acquisition, while more complex tasks require information acquisition and information evaluation. Complexity, therefore, is synonymous with a greater amount of information, which in turn requires the decision maker to partake in more complicated analytical evaluation.

Daft and Weick (1984) also support the need for organisational information awareness. Having studied organisations as information interpretation systems, they posit that "*organisations must develop information processing mechanisms capable of detecting trends, events, competitors, markets and technological developments relevant to their survival*" (Daft and Weick,

1984, p. 285), and they have concentrated their research on the mechanisms whereby top managers develop models for understanding and for learning about their environments as discussed in section 2.3.6. Top managers who broadly scan internal and external environmental domains, develop a more accurate view of key environmental attributes (Sutcliffe and Weber, 2005). Managing the environment is concerned with modifying the organisation's environment, or modifying the organisation's response to the environment in an attempt to reduce uncertainty about critical events (Galbraith, 1977). Effective handling of environmental uncertainty is a function of matching information processing capabilities with information processing requirements, especially when the environmental dimensions change and new information is required (Duncan, 1972; Galbraith, 1977; Tushman and Nadler, 1978; Fairbank *et al.*, 2006). Acquiring accurate environmental information consumes scarce time-constrained organisational resources and the attention of top managers, who either moderate their quest for information or match their efforts to the volatility of the environment (Sutcliffe and Weber, 2005). When the environment is volatile, they contend that information accuracy is of lesser importance, and that the interpretation of the acquired information is the significant activity. In earlier research, Weick and Sutcliffe (2001) observed that a misunderstanding of the environment generates an outcome which is different than that which would have been expected, thus initiating unexpected and unintended scenarios. Therefore, making proper sense of the environment is a critical factor in any decision making process, because it is imperative that managers fully understand the problems that require a decision.

Information overload is often the source of the decision maker's dilemma having an abundance of conflicted meanings for the available information (Weick, 1979; 1995), and equivocality (Daft and Lengel, 1986; Daft, Lengel and Trevino, 1987). Zack (2004) theorised the 'four problems' model in which a lack of information or knowledge has the effect of exacerbating issues of uncertainty and ambiguity, while contrarily, information overload gives rise to further complexity and equivocality. In reality, these two scenarios (lack of information

and information overload) are not mutually exclusive and organisations must have both the capability of acquiring and of processing external data as well as its interpretation (Huber and Daft, 1987).

Thompson and Tuden (1959) studied the relationship between information and decision making, but they distinguish between uncertainty over the objectives of the organisation and the uncertainty over the cause-and-effect relationships that are embodied in particular organisational actions. Their framework represents the different types of decision modes identified in these conditions as presented, in Figure 2.5.

		Uncertainty over preferences	
		Low	High
Uncertainty over cause and effect	Low	Decision by Computation	Decision by Compromise
	High	Decision by Judgement	Decision by Inspiration

Figure 2.5. Relationship between decision making and Uncertainty (Thompson and Tuden, 1959)

This framework indicates a correlation between 'decision by computation' and structured decision problems, which is synonymous with low uncertainty situations, when objectives are clearly defined and undisputed. When any of the dimensions of uncertainty are in the 'high' zone, then the decisions fall under the remit of unstructured or semi-structured decision problems. Moreover, 'decision by compromise' would indicate a satisficing (Simon, 1957) scenario, or it would indicate that a solution is achieved through bargaining (Nutt and Wilson, 2010) or trade-off. Decision making in a judgemental mode occurs when the uncertainty pertains to the consequences of the manager's actions, even though the objectives are relatively clearly understood and judgment is relied upon to achieve the optimal outcome (Speier, 2006). In this situation, the uncertainty is considered threatening and it tends to be masked rather than exploited to present a possible learning experience.

Each of the different types of decision mode requires a different type of information, indicating that the information processing capability of an organisation will directly influence the effectiveness of the decision making capabilities in each of the four decision modes of the framework. Earl and Hopwood (1980) superimpose various roles of information systems on the decision making processes considered by Thompson and Tuden (1959), and they use a machine metaphor to describe information systems, as presented in Figure 2.6.

		Uncertainty over preferences/objectives	
		Low	**High**
Uncertainty over cause and effect	**Low**	Decision by Computation Answer Machines	Decision by Compromise Ammunition Machines instead of Dialogue machines
	High	Decision by Judgement Answer Machines instead of Learning Machines	Decision by Inspiration Rationalisation Machines instead of Ideas Machines

Figure 2.6. Potential Role of Information Systems for handling uncertainty (Earl and Hopwood, 1980)

When decision making by 'computation' is possible, information systems serve as 'answer machines' in programmable (Simon, 1977) or well structured (Gorry and Scott-Morton, 1971) decision situations. When the uncertainty is related to disagreement regarding causation, the information system may be a 'learning machine' providing a range of ad-hoc or, 'what-if' analysis. However, Earl and Hopwood (1980) note that the use of computational information systems are extended into this area, resulting in the use of 'answer machines', "*which mask the uncertainty… and very often assume the very certainties that cannot be found*" (Earl and Hopwood, 1980, p. 9). When uncertainty and disagreement relate to the organisational objectives, decision making assumes a 'political' flavour, where values, expectations and preferences conflict. The opportunity exists to use 'dialogue machines', which would facilitate consultative and participative processes when exploring possible solutions. However,

information systems are used as 'ammunition machines' which facilitate the promotion and articulation of a particular preference position, which is then used to influence the outcome by shaping what is regarded as problematic and by emphasising a credible solution. When uncertainty over causation further complicates the decision problem and inspired decision making is required, an 'ideas machine' would generate opportunities for brainstorming and for creative thought.

In reality, information systems are used to rationalise and to defend decisions thus enabling the decision maker to legitimise and to justify actions that have already been decided upon, and are rarely used to actually help decision makers to make a decision (Brown and Vari, 1992). As noted by Mason and Mitroff (1973, p. 480) a manager uses information as the "*evidence upon which his decisions will be based*". The perception of 'Answer Machine information' as being 'true' is much higher than the perception of information which results from a process of rationalisation and experimentation, which of itself has very few 'guarantees' for the manager. While this indicates a lost opportunity, management perception of a robust decision making process remains as one where decisions taken can be justified and rationalised with verifiable information (Feldman and March, 1981).

There is clearly a need for the information systems which exist at each node of the Earl and Hopwood framework. These information systems suggest an appropriate fit between an organisation's ability to handle information and the type of information that is required for the organisational strategies that are in place. However, many of the opportunities associated with the information systems that could be developed are lost: including information systems which would facilitate learning possibilities based on outcomes from decision makers' chosen actions; and information systems that would facilitate creativity and inspiration bases for "ideas" generation. The possibilities and opportunities as discussed are influenced by the designers of these information systems. Therefore, the following section considers some aspects of DSS design, including the role and the potential influence of the DSS designer.

2.5. Decision Support Systems: Their Design and Use

The inherent value of information use during the decision process has been discussed in Section 2.4. This section begins by arguing that most of the organisational information available to decision makers is provided by Decision Support Systems (DSS). Managers and decision makers rely on DSSs to provide information that is not just reliable, accurate and timely but which focuses on their specific requirements. Section 2.5.1 discusses the prevalence of DSS for information availability. Decision support systems were initially identified in the seminal work by Gorry and Scott-Morton in 1971 and have evolved to include some of the major investment areas in organisations today and include Business Intelligence, Business Analytics and Big Data. Keen (1980) describes DSS development as a function of the interaction of the decision maker, the DSS designer and the DSS. The role of DSS designer is discussed at length in section 2.5.2. This is followed by an examination of the interaction of the DSS and the decision maker in section 2.5.3, as it is the judicious use of information and a keen understanding of its interpretation that is crucial in the decision making process, so that a good outcome is achieved.

2.5.1. Decision Support Systems

Decision Support Systems (DSS) are recognised as a subset of computer-based information systems (IS) that focus on supporting and improving managerial decision making (Silver, 1991; Arnott, 2004), and in particular, supporting decision making in relation to complex and unstructured tasks (Alavi and Joachimsthaler, 1992). Computer-based technology, referred to as Information Technology (IT), is any mechanism that refers to the gathering of information, the transformation of data into information and the storage and communication of information in the organisation (Egeihoff, 1982). According to Turban *et al.* (2007, p. 21), a DSS is "*any computerised system that supports decision making in an organisation*". DSSs support decision makers by reducing

uncertainty in the decision making process (Arnott and Pervan, 2005; Clark *et al.*, 2007).

2.5.1.1. The origins of Decision support systems

Many of the concepts and definitions of decision support are based on the pioneering work of Gorry and Scott-Morton (1971). In their seminal article *'A Framework for Management Information Systems',* they developed a framework that has become the foundation stone for much of the research work in DSSs. In developing this framework, Gorry and Scott-Morton (1971) combine the work of Anthony (1965), who discussed managerial activity at three levels in the organisation, and the work of Simon (1977), who differentiated between programmed and non-programmed decisions. Decision problems are analysed in terms of Anthony's categorisation of managerial activity, which are strategic planning, management control and operational control. The decision problem is further classified as structured and unstructured. A structured decision problem is considered programmed, and an unstructured decision problem is non-programmed. Subsequently, Gorry and Scott-Morton (1971) defined a framework which identified the different types of information required for each managerial activity. Gorry and Scott-Morton (1971) argue that computer systems that focus on semi-structured or unstructured decisions should be termed DSSs.

Over time, the emphasis has broadened towards systems that provide information required by managers for the full range of managerial activities, which incorporate the many computer systems designed to summarise and to analyse business information. This includes Executive Information Systems (EIS); Knowledge Management Systems (KM); as well as DSSs and Business Intelligence systems (Forgionne and Kohli, 2000; Clark *et al.*, 2007) all of which have expanded the decision support domain. Executive information systems which summarise transactional and operational data for managers, while originally considered as systems designed to support senior executives (Rockart and De Long, 1988), are now utilised at all management levels (Arnott, 2004) and

provide an extensive range of information required for all management activities, not just for decision making.

2.5.1.2. Defining a Decision support system.

Keen and Scott Morton (1978, p.57-58) propose a widely accepted definition of DSSs that implies the use of computers to: 1) assist managers in their decision processes in semi-structured tasks which are issues of managerial problem solving, 2) support rather than replace managerial judgment, and 3) improve the effectiveness of decision making rather than just its efficiency. Stabell (1983) considers the function of a DSS in its role of assisting human decision makers in the exercise of judgement, but which, by itself, does not make the decision. Sprague (1980, p.1) incorporates the concept of data models and interactivity, and defines DSSs as "*interactive computer based systems which help decision makers utilize data and models to solve unstructured problems*".

Early definitions of DSSs focus on a solution for one specific problem and a stable representation of that problem. Alter (1977) categorises DSSs in terms of their generic functional capability: retrieving a single item of information; providing a mechanism for 'ad-hoc' data analysis; providing pre-specified aggregation of data in the form of reports; estimating the consequences of proposed decisions. Functionality of a DSS is considered within a 'what-if' analysis, and 'roll-up' aggregation. This in turn, facilitates decision maker's 'look-ahead' reasoning, indicating that DSSs are 'look-ahead' machines (Pomerol, 1997). A broad definition from DSSResouces.com, which emphasises the multifaceted dimension of a DSS, states that: "*an interactive computer-based system or sub-system intended to help decision makers use communication technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks and make decisions*" (Power, 2007).

2.5.1.3. The newer offerings: BI, BA and Big Data

More recently, new terms such as Business Intelligence, Business Analytics and the related field of Big Data have emerged as an important area of

study in both the academic domain as well as in practice (Chen, Chiang and Storey, 2012) and have been presented as a means to deliver effective real time decision making information (Dover, 2004; Gitlow, 2005; Burstein and Widmeyer, 2007). Business Intelligence (BI), as a term, was coined in the early 1990's by Howard Dresdner, a Gartner Group analyst, to describe Information Systems that help decision makers throughout the organisation to understand the state of the company's world – internally and externally. Business Analytics (BA) represents the key analytical components of BI may be used to provide decision support by facilitating the creation of reports that are filtered by specific criteria relevant to the decision maker's requirements, enabling managers and other decision makers to interpret organisational data (Davenport, 2006). Meantime Big Data has been used to describe a dataset that is so large and complex that they "*require advanced and unique data storage, management, analysis and visualisation technologies"* (Chen *et al.*, 2012).

The term Business Intelligence describes a set of concepts and methods used to improve business decision making by using data-driven DSSs (Power 2002), or fact-based systems (Watson and Wixom, 2007). Initially, BI was coined as a collective term for data analysis tools and subsequently it was broadened to include all components of an integrated decision support infrastructure (Lahrmann, Marx, Winter and Wortmann, 2011) and a collection of decision support technologies (Chaudhuri, Dayal and Narasayya, 2011). BI combines architectures, databases, analytical tools, applications and methodologies (Negash, 2004; Watson and Wixom, 2007). Among the common functions of BI technologies are multidimensional data analysis, query and reporting tools, online analytical processing (OLAP), data and database mining, visualisation, digital dashboards and scorecards, and other tools to enable the manipulation of internal company data (Power, 2007; Negash and Gray, 2008). Techniques such as regression, optimisation, data mining and simulation may be used to find patterns within business data and to facilitate an iterative process for a 'trial-and-error' and 'fine-tuning' approach, even when handling large volumes of data (Khan, Ganguly and Gupta, 2008; Davenport, 2009; Davenport *et al.*, 2010).

Essentially, Business Intelligence provides access to diverse data as well as the enabling of the manipulation and the transformation of these data, that may provide business managers and decision makers with the ability to conduct appropriate analysis (Turban, Sharda, Aronson and King, 2008) so that they can make better and faster decisions (Chaudhuri *et al.*, 2011). The promise is a 'single version of the truth' through the use of intra-organisational data and the provision of a fully integrated infrastructure to support management decision making activities in a timelier manner (Eckerson, 2003; Negash, 2004). BI systems fall firmly within the domain of DSSs, and academic researchers as well as BI vendors, emphasise the impact of BI on decision making (Russell, Haddad, Bruni and Granger, 2010). Since BI systems combine data storage and information management with analytical tools, decision makers can convert complex internal and external competitive information into effective decisions (Negash, 2004). More recently Managers and decision makers use Business Analytics to interpret organisational data to improve decision making and to optimise business processes (Watson and Wixom, 2007). Eckerson (2003) suggested that three quarters of users continue to use routine reports that describe historic status for decision support. This viewpoint is supported by Negash and Gray (2008) while, at the same time acknowledging that analytics and *ad-hoc* query availability may provide more sophisticated information and may facilitate predictive analysis.

Since data is the underlying resource for BI, a central component of BI systems is the Data Warehouse, which integrates data from various transactional Information Systems for analytical purposes, and which involves the structuring, storage and use of large amounts of high quality data. However, an enormous amount of industry, company, product and customer data can be gathered from many external and internet sources including online social media forums, web blogs and social networking sites, most of which is unstructured and is considered as 'Big data'. Big data refers to an vast amount of data that conventional data warehouse technologies cannot store, manage or analyse, but is required by organisations "*to provide greater insights when assessing new business opportunities and for better decision making"* (Rahman, Aldhaban and

Akhter, 2013). The three key attributes of big data are volume, velocity and variety. These attributes capture the essence of big data:

- the large volumes of data that is available and the benefits from having more data to develop better models
- despite the large volume of data, data can be processed faster, thereby better facilitating decision making and action taking
- data is messy and complex due to the many sources of the data and the many formats of the data with more than ninety per cent of big data being unstructured (McAfee and Brynjolfsson, 2012) and inconsistent (Lycett, 2013).

Some researchers includes '*value'* as a fourth "V", indicating that top-performing organisations cite Big Data and Business Analytics as a key differentiator (LaValle, Lesser, Shockley, Hopkins and Kruschwitz, 2011; Davenport, 2013) to guide both future strategies and day-to-day operations (Lycett, 2013). Each of these attributes (volume, velocity variety and value) in turn, gives rise to a new development requirement that will cater for the technological demand of the specific attribute. For example, collecting large amounts of data, including those termed as 'big data' requires new technologies for storage and more powerful levels of computing power to do the data crunching and analysis.

A number of empirical studies have discussed BI application systems implementations and their resulting performance gains (Carte *et al.*, 2005; Piccoli and Watson, 2008; Hopkins and Brokaw, 2011). However, most of these studies focus on specific BI applications (tools) within business processes, rather than on an enterprise-wide level. Of the current BI investment, many have been deployed to provide a more interactive presentational format for inquiries or reports and are often, merely replacing existing reporting systems (Davenport *et al.*, 2010; Shanks, Sharma, Seddon and Reynolds, 2010), and they continue to require improvements when dealing with semi-structured and unstructured data (Negash and Gray, 2008). As a result, empirical reports on the impacts of BI, BA and Big data have been inconclusive, especially where managers are operating within highly uncertain situations (Speier and Morris, 2003; Speier, 2006; Buhl,

Röglinger, Moser and Heidemann, 2013; Lycett, 2013). As organisations continue to develop Information Systems that support decision making activities in today's rapidly changing business environments, it seems BI systems and other new tools and techniques, are having a similar fate as previous instalments of DSS technologies. They continue to struggle with many of the same functionality issues as have been reported since their inception (Alter, 2004) and Lycett (2013, p. 381) contends that the primary barrier to achieving the promise of big data is the "*lack of understanding of how to use analytics to improve the business*". Interestingly, Huber (1981) suggested that DSSs are almost all designed to function in a rational decision making environment, even though decision environments vary greatly across different organisations.

2.5.1.4. The emphasis is on support.

In the modern decision making environment, with the additional connectivity afforded by the Internet and by mobile devices, managers increasingly need help merely to cope with the abundance of sources of information (O'Donnell and David, 2000; Power, 2009). The Data Analytics area and the corresponding Big Data discussion are mostly predicated on the idea that managers need presentational and computational help in dealing with the volume of data available to them. This is an on-going problem (Ackoff, 1967), but existing research suggests that the proportion of business transactions made (or captured) on-line is such that available data provides, at least the illusion of being holistic – a near complete and near real-time representation of the real world, simplified with parsimony to answer managers' specific questions (Pfeffer and Sutton, 2006; Davenport *et al.*, 2010).

The emphasis on enabling and improving human decision making has been re-stated by Arnott (2006), who argues that *"Decision Support Systems (DSS) is the area of Information Systems (IS) devoted to supporting and improving human decision-making"* (Arnott, 2006, p.56), and "*represents a variety of techniques and technologies usually borrowed from a range of disciplines, which aim at improving access to necessary information for more effective decision*

making" (Burstein and Widmeyer, 2007). The overarching principle is one of human decision making support by providing access to "*the right knowledge.. the right processes in the right representation and at the right time*" (Holsapple and Joshi, 2003). Moreover, as organisations gain more experience in the use of DSSs, including BI Systems, and as they develop better analytics capabilities, these systems become an integral part of the information provision routines in an organisation (Adam, Fahy and Murphy, 1998). The evolution of DSSs, including BI, can occur for many reasons, and are a combination of cognitive and environmental factors (Arnott, 2004, p.258). Cognitive causal factors typically occur as a result of the decision maker's learning and further understanding of functionality and of potential functionality, which can subsequently create a need to incorporate new features and processes, often in an iterative manner. Environmental causal factors include: changes in technology; change of actual decision maker who has a different conceptualisation of the task or different cognitive abilities; and changes in government regulations.

Therefore, a greater level of use will indicate the need for further development and evolution of the decision aiding and decision supporting systems. The two principal groups of people, who play a very significant role in the evolution of DSSs and in the provision of meaningful and relevant information, namely the DSSs' analyst and designer and the decision maker, are discussed in the following two sections.

2.5.2. The role of the decision support systems' designer

As discussed in the previous section, DSSs are designed to improve decision making, and in particular to "*promote desired or desirable consequences while avoiding adverse effects*" (Silver, 2008). A DSS is an intervention in the decision making process, and in itself, may influence the decision maker's cognitive judgement, and therefore, the preferred 'outcome set' and the final choice selection (Silver, 1991). In turn, this can ultimately lead to individual and organisational change (Silver, 1990). DSS development is recognised as an evolutionary process where both the decision maker and the systems analyst

actively contribute to the shape, nature and logic of the system (Arnott, 2004). Keen (1980) describes DSS development as a function of the interaction of the decision maker, the systems designer, and the DSS. The interactivity between the decision maker and the DSS defines the degree of control the decision maker has over the process of decision support (Klein and Myers, 1995). Within this context the role of the designer should be understood, and their influence should be recognised, because in many situations decision makers are utilising DSS in a passive and naïve manner.

2.5.2.1. Decisional guidance

Silver (1991) carried out extensive research on the design of a better DSS, and concentrated on the potential influence of the design of Information Systems, for which he adopted the term 'decisional guidance'. Decisional guidance refers to the design attributes of an IS that enables the user to take advantage of the system and to maximise the value of its use. Silver (1991, p. 107) defines decisional guidance as: *"How a Decision Support System enlightens or sways its users as they structure and execute their decision-making processes, that is as they choose among, and use the system's functional capabilities".*

There are a number of criteria associated with decisional guidance. Firstly, decisional guidance is considered in relation to two primary categories of the decision process; namely, the structuring of the decision process and the implementation of the outcome choice by the decision maker. Secondly, there are many dimensions of decisional guidance described by Silver (1991), and each dimension is significant in DSS design. The dimensions are presented by Silver in a polarised manner and include: Mechanical versus Decisional Guidance; Inadvertent versus Deliberate; and Suggestive versus Informative.

The design of a DSS can influence the consequences of the decision in either a 'directed' or a 'non-directed' manner (Silver, 1990). 'Non-directed change' occurs where the system's designer understands that the use of the DSS will drive change, but will allow the change to be determined by the decision maker who is using the system, and where the designer does not try to influence

the decision maker's judgement. However, if a designer "*deliberately attempts*" to force the direction of change through the design of the DSS, this would be an example of 'directed change'. Many of the early DSSs designs were in the 'directed' category (Gerrity, 1970; Keen and Scott Morton, 1978), whereby the design substantiated the normative model of how the decision *should* be made.

The primary distinction between Mechanical and Decisional Guidance is fundamental to the other dimensions of the Silver (1990, 1991) topology. Mechanical guidance refers to the support provided to improve the understanding of the operation of the system, and how the user's choices are influenced through the operation of a DSS. Decisional guidance impacts upon the choices a decision maker selects in a substantive way by influencing the form and nature of the interpretation of the information output of the system (Silver, 2008).

Mechanical guidance refers to guidance mechanisms and operating mechanisms incorporated into the system. It includes aspects of menu design and help screen design, as well as the implications of display output formats on the decision maker's choices, when such display formats can be designed by the decision maker, and not just by the designer as in previous iterations of DSS (Mahoney, Roush and Bandy, 2003). Mechanical guidance is a feature in interactive and personalised web based systems when the menu order can be changed to reflect the users' most frequently used options, or navigational approaches that help users find information more easily (Lankton, Speier and Wilson, 2011). In earlier research on Executive Information Systems, Bjorn-Anderson, Eason and Robey (1986) noticed that managers would have never spent hours practicing and experimenting with their DSS. This is still true today, such that usability is as important for decision support type applications, as it is for all computer applications: "*A Decision Support System cannot successfully achieve its objectives, if it is never used*" (Silver, 1990, p. 54). Extended use of computer applications is a condition for success, as it is evidence of a manager's interaction with their decision support applications, as well as their engagement with the support staff when tackling problems of increasing difficulty (Levine and

Pomerol, 1995; Adam *et al.*, 1998). Frequency of use and the duration of use of their DSSs also improves problem identification speed, decision making speed and the depth of analysis that can be achieved (Leidner and Elam, 1993).

In contrast to mechanical guidance, decisional guidance influences the decision maker's decision and judgement task at hand, and refers to the features of a DSS that affect the choices people make when interacting with an interactive system. The level of decisional guidance which can be incorporated into a DSS is dependent on the level of discretion afforded the decision maker. A low level of discretion would indicate a limited role for decisional guidance. Therefore, decisional guidance is relevant for DSS that are used in the semi-structured and unstructured decision categories.

Silver (1991) distinguishes between *deliberate guidance*, where users are directed towards decision making paths in a way that is intended by designers and developers, and *inadvertent guidance* where users are unintentionally swayed in their decision making as a result of their use of the DSS. Deliberate guidance can be controlled and can be used to resolve conflicts over the objectives of an application, whereby it can provide recommendations, as well as unbiased and relevant information for the user. Silver also proposes a reflection on the difference between guidance which is underpinned by information referred to as *suggestive decisional guidance*, and guidance aimed at prescribing choices, which he calls *informative decisional guidance*. DSSs can be designed so that the effort involved can be reduced, when decision makers are required to follow the preferred organisational strategy (Todd and Benbasat, 1991).

2.5.2.2. The interface with the Information System

Supporting decision making requires an understanding of both the processes involved, and of the provision of a computer-based system that supports these processes, so that the processes are carried out more effectively. When considering the design of a decision support type system, the designer must, therefore, consider the sources of data, the range of alternatives which may be available to the decision maker, and the level of discretion that the

decision maker is afforded (Stabell, 1983). Mason (1969) considers the design of an IS from the perspective of the interface with the decision maker. He identifies five entities relevant to the design of a decision supporting system, which could fulfil Stabell's (1983) recommendations with a high degree of cohesiveness as well as affording the decision maker some flexibility. The entities discussed by Mason (1969) are namely; the sources of data; the data stored in the system; the predictions and inferences made; the decision maker's values and choices; and the action taken. These are depicted in Figure 2.7a.

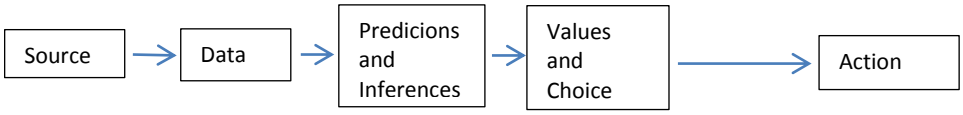

Figure 2.7a. Entities in an IS supporting decision making. Mason (1969)

A qualitatively different system and level of decision support is provided, depending on which of the entities are included in the IS, and which are at the discretion of the decision maker. For example, Figure 2.7b illustrates a 'Databank' IS where data is merely stored and classified, and all further interpretation and processing of the data is the responsibility of decision maker. The decision maker must determine the 'meaning' of the data and its value, based on their own preferences and the specific decision problem. A 'Databank' Information System is an instance of a 'nondirected' system, with minimal, if any, decisional guidance.

Figure 2.7c is a depiction of a 'predictive' IS' (Mason, 1969), which has preferences and inferences incorporated into the design of the IS, as well as data collection and storage capabilities. Enterprise Resource Planning (ERP) type systems are typical instances of predictive Information Systems, and they provide 'current status' reporting. However, the decisions required, which relate to organisational activity, are at the discretion of the decision maker. For

example, the ERP reports will highlight the most profitable products on the organisation's portfolio, but the manufacturing schedule is decided upon by the relevant decision maker or scheduler, which, in turn, is determined by the organisation's or decision maker's objectives and preferences at the current time.

When some, or all, of the objectives and values of the decision maker are part of the IS, then the IS is closer to becoming a decision making system, as depicted in Figure 2.7d. A decision making system would include the criteria of choice as part of the IS design. However, the action choice is not automated. When all the system entities are incorporated into the system, then the Information System is a decision taking system, for example; an Expert system or a Process Control System. In a decision taking system, the decision is proceduralised and automated, thereby precluding the need for human interaction, and essentially such systems are not considered as being in the DSS category (Pick and Weatherholt, 2012), and the designers and developers are the decision makers in an automated system (Levine and Pomerol, 1995).

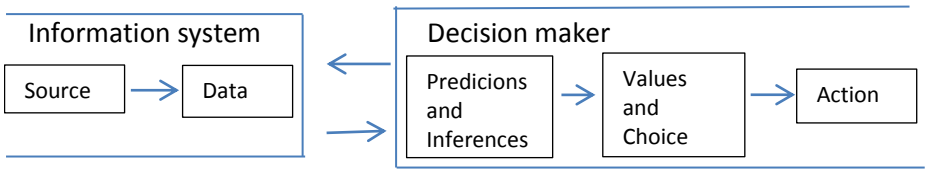

Figure 2.7b. Databank type Information Systems

Figure 2.7c. Predictive Information Systems

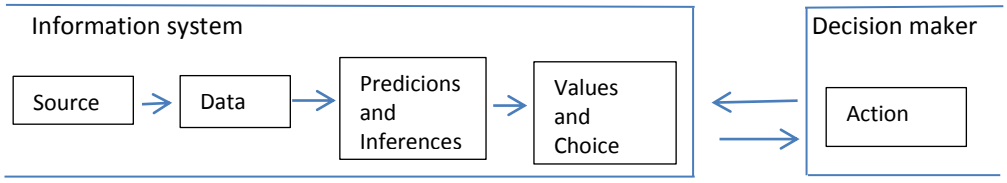

Figure 2.7d. Decision Making Information Systems

Mason's reference to Information Systems was before the term DSS was coined, and the premise of his argument is in relation to decision making and to decision support. Within each of the Information System types or DSS types, identified by Mason (1969), the involvement of the human decision maker is indispensable and is determined by the level of complexity of the system design, as well as the scope of the system. The scope of the system is determined, to a large extent, by the level of system restrictiveness incorporated into the system (Silver, 1990). System restrictiveness is defined as

"the degree to which, and the manner in which, a Decision Support System limits its users' decision making processes to a subset of all possible processes" (Silver, 1990, p. 52).

While DSSs can enable some decision making processes, other processes and functionality may be restricted, which consequently determines certain constraints and restrictions on the options available to the decision maker (Silver, 2008). System restrictiveness can affect the decision maker's behaviour and the decision outcomes. Decision makers may consider a system to be overly constricting, and therefore, may choose to ignore the system, or may decide that a minimally restrictive system, such as a Databank system, is too difficult to use, and also to ignore it. Moreover, Information Systems as they are traditionally developed often attempt to remove the uncertainties in the environment, especially when it involves procedures and processes that neither the manager not the designer fully understand. This is a particular concern when the procedures and processes require a high level of interdepartmental resource involvement, which will heighten the level of uncertainty within the organisation

(e.g. task uncertainty and task interdependencies as discussed in section 2.2.5). Thus, Carton et al (2011) have issued a warning in relation to the great need for managers to be totally educated about the methods underlying the metrics they use. Andre and Roy (2007) have also warned that any dashboard tool designed to help managers to monitor parameters under their control must primarily be able to account for the specific context in which managers operate, or else, they will lead to managers ignoring the support provided to them, or spend so much time in data manipulation that the benefits sought by providing the dashboard will be cancelled out. This can happen when both the designer and the decision maker deliberately or inadvertently restrict the system functionality. The danger is even more pronounced when it comes to parameters in the external environment which can neither be known about nor predicted (El Sawy, 1985; King, 1985). In recent times, BI systems exacerbate this scenario and make it even harder to support the manager's awareness and focus of weak signals in the environment, many of which may be effectively filtered out by structured BI tools (Ilmola and Kuusi, 2006; Hiltunen, 2008). Earl and Hopwood (1980) conclude that systems' developers, decision makers and managers must be very realistic in their analysis of information processing requirements, because constraints built into the system will restrict: 1) what the decision maker can do with the system during decision problem structuring; and 2) what the decision maker can do with the decision outcomes and subsequent actions (Silver, 1990; 2008). Silver's theory of system restrictiveness shares many of Mason's observations on how assumptions are incorporated into systems.

2.5.2.3. The impact of assumptions incorporated in systems

The build-up of assumptions as you move from source to action (from left to right on figure 2.8) is of significance to the users of the DSS, as very often, the assumptions are largely unidentified and decision makers are not made aware of the assumptions, which are inherent in the DSS as currently available to them. Moreover, when the outputs from one system become the inputs for another system, it becomes very difficult for the decision maker to separate the factual

information relating to the task, from the processed information which has been generated by the system (Speier, 2006), and which consequently can appear more objective and more independent.

In a Databank system (Figure 2.7b) the decision maker has access to all the data, and is required to discern and to investigate the relevant inferences pertinent to the current decision problem, as it is at this juncture that there is a minimum level of assumptions or restrictiveness designed into the system. As more and more of the entities are included in the DSS design, then more and more assumptions are built into the System, and the System becomes more specific and inevitably, more restrictive. Mason (1969) illustrated the build-up of assumptions, as portrayed in Figure 2.8, and the assumptions are qualitatively different at each stage of the DSS design. The predictive Information System (Figure 2.7c) contains assumptions pertaining to the 'cause and effect' relationships of different organisational activities, as well as the functional data transformations of organisational attributes, such as reporting periods. These assumptions overlay the databank assumptions, which are part of the database design.

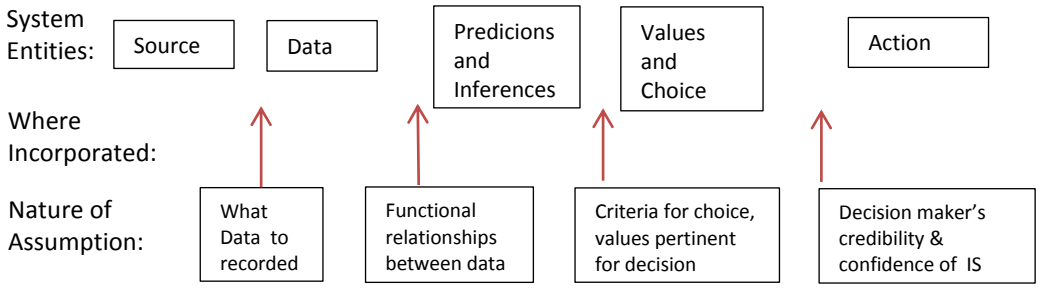

Figure 2.8. Assumptions introduced during DSS design (after Mason (1969))

Furthermore, in a decision making Information System, (Figure 2.7d) the criteria for choice must be designed into the system. Specifying a measurement value for all choice scenarios is very difficult unless the system functionality is very narrow and very generic to a specific process. Examples of such systems

include a fully automated process control system or a DSS system specific to an individual decision maker, as in many of the current BI offerings.

The nature of the assumptions incorporated into the IS influences the decisions made, and they should reflect the decision maker's needs, which, in itself, is a considerable challenge for designers. DSS designers should not provide artificially complete ready-made answers, but, rather, should design systems that promote judgement and dialogue amongst decision makers (Earl and Hopwood, 1980). Facilitating a design which will help decision makers envisage richer scenarios could improve the handling of complex situations, rather than a design that focuses only on choice recommendations (Pomerol, 1997; 2001). Consequently, designers are challenged to achieve a balance between flexibility and restrictiveness, by understanding the system's objectives and the decision maker's intended use, as well as the level of discretion afforded the decision maker. A system's restrictiveness should promote, rather than inhibit use of the system (Silver, 1990; 1991; 2008). The key issue is, therefore, which managerial problems lend themselves to the development of what Earl and Hopwood (1980) term answer machines, and what happens when the level of uncertainty and ambiguity involved means that the provision of answer machine can potentially compromise the ability of managers to make the right choices. "*Whether designers think about it or not, their designs will restrict, ….. and will guide*" (Silver, 2008, p. 289). The strictness of business process rules and regulations in an organisation as well as the level of risk tolerated, impacts the way BI supports decision making in an organisation (Işık, Jones and Sidorova, 2012).

In summary, inquiry systems are very often designed to provide specified answers rather than interrogation facilities. Furthermore, uncertainty tends to be voluntarily masked by the development of quasi-certain systems where assumptions are made to fill the gap in managers' understanding of their environment, as opposed to it being exploited for what it is. The implication for this evaluation is further discussed in the next section, where the role of the decision maker is considered. In some sense, a DSS analyst and designer acknowledges that the preferences involved in the decision maker's mind are

multi-disciplinary and multi-attribute (which excludes any simple utility function) and are personal. However, many Decision Support Systems have been designed that do not incorporate this idea, and instead, try to model and to impose an aggregation function in order to make the decision. In an ideal world, decision Support Systems should prompt executives to question their own assumptions (Drucker, 1995).

2.5.3. Decision Support Systems and decision maker interaction

In the previous sections, DSS have been established as representing a subsection of IS that is dedicated to supporting and to improving human decision making (Arnott, 2004). Furthermore, the objective of DSS implementation and use is to enable decision makers to complete the decision process and, consequently, make better decisions.

There is a long established body of research that proposes a number of solutions on how to support managers' decision making, from the traditional DSSs to recently populated terms such as Business Intelligence (Adam *et al.*, 1998; Arnott, 2004). All of these solutions involve computer-based techniques used in identifying, extracting, and analysing all types of business data, that can be delivered to users in reports, dashboards and on-screen inquiry formats (Daly, Adam and Pomerol, 2008). A DSS may help a manager to make decisions in situations where human judgment is an important contributor to the problem solving process, but where human information-processing limitations impede decision making. As explained by Silver (1991, p.102-103) "*A Decision Support System provides computer based assistance to a human decision maker. This offers the possibility of combining the best capabilities of both humans and computers. A human has an astonishing ability to recognise relevant patterns among other factors involved in a decision, recall from memory relevant information on the basis of obscure and incomplete associations, and exercise subtle judgments. …. The goal of a DSS is to supplement the decision powers of the human with the data manipulation capabilities of the computer (...) used to*

empower decision makers to engage in more intensive and extensive decision making behaviour".

The emphasis on the behavioural perspective of the relationship between the decision maker and the DSS, originated in the work of Simon and Newell in the 1960's. The role of the decision maker is considered indispensable, because the decision maker makes the final judgement, based on the output from the DSS and on the individual preferences of the decision maker. Hence, the main role of the decision maker is to "*complete the model, i.e., to tell the system what to do when there is a gap in the program*" (Levine and Pomerol, 1995, p.42); otherwise the DSS has automated the process, and no further decision is required. Automated decision technologies effect organisational performance by facilitating routine tasks, (Tushman and Nadler, 1978; Davenport *et al.*, 2010), while simultaneously the automation of routine and often tedious tasks allows a decision maker to explore a problem more thoroughly than would be possible without a DSS (Pick, 2008). In theory, the additional exploration and analysis may provide a better understanding of not just the problem, but also of the process in general, thus providing the opportunity to introduce further improvements to the decision process. Automated decision technologies may introduce a variety of managerial challenges because, ultimately, managers have the responsibility for defining the context and the limits for the automated decision. Davenport (2006) contends that exceptions occur in some twenty per cent of automated decisions, which highlights the need for manager intervention in these scenarios.

Gorry and Scott-Morton (1971) define unstructured decisions as those in which the decision maker must provide judgement, evaluation and insights into the problem definition. Evidently, ISs can help with decision making and information dissemination; yet, the precise ways in which computer systems can be used for these activities remain largely unknown. Despite the claims of software vendors, there is some evidence that the problems inherent in proposing effective decision support are of such a nature that modern graphical user interfaces (GUIs), interfaces and the myriads of tool kits available from software vendors to develop advanced dashboards with minimal programming

expertise, are unlikely to solve the real decision problems conclusively. It is the enlightened selection and the accurate capture of the critical indicators most useful to the business managers, within the organisation's currently available data sources, which is problematic. As discussed in section 2.3.2, Pomerol (1997) differentiates between the 'diagnosis' and the 'look ahead' aspects of the decision process as depicted in Figure 2.3 (see section 2.3.2). Diagnosis relates to the current state, which is known with some certainty. Look ahead relates to the decision maker's considerations of future states and their capacity to make trade-offs between short term and long term outcomes, and is not known with certainty.

The relationship between information processing theory and decision making is based on the assumption that individual decision makers have the ability to acquire, to interpret and to analyse information, and to have memories to store information on a long and short term basis. The interpretation and analysis of information is often in accordance with the application of one or more decision rules which simplifies the selection of one alternative over another. The purpose of decision rules is to specify the most preferred alternative, from a partial, or total ordering, or prioritisation of alternatives (Sage, 1981). The decision maker should have a set of alternatives that can be evaluated with respect to the realisability of the available alternatives. Decisions are made in accordance with formalised rules that are derived from an understanding of what is appropriate for an individual decision maker and a specific decision problem. Therefore, decision rules are a function of the decision maker's experience of observed events or interpretation of them, and therefore, decision rules can change during the course of the decision process (Hersh, 1999). Decision rules can also change when a decision strategy changes, because task knowledge changes as the decision maker learns more about the decision task (Payne, Bettman and Johnson, 1993). Decision strategy is the method by which the decision maker acquires and interprets information to make a decision (Jarvenpaa, 1989).

2.5.3.1. Decision rules in use

Schoemaker (1980) differentiated between holistic and nonholistic categories of decision rules. In a holistic decision rule, each alternative is assigned a value or utility. After all alternatives have been evaluated, they are compared, and alternative A is said to be preferred to alternative B, if it's evaluation has given it a greater utility such that U(A) > U(B). Holistic evaluation is the most prevalent form of inquiry and normally relates to routine events. This form of inquiry requires a considerable volume of information in order to provide meaningful results. During holistic evaluation, the decision maker will identify *"a set of well-defined objectives and goals, and is assumed to be able to express preferences between different states of affairs according to the degree of satisfaction of attaining these objectives and goals"* (Sage, 1981, p.650). March and Shapira (1987) warn against the use of expected value type inquiry when the decision problem relates to rare events with low probabilities and important consequences. Holistic evaluation is best suited for structured problems since the decision maker's preferences are clearly understood and are clearly stated, and evaluation of the outcomes is without ambiguity.

In nonholistic decision rules, individual alternatives are compared with one another, or with a standard, in a sequential elimination process equivalent to heuristic elimination (Sage, 1981). Heuristic elimination involves comparisons of one alternative with another, such as the comparison of an alternative against some standard or the comparison of alternatives' attributes with each other. Simon (1979) refers to heuristic decision rules as providing satisficing strategies or outcomes, such as finding optimum solutions within simplified less complex decision problems, and a satisficing solution in complex more realistic decision problem situations. Newell and Simon (1972) use the term "*heuristic search method*" to describe a mental model of search formulation for solving numerical, logical and other kinds of cognitive problems, and they suggest the effectiveness of particular heuristics as a function of the structure of the decision problem. Heuristic search is considered as 'what-if' analysis, which is regularly used to perform either sensitivity analysis or robustness analysis when comparing input

variables for decision outcome exploration (Pomerol, 1997). The decision maker's evaluation of the outcome set incorporates their own heuristics and preferences.

However, people tend to be inconsistent in such judgements, especially when evaluation of the outcome set is required within a short timeframe, when the outcome is critical or when the external environment is volatile and distracting (Tversky and Kahneman, 1974; Einhorn and Hogarth, 1981). Achieving an improved heuristic output may involve considerable additional information processing by the decision maker, and it may not generate a much improved outcome set, as invariably a plateau is reached that can be surpassed only with quite different heuristic searches (Newell and Simon, 1972). An example of the possibilities that can occur when significantly different heuristics are employed, is reported by Hopkins and Brokaw (2011), in relation to a system designed for selling credit insurance and debt protection products. A level of creativity and suggestive guidance incorporated into the resultant system, through the involvement of data analytics experts, achieved new and improved heuristics. However, such examples have been reported mostly for activity specific scenarios, and rely on the existence of clear modelling and reasoning to underpin the optimisation algorithms that are being applied. However, even in these limited examples, the benefits achieved would be inconceivable without computer-based process capability.

Sage (1981) proposed a further classification to describe a decision maker's understanding derived through reasoning by analogy and intuition, and other forms of nonverbal almost unconscious perception, which he classified as "*wholistic judgement*". Wholistic judgement is based on the previous experience of the decision maker, and is analogous to "*making holistic associations*" (Dane and Pratt, 2007), as discussed in section 2.3.2. Making holistic associations acknowledges the more complex aspects of intuitive processing usually associated with the intuitive decision making of experts. Making holistic associations involves "*a process in which environmental stimuli are matched with some deeply held (nonconscious) category, pattern or feature*" (Dane and Pratt,

2007, p. 37). The ability to make holistic associative connections between the environmental stimuli and their underlying cognitive structures is developed over time in a dynamic and deliberate way. Sage (1980) highlights the dangers of novice decision makers endeavouring to use wholistic decision rules. The dangers relate, not just to the experience attribute, but also to the associated lack of ability to recognise contextual relations and analogous situations that are inherent in the use of wholistic decision rules and making holistic associations. One of the mechanisms for wholistic inquiry is 'intuitive affect', and Klein (1993) refers to this process as '*recognition-primed decision making'* whereby patterns and features are recognised and matched to the current situation, which is recognised as a characteristic of intuition (Dane and Pratt, 2007).

The Sage hierarchical structure of decision rules, which identifies the three avenues for inquiry as holistic evaluation, heuristic elimination and wholistic judgement, is depicted in Figure 2.9.

Decision Rules	Wholistic Judgement	Intuitive affect
		Reasoning by analogy
	Heuristic elimination	Comparison against a standard
		Comparison across attributes
		Comparison within attributes
	Holistic evaluation	Expected utility theory
		Subjective expected utility theory
		Multiattribute utility theory
		Mean variance theory
		Subjective utility theory

Figure 2.9. Sage's (1981) hierarchical structure of decision rules

These three methods represent the cognitive means that decision makers apply when they are evaluating the criteria that will underpin their decision.

Mitroff and Linstone (1993) also consider three '*modes of inquiry*', namely: a functional mode which relies on known processes and information; an interpretive mode which stresses communication and interpretation; and a critical mode which is more heuristic in nature. However, they advocate the use of all three modes of inquiry when dealing with complex decision scenarios as "*together they give a richer base for decision and action*" (Mitroff and Linstone, 1993, p. 101). Moreover, Dane and Pratt (2007, p. 37,38) argue that decision makers "*nonconsciously, make holistic associative connections between the stimuli they encounter and their underlying cognitive structure, …. in an effort to integrate wide-ranging stimuli into usable categories of information"*. However, the strictness of business process rules and regulations in an organisation, as well as the level of risk tolerance, impacts the way DSS and BI support decision making in an organisation (Hostmann, Herschel and Rayner, 2007), which is further discussed in the following subsection.

2.5.3.2. Decision rules and Inquiry Systems

Another way to reflect on information inquiry has been presented by Adam and Pomerol (2008) who propose that decision makers can leverage the data provided by their support systems for three types of inquiry. These are: (1) Reporting: when managers ask questions that they understand well and where answers can be monitored over time with the use of tightly restricted models that embody previous decisions and ways to resolve them, (2) Scrutinising: where managers ask questions which they understand in broad terms, but still find difficulty asking specific questions in specific terms, and (3) Discovering: where managers are not sure what questions to ask, sometimes in the complete absence of a model, or even a specific problem to solve. There is an evident equivalence between the information available based on the three Sage (1981) decision rules categories, and the information available based on the three Adam

and Pomerol (2008) decision inquiry types. This equivalence is depicted in Figure 2.10.

Hierarchical structure of decision rules Sage (1981)			**Adam and Pomerol (2008) inquiry classification**
	Wholistic Judgement	Intuitive affect	Discovery
		Reasoning by analogy	
Decision Rules	Heuristic elimination	Comparison against a standard	Scrutenising
		Comparison across attributes	
		Comparison within attributes	
	Holistic evaluation	Expected utility theory	Reporting
		Subjective expected utility theory	
		Multi-attribute utility theory	
		Mean variance theory	
		Subjective utility theory	

Figure 2.10. Sage's (1981) hierarchical structure of decision rules and Adam and Pomerol (2008) inquiry classification

Moreover, the three inquiry classifications are practical from a designer or developer's viewpoint because they correspond to the level of knowledge that an analyst can gain *a priori* about an information need they are about to tackle, and it can be matched with the manager's pre-existing level of understanding of the decision problems they face. Mitroff and Linstone (1993) advocate the use of multiple modes of inquiry and it is also envisioned that managers and decision makers will leverage the three types of inquiry to some extent, depending on their levels of expertise and of experience, as well as the level of complexity associated with the query, and the organisation context at play. Managers and decision makers regularly summarise and interpret their own information, based on perception and observation of their own area of expertise and of the problem

decision. As noted by March and Simon (1993, p. 187), "*They become an important source of informational premise for organisational action…. and a great deal of discretion and influence is exercised by these persons*" This is analogous to Mason's (1969) discussion of the assumptions which have been built into ISs, which is highlighted in section 2.5.2. It is important, that all parts of the organisation act on the same premise (March and Simon, 1993), whereby, the assumptions are known and the implications of any inferences drawn are understood, whether the information comes from 'an analytical front end' in the form of a DSS, or when the decision maker is acquiring the information through direct inquiries. This is especially significant in situations where decision makers (and their staff) are given privileges to directly access the data warehouse for the creation of inquiries of the scrutinising and discovery type. Essentially, decision makers need information that is both reliable and relevant to the decision problem and to the complexity of the environment. This requires the processing of information at many cognitive levels on the part of the decision maker, which, by implication, is subject to possibilities of cognitive biases and information overload, all of which have a detrimental effect on the decision making outcome. Evidently, the selection and capture of this key business information requires meaningful collaboration between decision makers and their decision support aids, their staff as well as the available DSSs.

2.6. Evaluating the Maturity of the Available Decision Support

One of the main problems that confronts efforts at evaluating the benefits of any form of support for decision makers has to do with the nature of the decision outcomes themselves: namely, that in many situations, the benefits accrued are hard to quantify, and often, only appear years after implementation of the decision solution. The decision maker is dealing with an environment that is characterised by risk, uncertainty and complexity, and that changes over time, which of itself, makes it difficult to isolate the specific factors that influence the decision outcome.

As discussed in sections 2.4 and 2.5, the provision of timely, accurate and reliable information from a number of different types of IS has a positive effect on organisational performance and in particular on improved decision making (Earl and Hopwood, 1980; Alavi and Joachimsthaler, 1992; Clark *et al.*, 2007; Arnott and Pervan, 2008; Silver, 2008). Decision Support Systems (DSS), as discussed in section 2.4, is the area of Information Systems which focuses on the support and improvement of managerial decision making by adding value to the decision making process. The following sections discuss how decision support is evaluated from a 'maturity' perspective that will provide a measurement mechanism for the level of decision support in place in organisations.

2.6.1. Interpretations of maturity in IS domain

Measurement is the process by which numbers or symbols are assigned in such a way as to describe them according to clearly defined rules. A considerable focus, in the IS domain research, pertains to the measurement of the IS software development process, in an effort to measure various factors in relation to improved software quality. Measurement metrics can be classified as product metrics or process metrics. Product metrics relate to the product itself and is a measure of product quality. Process metrics focus on the IT development process and the establishment of a benchmark for the software development process with reference to a 'best practice' process.

Organisations have applied maturity models' concepts for various aspects of organisational activity. In particular, the notion of IT Maturity is not new and has been approached in a variety of ways by researchers (Earl, 1989; Galliers, 1993; Venkatraman, 1997; Khandelwal and Ferguson, 1999; Ross and Weill, 2002; Nolan and McFarlan, 2005). Maturity models are utilised in organisations to identify the strengths and weaknesses of specific domains within the organisation and over one hundred and thirty different IS oriented maturity models have been identified (Mettler and Rohner, 2009), which indicates a certain arbitrariness associated with the development and use of such models.

Many of the models identified in the IS domain are prescribed by practitioner researchers and vendors, for example TDWI, Gartner, HP, and Teradata. On the whole, these focus on the classic IT topics such as application development, data and infrastructure, and, for the most part lack verifiable reliability (Lahrmann *et al.*, 2011). Theoretical foundation is considered an important aspect of reliability, because it describes whether the model is explicitly based on accepted maturity model design theories (Mettler and Rohner, 2009). In their 2010 study of BI related maturity models, Lahrmann, Marx, Winter and Wortmann (2010) suggest that only one model of the ten models investigated can be described as theory-based, which is the Watson, Ariyachandra and Matyska Jr (2001) study and is underpinned by the stages of growth theoretic model suggested by Gibson and Nolan (1974). This lack of theoretical foundation suggests that the link between BI maturity and BI impact is unclear. Gibson and Nolan (1974) presented the four stages of growth model to represent the evolution of Information Technology deployment as it matures in organisations, culminating in maturity. They suggest that maturity is reached only when the computer resource is fully integrated into the daily management practices and thinking. Earl and Hopwood (1980) acknowledged that Gibson and Nolan's notion of maturity had yet to be realised at the time of their research.

The Capability Maturity Model (CMM) is one of the best know IS models, and establishes a maturity level for an organisation's software development process. The maturity level correlates proficiency with a quality rating, which is recognised as a barometer of the quality of the software developed. The use of maturity models both simplifies and provides a pragmatic and structured approach for measuring how well developed processes are, against a consistent and easy to understand scale, as well as identifiable capability improvements (Grembergen, Haes and Guldentops, 2004). The Capability Maturity Model has been criticised because on its overemphasis on the process perspective and its disregard of people capabilities (Mettler, 2009).

Maturity may be defined as "*the state of being complete, perfect or ready*" (Simpson and Weiner, 1989). Achieving maturity thus implies an

evolutionary process from an initial state to a desired end state. The initial state is normally characterised as an organisation with little capability in the domain under consideration. In contrast, the highest state represents a fully developed or totally mature state. Maturity models can be staged or continuous. The Capability Maturity Model is a staged model, in which the evolutionary path between the initial and mature state is characterised by a number of intermediary stages which can be achieved, and which are recognised as corresponding to specific identifiable capabilities and proficiencies at each stage. In staged maturity models each stage builds on the previous stage and is characterised by a set of criteria that must be fulfilled in order to achieve that particular level of maturity. Continuous maturity models are similar to staged models except the different dimensions at each level may mature at different rates. This type of maturity model is more flexible than a staged model and provides multiple paths to achieve maturity. The different dimensions within these maturity models may move either forwards or backwards, allowing context to be taken into account, opening up the possibility of specifying situational levels (Lahrmann *et al.*, 2011).

2.6.2. Decision Support Maturity

The notion of DSS maturity is not new either. Huerta Arribas and Sánchez Inchusta (1999) use DSS maturity, which is defined as "IT to aid decision making", as one of their factors in measuring IT maturity and they explained DSSs maturity as "*the degree to which companies incorporate IT to pursue organisational aims*" (p. 153). Adam et al (1998) discuss DSS maturity in a sample of eighteen organisations in terms of 1) a DSS spread score, which measures the use of DSS in an organisation, and 2) a DSS complexity score, which measures the complexity of the problems being resolved. As a result, the data show that the complexity level is proportional to the spread score, which implies that the volume of use of and the level of dependence on, specific DSS by decision makers will increase when more DSS are implemented in organisations.

Parkes (2009) considers the persuasiveness of a DSS as an indicator of the usefulness of the system. Persuasiveness is a positive predictor of reliance, and decision maker's reliance on their DSS increases when perceived task difficulty corresponds with a perceived usefulness of the system. He concludes that "*an improvement in persuasion levels will return additional value to the organisation by improving decision quality*". LaValle *et al.* (2011) go further however and claim that top performing firms are those that rely more heavily on, and are more sophisticated in their use of data analytics. Their survey yields the following conclusion (LaValle *et al.*, 2011, p. 22):

> *"For analytics-driven insights to be consumed – that is to trigger new action across the organisation – they must be closely linked to business strategy, easy for users to understand and embedded into organisational processes so that action can be taken at the right time".*

Essentially, DSS applications that are easy to use and easy to understand are persuasive. When persuasive systems are readily available within organisations then managers and decision makers rely on them.

For almost two decades, IS researchers (Venkatraman, 1997; Ross and Weill, 2002; Nolan and McFarlan, 2005) have been studying the idea of aligning business and the Information technology function through building the relationship and through repositioning role-patterns between the Information Technology function and the various business functions. Although the alignment has great value, it is only optimising an existing relationship and it is not establishing an optimal relationship between business and IT (Hinssen, 2009). When IS becomes an integral part of the day-to-day organisational process, such that it is indistinguishable from the process itself then a level of *"IT embeddedness"* exists in the organisation (Kohli and Grover, 2008). The level of IT embeddedness reflects the level to which IS has been entrenched into the day-to-day business activities (Sethi *et al.*, 2003).

Evolutionary progression via a continuum is a familiar concept in Information technology research and practice and is also incorporated by El Sawy (2003) as part of the debate on the quest for the core of the "IS field" and its

boundaries. He presented three different *views* of IS which correlate with three different levels of IT embeddedness within an organisation, namely: 1) a *connection view* whereby IT and IS are seen as tools to support work processes, but are not completely integrated, such that people can still continue their work without these tools; 2) an *immersion view* whereby IT and IS are part of the business environment and cannot be separated from work and processes because of the systemic relationships and the mutual interdependencies at play; and 3) a *fusion view* whereby IT and IS are fused within the business environment such that business and IT and IS, are indistinguishable to standard time-space perception and form a unified whole.

In summary, decision support maturity is considered in terms of the attributes of the support process, such as the availability of support tools and their reliability and responsiveness, which is influenced by the spread of systems across the full decision making domain, as well as their persuasiveness. Watson (2010) considers a BI-based organisation as equivalent to the immersion view of IT (El Sawy, 2003) where work processes and BI are highly interdependent and influence each other, especially in organisations that serve high-volume markets using standardised products and practices. Essentially, the fusion view implies a level of embeddedness which integrates decision support insights with individual decision makers' behaviours (Murphy and Adam, 1998) and beyond this, within the organisation's collective approach to the utilisation of information and the organisation's decision making processes and routines (Shanks and Bekmamedova, 2012).

2.6.3. Measuring Decision Support Maturity

As discussed in the previous two sections, (Sections 2.6.1 and 2.6.2), achieving decision support maturity implies an evolutionary process from an initial state of minimal and ad-hoc support, to a desired end state, where decision makers gain insights and decisional guidance through their use of the available tool set. Fundamentally, the decision support provided to managers

must be perceived to be easy to use and useful by its users, such that it will lead to an extended use where organisational actors recognise its value and rely on it for their critical decision making. Over time, the reliance on decision support will increase and reach higher levels of sophistication within specific domains of managerial complexity, often facilitated by the endeavours of specialists and domain experts (Adam and Murphy, 1995; El Sawy, 2003; Shanks and Bekmamedova, 2012).

In this study, a Decision Support maturity framework is developed, using Adam and Pomerol's framework of inquiry classification (Adam and Pomerol, 2008), as presented in Figure 2.10 in Section 2.5.3, and the dimensions of maturity outlined above. Accordingly, there are three types of problems that are supported by data from DSS or BI systems, and each is classified based on the degree of problem complexity: *reporting*, when decision makers (managers or specialists) understand the nature of the problem quite well (structured, routine problems); *scrutinising,* where decision makers understand the nature of the problem in a broader context, yet they struggle to articulate it in specific terms (explorative heuristic problems); *discovering,* when managers do not have a question in mind due to the highly abstract nature of the problem (unstructured and wicked problems). Accordingly, various DSS and BI tools are used to support the necessary inquiries for these types of problem complexity, from the basic static reporting tools to multidimensional data cubes and OLAP tools, and data mining.

Adam and Pomerol (2008) argue that, when managers can name specific performance indicators and when they know how these must be represented, the situation corresponds to the lowest representation level (level 1) in the Humphreys and Berkeley (1985) framework, (Table 2.5 in Section 2.3.6), especially if they are also able to calibrate performance level based on their own knowledge. This is essentially a reporting scenario where specific answers are given to specific questions. When, however, it is not exactly known how to measure or represent an indicator, this corresponds to levels 2 and 3 in the framework. This is more of a scrutinising situation where managers know the

broad parameters of what is required, but specifics are not known, suggesting that managers cannot specify the necessary controls which would allow them to formally monitor the desired indicator. Finally, when managers are not sure what indicator should be monitored to measure emergent changes in the activities of their organisations, or changes to market responses, this is more akin to a level 4 situation, because managers are still at the problem defining stage through scenario analysis and diagnosis. The development of the decision support capability of the organisation thus becomes an iterative process where problems and their representations improve over time and where discovery turns into scrutiny and scrutiny turns into reporting over time. This theoretical proposition, however, requires that the decision support capability of a firm is articulated around a complete portfolio of applications covering at least levels 1, 2, 3 and possibly level 4, if not all levels. To tackle this complexity, and in keeping with the research objective, this research project will use the Humphreys and Berkeley (1985) representation framework as a theoretical mechanism to measure Decision Support 'maturity'. Specifically, the researcher posits that the size of the footprint of Decision Support applications mapped against the portfolio of problems which an organisation faces across the categories of the framework can be used to indicate the relative level of Decision Support maturity of an organisation. If this footprint does not rise above level 3, then an organisation can be considered to be leveraging the concept of DSS. Only when the footprint rises to level 4 and even level 5 in tangible ways, can an organisation be termed to have reached DSS maturity, as in this scenario, DSS will be thoroughly entrenched and embedded in the decision making processes of top management. In a similar concept of the progression from the connection view to the immersion view to the fusion view, the notion of Decision Support maturity is equivalent to the Fusion view when decision makers at all levels of the Humphrey and Berkeley (1985) framework, or at least levels 1 through 4, achieve their decision problem outcomes through the utilisation of Decision Support tools which are immersed and indistinguishable in their daily routines and become their taken-for-granted paradigm of their work environment.

2.6.4. Conclusion: Propositions in relation to decision support

In the context of the constituent literature on organisational decision support maturity, the Adam and Pomerol (2008) inquiry classification (Table 2.10), is a good match to the objective of this study to analyse the impact of support systems in an organisation, and in particular, the 'messy' and 'wicked' problems managers encounter, as they strive to tackle the challenges facing them, irrespective of which representation level they operate at, at a particular point in time, as per the Humphreys and Berkeley (1985) classification. In this research, some key elements of the principles underpinning the inquiry classifications and the maturity proposal are identified in the shape of the following propositions, which will be validated in the empirical section of this thesis.

Proposition 5: *the decision support provided to managers is perceived to be easy to use and useful by its users, such that it leads to extended use where organisational actors recognise its value and rely on it for their critical decision making.*

Proposition 6: *over time, the reliance on decision support in a firm increases and reaches higher levels of sophistication within specific domains of managerial complexity.*

Proposition 7: *decision support applications have a tangible impact on managerial decision making, which can be analysed in terms of its alignment with the objectives of the firm on the one hand, and on the other hand, in terms of its fit to the specific situation and context in which the users of the decision support avail of its use.*

The research objective includes researching these propositions in the context of a case study of an organisation where good access to managers at a variety of levels can be obtained, and which is operating in an industry which is known to rely heavily on information, Business Intelligence and Decision Support.

2.7. Synthesising the Level of Decision Support Maturity

This chapter has shown that decision making is considered one of the core activities in organisations, and successful decision making is a differentiating feature of successful and enduring organisations. But research highlights that decision making is complex, and is impacted by a number of factors including the decision environment, the decision maker experience and the level of decision support which is available. Decision support as a research area, which acknowledges a broader context for support as advocated by Alter (2004), than the narrowed focus of DSS, has also been considered in this chapter. Decision support, including the full range of DSS that provides information for decision makers, continues to evolve, and purports to provide quality information which will enable better decisions by managers (Dover, 2004; Gitlow, 2005; Burstein and Widmeyer, 2007; Power, 2007; Watson and Wixom, 2007). While organisational decision making is complex and messy, acquiring and interpreting the information that will enable managers make better decisions remains problematic, and oftentimes elusive. Moreover, the development of applications that are required to provide the requisite models for support, at all levels of decision making activity, has not been realised This is especially true when the decision problems are unstructured and when the decision environment is unpredictable and highly competitive.

Decision making within an organisation is complex, and most of the decision problems encountered by executives, '*which take more than ten minutes to complete*' are ill structured (Mintzberg, 1973), wicked (Rittel and Webber, 1973) and messy (Ackoff, 1979). Complexity exacerbates ill-structured problems, mainly due to the levels of uncertainty and ambiguity which prevail in the decision environment. The organisational decision environment has always been complex and ill structured, however it is reasonable to assume the environment of the future will be even more so. The internal business environment is often contradictory and ambiguous, and the external business environment is becoming increasingly complex and unpredictable. Fast, high-

quality, strategic decision making in this context, represents a fundamental dynamic capability in high-performing organisations. King (1985) pointed out that the "*CEO's primary task is to integrate the complex elements involved in making a choice, both the numbers that can be analysed on a computer and the intangibles that require more in the way of judgment*". Effective handling of organisational complexity hinges on the ability of managers to describe the complexity, thereby understanding it. Subsequently, aspects of the complexity may be modified and controlled, which may ultimately improve the decision maker's ability to predict behaviour.

2.7.1. The research challenge for this research study

Despite the many models of a rational approach to decision making, Nutt (2001) indicates that half of managers' decisions fail because managers employ failure prone tactics. Decision making is not a linear process, and in most situations, there is 'no one' solution. This research considers a behavioural and cognitive approach to decision making, and utilises a 1985 framework which introduces a theory of decision making as a cognitive representation of the decision maker's cognitive realisations of a decision problem at each stage of the problem specification refinement, until a specific operational solution is implemented. The Humphreys and Berkeley (1985) framework facilitates the juxtaposition of the ideas of problem definition and problem solution within the framework, recognising that while both ideas are developing in tandem, the possible solutions evolve from an elucidation of the problem. At the same time, refinement of the problem occurs due to experiential information derived from the analysis, judgement and inspiration of the solution finders, which emphasises the convergent nature of decision making. Unfortunately, the participants in the 'problem' representation process, as well as solution finders often lack the resources for adequate "reality testing" before committing to a prescription for action (Humphreys, 1989).

Providing the right information at the right time and developing the decision support applications and models that match the decision makers'

requirements, has been the aspiration of IS researchers and practitioners and analysts for more than fifty years. DSS is one of the earliest categories of systems devised to support the organisational decision maker. In the intervening forty years since Gorry and Scott-Morton (1971) coined the phrase, many iterations of Management Support Systems have been proposed, including the more recently named 'Business Intelligence' offerings. DSS and BI systems help organisations meet their information processing needs by facilitating organisational information processing capacity. BI does so by combining data collection, data storage and knowledge management with analytical tools so that decision makers can convert complex information into effective decisions (Negash, 2004).

However, the issues surrounding decision support remain. Management's understanding of the decision problem, at the different organisational levels, must be treated differently when providing decision making support (Anthony, 1965). It has been argued that the early DSS applications supported only rational decision behaviour, even though decision making is neither rational nor orderly. (Earl and Hopwood, 1980; Huber, 1981). Moreover, Earl and Hopwood (1980) presented an ideal vision of information from IS that could be made available for decision makers. This ideal (using a 'machine' metaphor') includes dialogue machines and learning machines whereby decision makers could advance their decision making capability, as well as an ideas machine that could facilitate ideas generation. However the answer machines that have been developed over the last thirty years, serve the decision maker by providing information that can be used to rationalise alternative choices and to justify decision outcomes and actions taken. Moreover, such answer machines have come to be recognised as the exemplar for a robust system and are considered as 'best practice'.

In this thesis, decision making is represented by the Humphreys and Berkeley (1985) framework that differentiates between the decision problem representation and the problem solution representation, but also highlights the interconnectedness of these two elements, such that the decision problem is realised through the continuous evolution of the solution and the subsequent refinements of the problem. Decision support is considered from the prospective

of the information availability from the ideal IS as per Earl and Hopwood (1980), and from the perspective of the corresponding inquiring classifications of Adam and Pomerol (2008).

Decision making				**Decision Support**			**Maturity Footprint**
Cognitive representation Level and abstraction level (maximum to minimum) **(Humphreys & Berkeley 1985)**	**Decision Problem representation** **(Humphreys & Berkeley 1985)**	**Problem solution representation** **(Humphreys & Berkeley 1985)**		**Earl &Hopwood and Thomson and Tuden (1980) representation of Information and models requirements**	**Adam and Pomerol (2008) and Sage (1981) inquiring classifications**		
5	Conceptual ideas which recognise existence of decision problem	None, as situation makes no sense		Not applicable	Not applicable		High
4	Problem formulation and sub-problems identified	Interpretation and discourse		Information which facilitates Inspiration and idea generation	Discovery type inquiry providing 'Wholistic judgement'* output		
3	Problem structure defined	Models of possible solutions identified		Information that facilitates judgement	Scrutinising type inquiry providing 'Heuristic elimination' output		
2	Suitable alternatives represented, implementation implications known	Sensitivity analysis explored		Information that facilitates rationalisation / compromising argument			
1	Stable representation of decision problem	Best alternative choice		Information that facilitates computational process	Reporting type inquiry providing 'Holistic evaluation' output		Low

Table 2.8. Synthesis of decision problem representation and information /inquiry classification4

[4] Wholistic judgement, heuristic elimination and holistic evaluations after Sage (1980)

Table 2.8 presents a synthesis of the decision problem representation and information / inquiry classification as has been discussed and evaluated in the section. As discussed in Section 2.6.3, a level of decision support maturity can be understood based on the size of the footprint of the decision support capabilities that decision makers (managers and specialists) have available to them. The support capability can come from DSS and BI applications, as well as from more informal inquiry resources. When decision support is available up to and including Level 4 (and even Level 5) of the Humphreys and Berkeley (1985) framework, then reporting, scrutinising and discovery inquiry is facilitated, which represents a high degree of decision support maturity. The research design pursued in this study, which is discussed in Chapter three, must facilitate an approach to investigate decision support maturity as represented on Table 2.8.

2.7.2. The research direction for this research study

This research study proposes that the Humphreys and Berkeley (1985) framework facilitates the representation of the cognitive process which occurs from the point when a decision problem is known but cannot be formulated, to the end point of manager's cognitive thinking, when the decision problem is clearly and unequivocally defined and an appropriate solution is formulated. At the beginning of the process, the knowledge about the decision problem is based on the weak signals observed and interpreted within the decision environment. The Humphreys and Berkeley (1985) framework considers the decision process as a continuous one which occurs over some period of time. However the different levels of the framework allow the separation of the elements of the decision process, which will facilitate research at each level of the decision process, as well as the support considerations for each level. The four propositions identified in Section 2.3.7 are designed to facilitate and operationalise empirical application of the Humphreys and Berkeley (1985)

framework. The Humphreys and Berkeley (1985) framework has been discussed extensively, receiving some three hundred citations to various papers since the original Berkeley and Humphreys (1982) paper. However, this researched has not located research with an empirical testing of the framework in an organisational decision making setting.

There is a lack of clarity with regard to the current decision support offerings in relation to the positioning of decision support at many of the levels of the Humphreys and Berkeley (1985) framework. An understanding of the nature of the management decisions at the different representation levels would highlight the nature of the decision support requirements at each level. This in turn, will facilitate the researcher in identifying the range and extent of the decision support available, and ultimately, a decision support maturity level for the organisation. Propositions 5, 6 and 7 are designed to underpin some of the key elements of the decision support that is available in organisations, through the provision of information from the many reporting and inquiry systems in place. Table 2.9 restates the seven propositions within the context of the theoretical framework as presented in Table 2.8. The first four propositions facilitate the decision problem representation and the decision solution representation simultaneously, for each of the levels of the framework. The last three propositions enable an understanding of the decision support requirements at each of the levels of the framework. Therefore, the research design pursued in this research study (discussed in chapter three) must facilitate an approach to identify the decisions encountered by managers, and to identify the information sources that managers rely upon, to provide quality decision outcomes.

Decision making				Decision Support		
Cognitive Level	**Decision Problem representation**	**Problem solution representation**	**Propositions 1 – 4**	**Representation of Information requirements**	**Information & inquiry classifications**	**Propositions 5 - 7**
5	Conceptual ideas which recognise existence of decision problem	None, as situation makes no sense	**P1**: Managers identify the representation level of the decision problem. **P2:** Managers' understanding of problems emerges over time towards greater formalisation of each problem and the identification of an agreed upon set of solutions **P3:** Managers at different hierarchical levels specialise on the emergence of decision making processes at certain levels of the framework, such that top management is concerned with the more abstract levels and lower level managers focus on implementation and execution. **P4:** The level of constraint and specificity present at different levels provides a platform for the development of increasingly specific decision support, as problems migrate towards the lower levels of the framework.	Not applicable	Not applicable	**P5:** The decision support provided to managers is perceived to be easy to use and useful by its users, such that it leads to extended use where organisational actors recognise its value and rely on it for their critical decision making. **P6:** Over time, the reliance on decision support in a firm increases and reaches higher levels of sophistication within specific domains of managerial complexity. **P7:** Decision support applications have a tangible impact on managerial decision making, which can be analysed in terms of its alignment with the objectives of the firm on the one hand, and on the other hand, in terms of its fit to the specific situation and context in which the users of the decision support avail of its use.
4	Problem formulation and sub-problems identified	Interpretation and discourse		Information which facilitates Inspiration and idea generation	Discovery type inquiry providing intuitive and reasoning potential	
3	Problem structure defined	Models of possible solutions identified		Information which facilitates judgement	Scrutenising type inquiry providing Heuristic search outputs	
2	Suitable alternatives represented as well as implementation implications	Sensitivity analysis explored		Information which facilitates Rationalisation and compromising argument		
1	Stable representation of decision problem	Best alternative choice		Information which facilitates Computational process	Reporting and inquiry providing Holistic search outputs	

Table 2.9. Linking the research propositions and the theoretical framework

Chapter 3. Designing the Research Process

This chapter outlines the examination, selection and application of the research methodology for this study. There are many approaches when conducting Information Systems (IS) research that determine the philosophical perspectives adopted for the research objectives identified. One of the most interesting and important avenues of learning for this researcher is an understanding of how human minds solve problems and make decisions effectively, with and without the help of computers. Furthermore, improving our problem solving and decision making capabilities must be a suitable reward for any researcher. "*Whether from the perspective of psychology, economics, mathematical statistics, operations research, political science, artificial intelligence, as well as cognitive science, major research gains have been made during the past half century in understanding problem solving and decision making*" (Simon, 1987). Some twenty five years later, the requirement to push forward with research in the domain of problem solving and decision making is as critical and as interesting as when Herbert Simon continued to develop the incredible body of work attributed to him in this area of research.

Section 3.1 outlines the research objective and the research questions based on the conclusions of the literature review as presented in Chapter Two. The research approaches available to IS researchers and the philosophical roots of these approaches are discussed in Section 3.2. The exploratory nature of this study meant that a qualitative approach was the most appropriate in order to meaningfully explore the nature and extent of the decision support opportunities that facilitate management decisions. The research design chosen for this study is presented in Section 3.4. The research analysis and data display techniques adopted in the study are presented as an important part of the research process in Section 3.5. The chapter concludes with a presentation of the research protocol adopted in this research project.

3.1. Research Objective and Research Questions

The formulation of a research objective is considered one of the fundamental and most critical steps involved is undertaking a research study (Jenkins, 1985; Mumford, 1985). A well-defined research objective must be concise, accurate and unambiguous, and clearly define the research topic at hand which will enable the researcher to select an appropriate research strategy (Crabtree and Miller, 1999), ensuring that the subsequent steps in the research process will reduce the problems of poor decisions and trade-offs during the research process (Jenkins, 1985).

The aim of this research is to study the nature and extent of decision support that is available to organisational decision makers, at all levels of the organisation; and the nature of the decision problems which are supported. The review of the literature on organisational decision making in Chapter Two highlights complexity associated with many aspects of decision making, including the complex decision environment of organisations, the difficulty associated with formulation of the problem, and the uncertainty associated with the information and knowledge which is the basis for informing the decision solution. Therefore, to achieve the aim of this research, the attributes of particular interest for the research model employed in this dissertation are the complex decision problems which occur continuously in organisations, and the decision support, in the broadest sense, which will define the nature and the level of support available to decision makers, such that, decision solutions are devised based on high-value information that is easily accessible and is of relevance to the decision maker. The research objective for this study can be stated as follows:

> *An investigation into organisational decision support for decision makers, through the application of a cognitive framework that characterises decision problems based on their level of abstraction of problem representation and on their level of formalisation of the proposed solution.*

Once a research objective is identified, the next important stage in the research process is the identification of related research questions (Nissen, 1985)

which serve to ensure that the research objective is met. Defining research questions is considered one of the most important steps undertaken in a research project, as the research question influences the research method which will be used (Yin, 2003). Miles and Huberman (1994) argue that research questions accomplish two key purposes. Firstly, they are statements of hypotheses and, secondly, they support the data gathering phase by providing structure. The following research questions have been formulated to enable the achievement of the research objective.

Research Question One: *How can complex decision problems, which managers encounter, be represented and analysed from a decision support viewpoint, by using the Humphreys and Berkeley (1985) framework?*

This question is explanatory (Gregor, 2006) in nature as it seeks to explain decision problems as identified by organisational decision makers. The Humphreys and Berkeley (1985) framework, which is a representation of manager's cognitive thinking processes, is leveraged as a construct for understanding the decision problems identified. The first construct for understanding Decision Support involves understanding the organisational decision problems from a cognitive representation perspective. A cognitive representation perspective reflects the evolution of manager's thinking as they go through the decision making process and is indicated by the degree of abstraction of the manager's representation of the decision problem and by their level of understanding of the problem solution. The Humphreys and Berkeley (1985) framework facilitates the separation of what is essentially a continuous process into five qualitatively different representations of a decision problem, from the point where assessment and expression of the problem is problematic to the point where implementation of agreed routines and procedures that will resolve the problem can be specified. The representations are characterised by the degree of abstract cognitive thought on the part of the decision maker thus providing a mechanism that enables the researcher to apply structure to decision

makers' thinking. Four propositions, which are put forward in section 2.3.7 and are represented in Table 2.9, underpin the operability of Research Question One.

Research Question Two: *What level of decision support and decisional guidance is available to decision makers, individually and in groups, within the organisational decision environment, with respect to the different category of problems facing managers?*

This question is explanatory in nature as it seeks to explain the availability of the formal and informal decision support tools available to decision makers, which is the second construct for Decision Support maturity. By 'tools' the researcher means systems, routines, procedures and other forms of discussion and information dissemination that can be observed in a firm (Simon, 1977). The review of the literature in Chapter Two revealed that there is an abundance of literature with respect to Decision Support Systems and Business Intelligence Systems availability. However it is unclear whether decision support availability is consistent for all management levels and for all decision types. It would appear that in many cases, Business Intelligence Systems are characterised as having a very narrow remit, focusing on specific activities only, and within specific business units, and are generally, not enterprise wide. Therefore the purpose of this research question is to ascertain decision support availability and its application across the organisation. The three propositions which were put forward in section 2.6.4 and are presented on Table 2.9, will underpin the realisation of research question two.

Research Question Three: *How does the level of availability of a decision support portfolio to match the decision support needs of managers reflect the decision support maturity of an organisation?*

The answer to Research Question Three is explanatory in nature, and it aims to identify the factors which impact decision making support maturity.

Chapter Two concludes that the literature on what constitutes decision support maturity is highly ambiguous. Achieving decision support maturity implies an evolutionary process from an initial state of minimal and ad-hoc support to a desired end-state, where decision makers gain insights and decisional guidance through their use of the available decision support tool set. The focus of Research Question Three is to understand the extent of decision support at each of the representation levels where decision problems have been identified. Thus, the relationship between the supply of decision support and the demand of the decision problem formulation is being examined. A model of decision support maturity is presented which suggests that the availability of all three inquiring classifications as per Adam and Pomerol (2008) would indicate a highly mature level of decision support in an organisation. Therefore Research Question Three is a synthesis of the findings in relation to the first two research questions, which gives the researcher the opportunity to discuss the scope and quality of decision support provided in the organisation at each of the cognitive representation levels.

3.2. An Overview of Research in the IS Field

While there are a large number of research methodologies that are applicable to MIS research (Jenkins, 1985), a number of factors need to be considered when deciding which research strategy to adopt for a particular study. In order to make a decision on the most suitable research strategy for this study, it is firstly necessary to obtain an understanding of the philosophical views underpinning IS research and their associated research paradigms, and this discussion is the subject of this section.. Section 3.2.1 examines the ontological, epistemological and methodological assumptions underpinning IS research and discusses research paradigms. Two research paradigms are subsequently reviewed in detail; positivism in section 3.2.2 and interpretivism in section 3.2.3. The consideration of qualitative versus quantitative data, another issue traditionally associated with research, is discussed in Section 3.2.4. The next section, Section 3.3, concludes by arguing that due to the exploratory nature of

this study, qualitative data represents the best approach for exploring decision making in organisations. In summary, this study presents a research objective and set of research questions that require theory building to be adequately addressed. In this section and in the next section, this study is positioned within the research paradigm debate and the theory building approach is discussed in further detail, as it relates to this study and the IS research field as a whole.

3.2.1. Understanding Research Philosophies

An understanding of underlying philosophies underpinning IS research impacts upon the quality of a research study, as it can help the researcher to recognise the most suitable research design for their project. Furthermore, knowledge of these research philosophies can help the researcher identify research designs that they may not have used in the past (Guba and Lincoln, 1994). In selecting a research paradigm, Remenyi and Williams (1995) note that the researcher should be cognisant of the weakness of their preferred approach as well as being able to satisfy their own ontological and epistemological preferences.

A paradigm represents the underlying set of assumptions relating to ontology, epistemology and methodology (Guba and Lincoln, 1994; Crabtree and Miller, 1999), each of which can be explained in terms of a researcher's belief about reality. A research paradigm provides a context through which the reader may interpret the research findings (Patton, 1990). A paradigm influences how we comprehend the world. More recently, Guba and Lincoln (2004) describe a research paradigm as a set of basic beliefs that collectively represent the "worldview" of the researcher. This "worldview" definition is one that appears frequently (Burrell and Morgan, 1979; Patton, 1990) within literature. A worldview implies the presence of a "common language" through which researchers may understand and unify their efforts (Benbasat and Weber, 1996). Within the research process, the beliefs a researcher holds are reflected in how their research is designed, how the data is collected and analysed, and how results are eventually presented. It is important that a researcher recognises

their specific paradigm, as this allows them to identify their position in the research process, and determine the course of the research study (Guba, 1990).

However, there is no single research paradigm to which all researchers subscribe, and therein lies the motivation for the paradigm debate that has been on-going within the field of IS research for the past 40 years (Chen and Hirschheim, 2004). In the beginning, the field of IS research was dominated by the natural science approach, which was characterised by a positivist paradigm and associated quantitative methods (Galliers and Land, 1987; Orlikowski and Baroudi, 1991). Since 1990, a growing number of researchers recognise that a diversity of research methods in the IS field advances the academic standing of IS research, recommending a more interpretive approach (Robey, 1996; Chen and Hirschheim, 2004). Consequently, there was a move away from blindly adopting one research paradigm, with greater consideration towards understanding the research problem at hand and identifying the most suitable approach (Orlikowski and Baroudi, 1991). To facilitate a more informed decision, Guba and Lincoln (2004) shed light on the research paradigm question by providing a classification system. They stated that the basic beliefs that define a particular research paradigm might be summarised by the responses given to three fundamental questions:

1. The **ontological** question, i.e. what is the form and nature of reality?

Ontology refers to the assumption that a certain reality exists (Guba and Lincoln, 1994), and to the nature of that social reality (Orlikowski and Baroudi, 1991). For example, a realist perceives the social world as tangible, i.e. made up of relatively immutable structures that exist independently of our individual descriptions. The social world is real and external to the individual. In contrast, the nominalist views reality as constructed in the names, labels and concepts that are used to structure that reality. Therefore, individuals create the social world, resulting in there being multiple realities (Guba and Lincoln, 1994).

2. The **epistemological** question, i.e. what is the basic belief about knowledge?

Epistemology forms the basis of that search for reality (Crabtree and Miller, 1999). It refers to assumptions about knowledge and how it can be obtained (Hirschheim, 1985). Brannick and Roche (1997) purport that the researcher's epistemological perspective determines what they consider as a valid and legitimate contribution to theory development. Epistemology deals with the relationship between the researcher and what can be known (Denzin and Lincoln, 2005). Burrell and Morgan (1979) note that epistemological assumptions determine whether knowledge is something which can be acquired or which needs to be experienced. This has resulted in a methodological split between researchers in relation to methodological orientation. Therefore, epistemology refers to the nature of knowing and the construction of knowledge, and is divided into positivist and interpretive perspectives (Chen and Hirschheim, 2004). The positivist believes that true objectivity is possible as an external observer, while interpretivists believe that the knower and known are interdependent, and that social science is essentially subjective. The positivist studies the parts to understand the whole, looking for regularities and causal relationships to understand and predict the social world. To the interpretivist, the social world may only be understood by occupying the frame of reference of the participant in action.

3. The **methodological** question, i.e. how can the researcher determine whether what they believe can be known?

Finally, there are assumptions about the research process, i.e., the methodology (Orlikowski and Baroudi, 1991). Nomothetic methodology focuses on an examination of regularities and relationships to universal laws, while ideographic approaches centre on reasons why individuals create and interpret their world in a particular way. The social world may only be understood by obtaining first-hand knowledge of the subject under investigation.

By using the three questions in relation to ontology, epistemology and methodology, as a guide, five major paradigms may be identified: (i) Positivism; (ii) Post-positivism; (iii) Critical Theory; (iv) Constructivism, and (v) Participatory (Guba and Lincoln, 1994). These are the five core lines of inquiry currently considered by IS researchers. The philosophical assumptions of these five research perspectives are presented in Table 3.1. According to Guba and Lincoln (1994, p.108) "*the methodological question cannot be reduced to a question of methods; methods must fit a predetermined methodology*". In other words, they suggest it is ineffective to consider the issue of methodology in the absence of a consideration of the other two questions.

Belief	**Positivism**	**Post-positivism**	**Critical theory**	**Constructivism or Interpretivism**	**Participatory***
Ontology	Naïve realism- "real reality but apprehendable	Critical realism – 'real' reality but only imperfectly and probabilistically apprehendible	Historical realism – virtual reality shaped by social, political, cultural, economic, ethnic, and gender values; crystallized over time	Relativism – local and specific constructed and co-constructed realities	Participative reality – subjective-objective reality, co-created by mind and given cosmos
Epistemology	Dualist/ objectivist; findings true	Modified dualist/ objectivist; critical tradition/ community; findings probably true	Transactional/ subjectivist; value-mediated findings	Transactional/ subjectivist; created findings	Critical subjectivity in participatory transaction with cosmos; extended epistemology of experimental, propositional and practical knowing
Methodology	Experimental/ manipulative; verification of hypotheses; chiefly quantitative methods	Modified experimental/ manipulative; critical multiplism; falsification of hypotheses; may include qualitative methods	Dialogic/ dialectical	Hermeneutical/ dialectical	Political participation in collaborative action inquiry; primacy of the practical; use of language grounded in shared experimental context

*Table 3.1. Philosophical perspectives of research paradigms (Developed from Guba and Lincoln (2004), and Orlikowski and Baroudi (1991). * column based on Heron and Reason (1997))*

From an initial three paradigms, (positivism, post-positivism and interpretivism), Guba and Lincoln (2004) revised their 1994 table to include the contributions of Heron and Reason (1997). Heron and Reason (1997) advocate that the participatory or cooperative paradigm, which Guba et al. (2004, p.164) describe as the "*hermeneutic elaboration*" of their view of constructivism, should be considered as an independent paradigm of inquiry. In addition, Adam (2000) based on the work of Schwandt (1994) postulates that constructivism is a neighbouring concept to interpretivism and can therefore be used to describe the same category. Based on this, Table 3.1 uses both terms to present the research paradigms.

Synthesising what they refer to as '*research dichotomies'*, Fitzgerald and Howcroft (1998) also include the axiological level of relevance versus rigour to the list of alternative research paradigms. This level of inquiry contests the external validity of research against the internal validity of testing under tight experimental control. More recently, Guba and Lincoln (2004) hold the view that axiology should be grouped as a characteristic of the 'basic beliefs' outlined above.

The selection of an appropriate research paradigm is an area which has seen much debate throughout the years, with researchers arguing towards the strengths of their preferred approaches. Of the five perspectives documented in Table 3.1, both the positivist and interpretive paradigms have received most attention in the IS field to date, and are considered in further detail in the next sections.

3.2.2. Exploring Paradigms: Positivism

The positivist approach has its origins in a school of thought within the philosophy of science known as "*logical positivism*" or "*logical empiricism*" (Lee, 1991) and is characterised by the scientific principles of repeatability, reductionism and refutability (Checkland, 1981; Galliers, 1991). Core to this approach is the belief that every meaningful statement is either logically true or

empirically testable (Landry and Banville, 1992). Hirschheim (1992) contends that the positivist paradigm is fundamentally based upon five pillars, which reflect its underlying view that all phenomena conform to fixed laws of causation, which include: 1) The unity of scientific method; 2) The search for causal human relationships; 3) The belief in empiricism; 4) The value free nature of science; and 5) The logical and mathematical foundations of science.

Traditionally, the positivist or 'scientific' strategy is the more dominant IS research paradigm (Nissen, 1985). Orlikowski and Baroudi (1991, p.5) define positivism as "*the existence of a priori fixed relationships within phenomena which are typically investigated with structured instrumentation*". Positivist research seeks to explain and predict what happens in the social world by searching for regularities and casual relationships between its constituent elements (Burrell and Morgan, 1979). Applying the positivist approach to IS research focuses on the nature of quantitative data by testing theories and hypotheses, in addition to the quantifying of variables and propositions, in an attempt to increase the predictive understanding of phenomena (Orlikowski and Baroudi, 1991). Evered and Louis (1991) note that when working within the positivist paradigm, the researcher is like an observer in the laboratory. Braa and Vidgen (1999) argue that any intervention must be controlled in order to provide replicability and predictive power, which are two characteristics deemed important for IS research (Checkland, 1981). Positivist researchers believe in the absolute supremacy of the methods of the natural sciences and advocate the fundamental importance of objectivity and rigour (Klein and Lyytinen, 1985). Indeed objectivity and rigour are deemed to be two of the key strengths of the positivist approach to research. Klein and Lyytinen (1985, p.137) refer to this:

> *"To achieve both it teaches respect for facts, i.e. to refrain from armchair speculation when relevant facts can be brought to bear on issues. In using facts to support inferences, it puts the emphasis on rigor that is on inter-subjectivity, reliability and reproducibility. These criteria are closely related and are to ensure that all trained observers at all times should be able to reach the same conclusions".*

Due to these strengths, researchers note that the positivist paradigm dominated IS research in the 1980s and 1990s (Orlikowski and Baroudi, 1991; Walsham, 1995), and continues to do so (Chen and Hirschheim, 2004). Orlikowski and Baroudi (1991) examined IS research between 1983 and 1988, and observe that the vast majority is of a positivist nature, and recommend the greater adoption of interpretative research. Chen and Hirschheim (2004) completed similar research in relation to the time period 1991 to 2001 and note that the trend has not changed and the predominant research paradigm in IS research continues to utilise positivist methods. This 'hard' approach is more popular amongst North American researchers and is traditionally considered the more rigorous of the two paradigms and typically perceived to be quantitative in nature. Fitzgerald and Howcroft (1998, p. 321) suggest that *"the preoccupation in the IS field with 'hard' research approaches is manifest in the excessive reliance on positivist and quantitative, often laboratory-based, strategies for IS research".* They refer to the early years of the IS discipline (1970s) where researchers struggled to establish credibility, and believed that pursuing the 'scientific' research methods would overcome that perception, at that time.

While such research suggests that the positivist paradigm is the most prevalent paradigm in IS research, this approach is not without its critics (Nissen, Klein and Hirschheim, 1991). The paradigm has been criticised for applying the same logic to social science research as that applied to research in the physical sciences. Klein and Lyytinen (1985, p.138) refer to this fact when stating that "*Information Systems will remain a dubious science as long as it tries to emulate the so-called scientific method as the only ideal of academic enquiry"*.

Positivism has also been criticised for achieving rigour at the expense of relevance. Klein and Lyytinen (1985) state that the question of "relevance to whom?" is not accessible to the rigorous methods employed by the positivist approach. They argue that achieving 'scholarly consensus' for the relevance of the research is no different, whether utilising positivist or non-positivist paradigms. They state that "*by relying on human consensus for the interpretation*

of data, scientific research violates its own standards of objectivity and rigor" (Klein et al. (1985, p. 139).

The appropriateness of the positivist paradigm for research in the IS field is further questioned by researchers (Galliers and Land, 1987; Chen and Hirschheim, 2004; Davison and Martinsons, 2011; Galliers, 2011) because of the nature of the IS field. These researchers adopt a social science perspective in relation to IS and IS is viewed as a social system, which involves human action rather than mere technical or scientific systems. Within a positivist approach, only a limited number of factors can be studied, especially during rigorous laboratory experiments. The necessity to apply values to variables may lead to the exclusion of relevant factors which are difficult to measure (Galliers and Land, 1987). Therefore, numerous theorists have questioned the applicability of the methods and procedures of the scientific approach to IS domain (Nissen, 1985; Galliers, 1991; Guba and Lincoln, 1994). Positivist studies ignore the fact that people think and act, that people are active makers of their physical and social reality (Orlikowski and Baroudi, 1991). Another criticism levelled at positivist studies by researchers is the fact that repeatability may not be possible due to the fact that no two organisations are the same. Klein and Lyytinen (1985) go even further by arguing that many research issues cannot be resolved through the positivist approach which narrows the scope of those issues. This means that, in many cases complex issues may not be researched using positivistic methods, and therefore, they are ill-suited to the exploratory nature of this study. An alternative approach that considers the relevance and importance of an interpretive or qualitative research strategy is presented in the next section.

3.2.3. Exploring Paradigms: Interpretivism

Interpretivism is the alternative paradigm to the positivist approach and is widely regarded in the IS field as being in direct competition with the positivist paradigm (Braa and Vidgen, 1999). Interpretative research has gained much more importance as a paradigm in IS research (Walsham, 1993; Klein and Myers, 1999), with researchers calling for more widespread utilisation of this principle in

the IS field. Interpretivism is concerned with meaning in context (Kaplan and Duchon, 1988). The interpretive school of thought maintains that "*the same physical artefact, the same institution, or the same human action, can have different meanings for difference human subjects, as well as for the observing social scientist*" (Lee, 1991, p.347). Essentially, this means that the researcher interprets reality in terms of what it means to people (Lee, 1991). The interpretive paradigm is considered a 'soft' approach to IS research (Fitzgerald and Howcroft, 1998), and it deems the natural sciences' research methods as inappropriate for IS research, mainly because different people interpret a situation in different ways (Braa and Vidgen, 1999). Walsham (1993, pp.4-5) stated that the interpretative approach is suitable for the study of IS as it *"is aimed at producing an understanding of the context of information systems and the process whereby the information system influences and is influenced by its context".* Interpretivism assumes that people create and associate their own subjective and inter-subjective meanings as they interact with the world around them. It aims to better understand the deeper structure of the phenomenon under study by accessing the meaning assigned to it by participants (Lee, 1991; Orlikowski and Baroudi, 1991). This point is reinforced by Darke, Shanks and Broadbent (1998, p.276) who comment that "*the interpretive approach is based on an ontology in which reality is subjective, a social product constructed and interpreted by humans as social actors according to their beliefs and value systems".*

There are advantages to utilising the interpretative approach for IS research. Galliers and Land (1987) argue that the interpretative approach can overcome many of the shortcomings of the positivistic approach. These advantages very much espouse the systems and social nature of IS research. Kaplan and Duchon (1988, p.572) contend that *"interpretive researchers attempt to understand the way others construe, conceptualize, and understand events, concepts, and categories*". Indeed, Klein and Myers (1999, p.67) state that one of the key advantages of interpretative research is that it can *"help IS researchers to understand human thought and action in social and organisational contexts and*

has the potential to produce deep insights into information systems phenomena". Therefore, an interpretative perspective is much more closely aligned with the epistemological assumptions that have been adopted for this study.

However, the interpretative approach is not without its critics. It has been criticised for being subjective and reliant on the researcher's own interpretation. The researcher is responsible for the difficult tasks of accessing other people's interpretations; filtering through their own conceptual apparatus; and feeding a version of events back to others (Walsham, 1995). Consequently, the potential for researcher bias and improper interpretation is a widely cited limitation of qualitative research (Kaplan and Duchon, 1988). Keen (1991) argues that relevance should come first and drive rigour. While interpretive research is often criticised for lacking rigour, this is not necessarily true. However, researchers (Eisenhardt, 1991; Darke *et al.*, 1998) argue that the selection of appropriate research methods and coding techniques can ensure that interpretive research may adhere to the principle of rigour while also being relevant. An interpretive approach can facilitate a more flexible level of commitment to hypotheses before gathering the data, and thereby, incorporate the value of context in IS research (Kaplan and Duchon, 1988). Traditionally, qualitative data is associated with the interpretative paradigm, while quantitative data is associated with positivism. The qualitative versus quantitative debate will be covered in the next section.

3.2.4. Beyond Paradigms: The Qualitative vs. Quantitative Debate

The qualitative versus quantitative debate is not new and, as in the case of positivism versus interpretivism, tradition and geography play a key role in the decision by researchers to adopt one approach over the other. Quantitative and qualitative research approaches may be used in conjunction with both the positivist and interpretive paradigms described above (Denzin and Lincoln, 1998). Beyond the traditional approaches, the combination of an interpretive strategy with a quantitative approach is most common. However, while Denzin and Lincoln (1998) state that many researchers utilise statistical measures, methods,

and documents, finding are seldom reported in terms of complex statistical measures or methods to which quantitative researchers are drawn. One interpretation which may be taken here is that while it is possible to use quantitative data together with the interpretive approach, it is not utilising the quantitative approach in its purest physical sciences sense. Therefore, while a blurring of the traditional boundaries between the positivist/quantitative and interpretive/qualitative strategies would appear to be taking place, the traditional approach is still in vogue (Denzin and Lincoln, 1998).

Quantitative studies emphasise the measurement and analysis of pre-defined variables (Denzin and Lincoln, 1998). However, such studies have been criticised for a number of reasons including their tendency to strip context through their focus on a number of pre-selected variables, and their inability to understand human behaviour (Guba and Lincoln, 1994). Indeed Kaplan and Duchon (1988, p.572) question the applicability of quantitative methods for the study of social systems, where there are "*so many uncontrolled and unidentified variables*". Therefore, the use of quantitative research methods is not considered appropriate in the context of this study.

In contrast, qualitative research has emerged as a result of a core grouping of researchers believing in the social sciences nature of information systems (Walsham, 1995). Denzin and Lincoln (1998, p.3) define qualitative research as "*multimethod in focus, involving an interpretative, naturalistic approach to its subject matter*". Qualitative studies redress many of the drawbacks of their quantitative counterparts by allowing the researcher to get close to the subject's perspective (Guba and Lincoln, 1994) and by providing increased accuracy, richer descriptions and deeper understandings of social phenomena (Marshall and Rossman, 1989).

Denzin and Lincoln (1998, p.7) note that there has been resistance to qualitative research, with many researchers who utilise this type of research strategy being referred to as "*journalists*" and "*soft scientists*". Indeed, Carey (1989), quoted in Denzin and Lincoln (1998), states that qualitative research is often seen as being an assault on the natural sciences. In addition, Denzin and

Lincoln (1998) note that the natural sciences attack on qualitative research is seen as an attempt to legitimise the quantitative form of research over qualitative. Marshall and Rossman (1989) consider that qualitative research is most appropriate where it is necessary to have an in-depth appreciation and understanding of the underlying complexities and processes of the phenomenon under investigation or where existing theory and processes are inadequate to explain reality and therefore further exploration is necessary. In particular, they advocate a qualitative approach when exploring new avenues of research in an attempt to uncover the unexpected. Therefore a qualitative approach is considered appropriate in the context of this research. This research seeks to understand the applicability of a framework for representing the cognitive perspectives at each of the stages of problem formulation in the decision process, and to measure the extent to which information systems are used in, or have an impact on, the decision maker during each stage of the decision process.

3.3. The Research Approach

This section explains the research approach adopted for the study. It argues that the case study method best suits the requirements of this study. The purpose of research and the options available to researchers are considered in section 3.3.1 and section 3.3.2 respectively. This is followed with a description of the research approach adopted for this particular study, in section 3.3.3. Section 3.3.4 discusses the theoretical sampling undertaken and section 3.3.5 describes the process of selecting an *exploratory research study* prior to completing the primary case. The main case study protocol is discussed in section 3.3.6.

3.3.1. Theory building and IS research

Theory building requires the on-going comparison of data and theory (Glaser and Strauss, 1967) and the continuous refinement between theory and practice (Lynham, 2000). As Kuhn (1996, p.7) noted, "*new theory, however special its range of application, is seldom or never just an increment to what is already known. Its assimilation requires the reconstruction of prior theory and the*

re-evaluation of prior fact, an intrinsically revolutionary process that is seldom completed by a single man and never overnight".

Theory is the why of the phenomenon, not the what. Theory explains the key actors in the phenomenon under study (the independent and dependent variables), how they interact (the plot), and why they interact as they do (their motivation). In the same way that a book or movie would be uninteresting if we did not understand the characters' motivation, so too is a research study that lacks theory. Dubin (1969, p.9) provides a definition of theory which is quite specific: "*a closed system from which are generated predictions about the nature of man's world that must be open to some kind of empirical test*". This definition highlights the generation of predictions (propositions) and the requirement for testing. The purpose of testing is to discover new and more powerful generalisations (Kaplan, 1964) by which to understand a given phenomenon.

This research is exploring the decision support which is available to organisational actors, using the Humphreys and Berkeley (1985) framework as a research mechanism, to map decision problem formulation and decision problem solution evolution. The level and extent of the decision support will indicate a decision support maturity. The concept of decision support maturity, however, is difficult to operationalise in research on decision support, because it seeks to assess the overall capability of the firm, which, in a large organisation is very difficult to achieve. In many cases, the answer to the question: "how well does this firm use DSS tools" leads to a contingent answer: "it depends", because the deployment and use of decision support is rarely homogenous in an organisation. Some functional areas are likely to be better supported than others. The well-researched influence of a given task environment on decision maker behaviour also contributes to this contingency across, as well as within, large organisations (Montazemi, Wang, Khalid Nainar and Bart, 1996).

3.3.1.1. Unit of analysis

To tackle this complexity, this research proposes to reduce the unit of analysis to the level of individual decision problems, as suggested by (Langley *et*

al., 1995), because the study of decision making is, at least in part, the result of the attraction of researchers to an easy to identify unit of analysis: a decision problem or a decision making process. Patton (1990, p.168) argues that the "*key issue of selecting and making decisions about the appropriate unit of analysis is to decide what it is you want to be able to say something about at the end of the study*". This unit of analysis is also a better match to the Humphreys and Berkeley framework, which is geared towards an analysis of one or a set of decision problems faced by managers. Thus, in this research study, the concentration is on the level of a set of individual decision support applications as a surrogate measure for the overall decision support maturity of a firm.

3.3.2. The research options available

The research approach may be defined as a plan for conducting research in order to arrive at answers to the research questions and to interpret the results with a minimum degree of ambiguity (Yin, 1994; Remenyi and Williams, 1995; Yin, 2003). Given that the IS field is so diverse, it is unrealistic to believe that there is 'one best way' to conduct research in the area (Jenkins 1985), or in any area for that matter (McGrath 1984). The limitations of experimental research, especially survey research and field research, is discussed by McGrath (1984), who argues that research methods can be evaluated on three dimensions:

- Generalisability with respect to the evidence collected;
- Realism for the participants;
- Precision in the control and measurement of variables.

It is literally impossible to design a research study that satisfies all three dimensions, although sometimes it is possible to strike an uneasy balance among two of the three (and fail miserably on the third) (McGrath, 1984). Laboratory experiments for example, maximise precision but usually fail to satisfy generalisability or realism. Field studies maximise realism, but fail to satisfy generalisability (because they study a small number of non-randomly selected situations) or precision (because there are a host of uncontrolled factors).

Surveys maximise generalisability, but fail to satisfy realism (because they do not study actual behaviour but instead ask participants to recall perceptions) or precision (because there are a host of uncontrolled factors). All research methods are imperfect, but some are better at some aspects of the research process and worse at other aspects.

Therefore, the research strategy pursued is actually a trade-off for researchers between the various strengths and weaknesses of the different research methods that exist (Jenkins, 1985; Galliers, 1991). The key concern in relation to research methodologies is the need to ensure alignment between the research objective and the capabilities of the research method (Jenkins, 1985; Yin, 1994). The possibility of weaker findings is magnified by the selection and use of an inappropriate research methodology (Franz and Robey, 1986). A number of taxonomies (Galliers, 1985; Marshall and Rossman, 1989) are present in the literature in order to assist researchers in choosing the most appropriate research method based on the nature of the research being conducted.

Purpose of Research	Research Question	Research Method	Example of data collection techniques
Exploratory To investigate little understood phenomena. To identify / discover important variables to generate hypotheses	What is happening in the social program? What are the salient themes, patterns, categories in participant's meaning structures? How are these patterns linked?	Case study, Field study	Participant observation, In-depth interviewing; Elite interviewing.
Explanatory To explain the forces causing the phenomenon in question. To identify plausible causal networks shaping the phenomenon.	What events, beliefs, attitudes and policies are shaping this phenomenon? How do these forces interact?	Multi-site case study, History, Field Study, Ethnography	Participant observation; In-depth interviewing; Survey questionnaire; Document Analysis.
Descriptive To document the phenomenon of interest.	What are the salient behaviours, events, beliefs, attitudes and processes occurring?	Field study, Case Study, Ethnography	Participant observation, In-depth interviewing, Document analysis, Unobtrusive measures,Survey questionnaire.
Predictive To predict the outcomes of the phenomenon. To forecast the events and behaviours resulting from the phenomenon.	What will occur as a result of this phenomenon? Who will be affected and how?	Experiment Quasi-experiment	Survey questionnaire (large sample), Kinesics / Proxemics, Content Analysis.

Table 3.2. Marshall and Rossman's Research Framework (1989)

The Marshall and Rossman (1989) framework is most useful in matching the purpose of research and the nature of the research questions being asked, with suitable research methods. The selection of an appropriate approach for a research study is primarily influenced by the goals of the researcher and the nature of the research topic (Jenkins, 1985; Mumford, 1985; Galliers and Land, 1987; Yin, 2003)

3.3.2.1. Case study research

This research project employs a case study approach. Case study research can be defined as an "*empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident*" (Yin, 1994, p.13). Therefore, case study research involves the examination of phenomena in their organisational settings and requires a detailed contextual analysis of a limited number of events or consequences and their relationships. The case study method is especially appropriate for research in new topic areas, with a focus on "how" or "why" questions concerning a contemporary set of events (Eisenhardt, 1989). Case study research excels at developing an understanding of a complex issue, and can substantiate what is already known through previous research (Dooley, 2002). Case studies are a common method for conducting research into the use of information systems in the real world (Galliers, 1991). Case studies can be either simple or complex (Stake, 1994), and can be used for either theory testing or theory building (Yin, 1994). Case study research that employs multiple cases should follow replication logic (Yin, 1994). A mix of different perspectives can increase the likelihood of discovering novel insights through the incorporation of a variety of experiences and complementary insights (Eisenhardt 1989). A case study is a means of describing the relationships that exist in a particular situation of interest (Galliers, 1991).

The case method does not control or manipulate variables; it allows the study of phenomena in their natural context; it studies the phenomenon at one or few sites; and it allows the use of qualitative tools and techniques for data

collection and analysis (Cavaye, 1996). One of the main strengths of the case studies is that it allows the researcher to capture reality in greater detail and allows the analysis of a larger number of variables (Galliers, 1991). The strengths of the case study method can be summarised as:

- The researcher can study information systems in a natural setting and can learn about the state of the art and can therefore generate theories from practice;
- The case study allows the researcher to understand the nature and the complexity of the process under study (Benbasat, Goldstein and Mead, 1987; Gable, 1994) ;
- Valuable insights can be gained into new information systems topics (Gable, 1994), and novel theories can be generated from practice when the research phenomenon is not supported by a strong theoretical basis (Benbasat *et al.*, 1987; Gable, 1994);
- Research an area where few previous studies have been carried out (Benbasat *et al.*, 1987; Yin, 2003). In this situation the researcher can exploit case studies' strength in its ability to deal with a variety of evidence for example, interviews and documents.

Case studies are a common method for conducting research into the use of IS in the real world (Galliers, 1991; Orlikowski and Baroudi, 1991). This marks a transition from the typical statistical positivist type IS industry research study to an increasingly qualitative approach to research at this level of analysis. A case study is a means of describing the relationships that exist in a particular situation, usually one single organisation (Galliers, 1991), although case study research may be conducted in multiple sites (Miles and Huberman, 1994; Cavaye, 1996). Benbasat *et al.* (1987, p.370) suggest that "*a case study researcher may have less a priori knowledge of what the variables of interest will be and how they will be measured*". This contrasts sharply with a positivist approach where hypotheses are constructed before data collection is undertaken.

However case research also has weaknesses. These include:

- The inability to generalise case research findings statistically to a population (Stake, 2000). It does not facilitate replication and so, a single case may represent the sampling of a response to a rare, extreme and unique event occurring in other organisations (Bouchard 1987);
- There is a danger of information overload which makes it difficult to keep the case study to a compact and disciplined document (Siggelkow, 2007);
- The lack of control over independent variables may limit the internal validity of any conclusions reached through the case research method (Miles and Huberman, 1994).

Case studies can be used to accomplish various aims: to provide description (Kinder, 1982), test theory (Pinfield, 1986; Anderson, 1983), or generate theory (Harris and Sutton, 1986; Gersick, 1988; Eisenhardt, 1989; Dooley, 2002). From the perspective of this research study, the following description of the appropriateness of a case study to a particular type of research seems accurate: *"case research is particularly appropriate for certain types of problems: those in which research and theory are at their early, formative stages, and sticky, practice-based problems where the experiences of the actors are important and the context of action is critical"* (Benbasat *et al*., 1987, pp.369). Moreover, Schramm (1971, p.21) stated that *"the essence of a case study, the central tendency among all types of case study, is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result"*. Therefore, a case study approach seems particularly suited to the research problem and research questions developed in section 3.1.

3.3.2.2. Alternatives to case research

In contrast to case research, a field study is a study conducted in a natural setting with human subjects (Jenkins, 1985). With a field study, there is assumed to be more prior knowledge of what the variables of interest will be and how they will be measured than with a case study (Gable, 1994). Moreover, one of the identified weaknesses of the field study is that the external validity is not as high as other approaches (Jenkins, 1985). This external validity refers to the

applicability of the results to different environments and populations (Jenkins, 1985). Researchers (Galliers, 1985; Braa and Vidgen, 1999) note that field studies (also referred to as field experiments) represent an extension of laboratory experiments into an organisational context.

However, field studies require that the researcher entering the field has a priori definition of constructs and relationships (Benbasat *et al.*, 1987) which in this case is not possible, because the research instrument has not, previously, been empirically tested in an organisational context. Therefore the field study approach was deemed inappropriate and the case study approach emerged as the most effective methodology to achieve the research objective.

3.3.3. The research approach adopted for this research project

This research project investigates the organisational decision making process from the perspective of a cognitive understanding of manager's thinking. A framework developed in 1985 by Patrick Humphreys and Dina Berkeley provides the theoretical instrument for the analysis. The Humphreys and Berkeley's framework, first presented in 1982 within the psychology research domain of that time, has received citations to over three hundred various papers, but has not been empirically tested in the organisational decision making literature. Therefore, this research is an example of what Marshall and Rossman (1989) refer to as exploring new avenues of research, and they advocate a qualitative approach, so that data gathering can respond to increasingly refined research questions that will encourage exploration, but will also delimit the study. The research questions have been formulated to focus on the interactions and the processes of decision makers, which requires an approach based on openness and dialogue, rather than method centred manipulation and control (Kaplan and Duchon, 1988; Guba and Lincoln, 1994; Strauss and Cobin, 1997). As a result, a description of a phenomenon in context is important "*if you want people to understand better than they otherwise might, provide them information in the form in which they usually experience it*" (Lincoln *et al.,* 1985 p.120). For example, an interpretive approach to research, typically rich with

detail and insights into participants experiences of the world "*may be epistemologically in harmony with the reader's experience*" (Stake, 1978, p.5) and therefore more meaningful. In fact, Galliers (1993) believes that interpretive research approaches present the highest degree of efficacy and accuracy relative to the investigation and illustration of Information Systems used in organisations, because they force a more rounded study of the overall problem and provide greater depth to the research (Marshall and Rossman, 1989).

3.3.4. Theoretical sampling of cases

The selection of cases, the sampling problem, is an important aspect of any type of research approach, especially when building theory from case studies. However, more importantly, a theoretical sampling plan, or a purposeful strategy (Patton, 1990), should be followed where cases are chosen for theoretical, and not statistical reasons (Eisenhardt, 1989). According to Eisenhardt (1989, p.537) *"cases may be chosen to replicate previous cases or extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types"*. Furthermore, Eisenhardt (1989) stated that while cases may be chosen randomly, *"random selection is neither necessary, nor even preferable"*. Therefore, as with hypothesis-testing research, the concept of an appropriate population is critical as it controls extraneous variation and helps define the limits for generalising the findings. Therefore, in order to increase the quality of research design, the selection of cases needs to be driven by two main issues: appropriateness and adequacy. Appropriateness is related to demonstrating a fit between both the purpose of the research and the phenomenon of inquiry, while adequacy is concerned with the number of cases (Patton, 1990; Miles and Huberman, 1994; Kuzel, Engel, Morse, Swanson and Kuzel, 2001).

The single versus multiple-case approach to IS research remains a difficult decision based on extant research in the area. Patton (1990, p.184) states that *"there are no rules for sample size in qualitative inquiry. Sample size depends on what you want to know, the purpose of the inquiry, what's at stake, what will be*

useful, what will have credibility, and what can be done with available time and resources". He contends that there is little rationale for following the rules of probabilistic sampling in pursuing qualitative research studies as there are no claims that the cases selected are representative of a population (Patton, 1990). However, the argument for single versus multiple case approach persists, and Eisenhardt (1989, p.534) defines single site case studies as a *"research strategy which focuses on understanding the dynamics present within single settings"*. According to Darke *et al.* (1998, p281) *"single cases provide for in-depth investigation and rich description".* Yin (2000) advocates five reasons for selecting a single case approach, where the researcher identifies:

1. The **critical case** that meets all the conditions for theory testing;
2. The **extreme or unique case** where some phenomenon is so rare it is worth documenting;
3. The **representative or typical case** where the objective is to capture the circumstances or conditions of an everyday situation;
4. The **revelatory case** where they are presented with the opportunity to access a phenomenon that was previously inaccessible to scientific investigation;
5. The **longitudinal case** which would specify how certain conditions change over time.

Siggelkow (2007, p.21) proposes the amusing metaphor of the 'talking pig' to illustrate the use of a single extreme case to gain "*particular insights that allow one to draw inferences about more normal firms*". However a single case approach has been criticised as lacking generalisability of events and Lee (1989) outlines difficulties associated with arriving at controlled conclusions and observations.

An alternative to a single case approach is a multiple case approach. A multiple case approach enables a researcher to analyse data across a number of cases which will enhance generalisability (Darke *et al.*, 1998; Cavaye, 2008). However, Galliers (1991) purports that there can be difficulties associated with gathering similar data from multiple cases; it may lead to issues in terms of

generalisability and the ability to rigorously interpret events. Stake (1994) supports this view by suggesting that this is the most complex stage of the research process. According to Stake (2005, p.457), comparison between cases is a research stage which is in competition with learning about and from a particular case. He stated that *"comparison is a powerful conceptual mechanism, fixing attention upon the few attributes being compared and obscuring any case knowledge that fails to facilitate comparison"*. Clearly, there is no perfect way of conducting research.

This research is leveraging the Humphreys and Berkeley (1985) framework as a construct for understanding the decision problems identified by managers and decision makers. The extent and the nature of the information available to managers in the form of reporting, scrutinising and discovery is the basis for determining the level of decision support maturity as pertaining to an organisation. The following section discusses the protocol for an exploratory case study utilising an instrumental case protocol. This is then followed with a description of the protocol deployed for the main case.

3.3.5. Research protocol for the exploratory case study

The decision to conduct an *exploratory study* (Marshall and Rossman, 1989) prior to pursuing the main study was made for several reasons. To begin with, an exploratory study afforded the researcher a chance to become more familiar with the subject and to gain rich insights which helped improve the methodology used for the main study (Yin, 1984; Stake, 2005). The selection of the case was opportunistic. It can also be termed an instrumental case study in that the actual case is of less importance than gaining a better understanding of the particular issues (Stake, 2005). The case plays a supporting role to facilitate an understanding of the applicability of the Humphreys and Berkeley (1985) framework in an organisational setting. Utilising a level of convenience with participant selection is acceptable for an exploratory study, which Yin (2009, p.48) refers to as a *'revelatory case'*. Stake (2005) advocates that a case should be selected whereby the researcher's learning can be maximised.

This researcher had access to, and enlisted the assistance of, practitioner managers who were participating in an Executive Management in Business Administration (EMBA) program, at University College Cork, and who were able to provide high levels of insight into a number of firms' decision making activities and decision support availability. This follows a well-established tradition in business literature to use industry practitioners engaged in educational programmes for research purposes (Remus, 1986; Edmundson, Lawrence and O'Connor, 1988). There has been intense debate over four decades whether college students are representative of 'people in general' for research purposes (Ashton and Kramer, 1980; Dobbins, Lane and Steiner, 1988). The debate is most critical of the use of undergraduate students as research subjects because these are 'unfinished personalities' (Carlson, 1971, p.212) in a relatively early life stage (Peterson, 2001, p.451). However, graduate business students have been accepted as suitable surrogates for business managers by a number of researchers. Sheth (1970, p.245) remarked on the *'remarkable degree of similarity between students and housewives*' when conducting direct consumer research with male graduate students. Remus (1986) conducted research that acknowledged there were no significant differences between business graduate students and that of line managers in their decision making capacity at this level. The students who participated in this research are all mid-career managers in their individual organisations, who are older and possess more life experience. They are essentially, closer to the independent thinking adults who are used as the comparative for the undergraduate students in the Peterson (2001) research. Moreover, they satisfy the criterion recommended for academic research as these students '*compose the population of interest'* (Gordon, Slade and Schmitt, 1986; Gordon, Slade and Schmitt, 1987).

Markus (1997, p.18) recommends '*research that describes and evaluates what is going on in practice*'. This study allowed the researcher to collect information on manager's decision activities within their own organisations. These practitioner managers provided the data for the exploratory study, which was subsequently analysed by the researcher. However, in an effort to ensure a

high level of rigour with the exploratory study, the requirements for the purposes of internal validity[5] (Campbell, Stanley and Gage, 1963) were such that the design of the exercise for data collection can be considered as controlling the main effects of history, maturation, testing and instrumentation.

The study was conducted across two phases, with two different groups of practitioner managers across two EMBA cycles. In each phase, the students were in their third semester of a four semester program. Therefore, these practitioner managers had participated in studies in the business domains of management and marketing, economics and accounting as well as their own business knowledge and know-how. Students had taken a module titled "Management Information Systems fundamentals" in a previous semester. Each semester, the MBA program director allocates students to groups, who then work together for the duration of the semester. Selection of the group members is random and is completed by the program director on a semester by semester basis. This process of group selection controls any threat to the selection process, or of statistical regression – where groups have been selected on the basis of extreme scores. Experimental mortality or differential loss of respondents from the groups has not been an issue for either study.

Each of these groups self-selected two target organisations for analysis, where a representative of the team members are employees and are engaged in decision making in the organisations. The other team members in the group provided critical validation for the decision level classification. The use of student feedback for research purposes has been found to be slightly more homogenous than that of non-student subjects, and therefore the researcher is cautioned

[5] Simply defined, validity relates to the correspondence between the researcher-collected data and the real world. Therefore, the extent to which the collected data reflects naturally occurring social behaviour and process determines validity. *Internal Validity*: considered in the context of description, suggests that, if data has internal validity, any significant differences observed in a comparison can be attributed to a predicted cause, and not to measurement or description error.

against any level of generalizations (Peterson, 2001). However, in this research, the observations are being made in the students own organisation and in their individual domain of expertise. The researcher did not influence or try to control the selection of the organisations where the assignment observations were conducted. Thus inter-session history, which can be considered a serious validity threat, is controlled. The issue of an instrumentation threat is controlled as the assignment accounted for one hundred per cent of the semester assignment, with a similar marking schedule and with the same observers and scorers. Moreover the scorers' (the researcher and the researcher's research supervisor) personal preferences or objectives were not communicated in any way. The subsequent feedback session was audio recorded, which helps to control the biases associated with any of the researcher's biases.

The self-selection process within the groups provided control of the selection-maturation interaction as the other team members in the group provided critical validation for the process. Decision making and decision support are topics that are not part of any other module on the EMBA program. The assignment formed part of their marking for the overall program and led to excellent work by most groups of students. The students were not aware of the researcher's experiment or research agenda, and in preparation for their field work, all the EMBA students were coached by the researcher in the application of the Humphreys and Berkeley (1985) framework. In this way, multiple-treatment interference is controlled as far as possible. The objective of the practitioner managers involvement was two-fold: Part 1) to develop a comprehensive understanding of decision issues encountered by the participants, in their day-to-day work environment; and Part 2) to understand the relationship between the decision problem identified and the available information sources that were used to facilitate the resolution of the decision problem, for each scenario identified in Part 1. The organisations that were selected for analysis varied in the extent to which they had adopted and assimilated information technologies and in particular, their Decision Support

Systems varied in sophistication in terms of reach and range. The research for each phase of the study is discussed in the following two subsections.

3.3.5.1. Phase one of the exploratory study

Phase one of the exploratory study took place in the Spring Semester of 2009. There were thirty two students in the class, allocated across six groups. The assignment question set for the groups was as follows: "*Identify decisions made in your organisation, and identify the DSS which facilitate decision making for these decisions*". Implicit in the question was to also identify the gaps in decision support.

The groups presented their analysis to the researchers in extensive presentations in the class room, and each group produced a detailed written report detailing the decision problem scenarios encountered and the decision support systems in use in two organisations. The objective was realised, which allowed the researcher to collect information on managers' decision activities in twelve organisations. The data collection process will be further discussed in section 3.4.

3.3.5.2. Phase two of the exploratory study

Phase two of the exploratory study took place in the Spring Semester of 2011, two years after the first phase of the study. There were twenty seven students in the class, allocated across five groups. Based on the analysis of the portfolio of decision support tools as presented in phase one of the research, the question posed for the second group was amended to place a greater emphasis on decision support and all sources of information, which should encourage the students to consider a wider range of decision support tools. The assignment question for the second phase of the study was as follows: "*Identify the decisions made in your organisation, and identify the decision support which facilitates the decision making for these decisions. Consider all sources of information taken into account in the decision making process".*

When undertaking the second study, a number of steps were taken to overcome the weaknesses of the phase one exploratory study, including changing the question in an effort to deemphasise DSS, more extensive coaching on the representation levels and on the framework itself, and a wide ranging discussion with the class on sources of information in general which are available to managers in organisations – non-computerised and computerised, formal and informal, internal and external (Stabell, 1994).

Once again the groups presented their analysis to the researchers in extensive presentations in the class room. Each group produced a detailed written report detailing the decision problem scenarios encountered and the decision support tools in use in two organisations. The data collection process in relation to phase two of the exploratory study will be discussed in further detail in section 3.4.

3.3.5.3. Conclusions from the exploratory study

Researchers are recommended to apply "*appropriate restraint*" when using students for research purposes (Gordon *et al.*, 1987, p.162). However, the criterion for this study and the involvement of students is considered as being acceptable on the basis of the following:

- The student body composed the population of interest;
- The study of a new set of particularistic propositions intended for application in organisations (Gordon *et al.*, 1987).

The exploratory study has been successful in applying the Humphreys and Berkeley (1985) framework as a mechanism to represent a cognitive perspective and representation of decision problems encountered by decision makers. The study has also been very successful in identifying the nature and the extent of the decision support which is available to the decision makers, at the different representation levels. The observations, across ten case studies of Irish firms, confirm that the higher levels of abstraction of decision problem identification and associated solution formulation are covered in a very limited manner by decision support, either formal decision support by DSS, or decision support by

other softer mechanisms. Just one of the ten firms has any concrete decision support above level 3 in the Humphreys and Berkeley (1985) framework and only five have conclusively considered what issues could be supported at level 4.

Another important finding of our exploratory case study is that it is difficult to engage with managers on the topic of a cognitive representation of decision making and decision support. Even in the relatively controlled environment of the class room, discussions with managers from real life organisations and the problems they face, on the basis of a well explained grammar (the Humphreys and Berkeley (1985) framework), still reveal the possibility of important bias and misrepresentation. This model for the exploratory study suggests that progress in the domain under investigation requires a detailed study of the work of real managers and decision makers at senior levels in actual organisations which could provide all levels of decision problem identification.

3.3.6. Research Protocol for the Main Case Study

The main study used a single case study method. The case can be termed a 'typical case' where the objective is to capture the circumstances or conditions of the everyday decision making situation (Yin, 2003). The main study was conducted shortly after the conclusion of the exploratory study, and used an explanatory case study research approach. In contrast to the exploratory study the main study cannot be chosen out of convenience. Instead the sample case must be chosen for theoretical reasons (Miles and Huberman, 1994; Stake, 2000; Yin, 2003). The objective is to select a case that provides a means to build an inductive theoretical framework which will confirm and elaborate on the processes and constraints within the research study domain (Eisenhardt, 1989; Miles and Huberman, 1994). With respect to this research, executive managers within a financial services organisation were chosen as the participant sample for the main study. The primary objective in selecting the participants and the organisation is to ensure that a comprehensive range of decision problems could be identified, at all levels within the organisation, during the study. This requires

access to participants who operate at the most senior level within an organisation. The unit of analysis in this research is at the decision maker or manager level.

The researcher was mindful of the fact that gaining access into an organisation is difficult, due to the time and commitment required by the members of the organisation involved in the research process. Keeping this in mind the researcher contacted two possible research sites and was hopeful to gain entry into at least one, in order to ensure a depth and breadth of organisational experiences. Both organisations operate in the Financial Services domain. Financial services organisations have implemented extensive IT infrastructure over the last three decades, being amongst the first big users and adapters of Information technology. It was hoped that an extensive range of decision support would be evident during the discussions. The requirement of senior executive participation determined the organisation selection, and over a two month period, one of the organisations agreed to allow the study to proceed. At the time of the study (2010) the financial services industry was going through a transitional period with a significant level of organisational change occurring as a consequence.

The study was conducted in the Global Markets Division within a large global financial institution, which will be referred to as BigBank[6]. The researcher had considerable access to senior executives in the organisation, up to and including global vice-president executives. The demographic detail of the interviewees is outlined in Table 3.3. The interviewee names have been changed so that their anonymity is maintained. The table presents the participants' pseudo name, their current position and management level. The 'years of service' column represents the number of years employed in the organisation. The 'staff' column represents the number of direct reports attributable to each

[6] BigBank is not the organisation's real name.

of the participants. The 'area of expertise' column, as in 'business' or 'technology', clarifies the organisational domain of the research participants. While Nick, Lorraine, Daniel and Raj were relatively new to the organisation, they each had considerable experience in other financial services organisations. Furthermore financial services organisations have implemented extensive IT infrastructure over the last three decades, being amongst the first big users and adapters of Information Technology. It was hoped that an extensive range of decision support would also be evident, during the discussions.

Name	Position	Title	Staff	Years Service at BigBank	Area of Expertise
Owen	EMEA Markets Head of Client Relationship	MD	12	15	Business
Anne	EMEA Markets CAO	MD	15	11	Business
Richard	Global Head Electronic Trading	MD	90	3	Business
Nick	EMEA Head of Equities	MD	400	3	Business
John	EMEA Equities Head of Electronic Trading	MD	25	2	Business
Ellen	EMEA Equities CAO	MD	16	9	Business
Steven	Global Head of Equities middle office	MD	50	5	Business
Jason	Global head of Project Office: prime finance & technology	SVP	1	2	Business
Raj	Electronic Trading Business Manager	SVP	8	2	Business
Lorraine	Emerging Markets Business Manager	SVP	2	1	Business
David	EMEA Equities Head of Technology	MD	150	10	Technology
Jim	Global Head of Prime Finance & Futures Technology	MD	400	6	Technology
Daniel	Prime Finance and Futures Technology	SVP	5	1	Technology
Adrian	EMEA Head of Risk Programs for Ops. and Technology	MD	3	12	Technology

Table 3.3. interviewees at BigBank, roles and responsibilities

3.4. Data Collection Techniques

A number of data collection techniques are accessible to the researcher (Galliers and Land, 1987; Marshall and Rossman, 1989). Data gathering techniques such as interviewing are heavily relied upon by qualitative researchers (Marshall and Rossman, 1989). This section details how data was captured for the exploratory case through utilising a class, and from the BigBank participants identified in the previous section (Table 3.3). Considering the study's qualitative nature and the research objective adopted, personal interviews and document analysis were identified as the most appropriate data collection techniques for the main case. Yin (1994) highlights the importance of corroborating and augmenting information from a variety of sources, which Denzen (1978) defines as data triangulation. Data triangulation is *"the combination of methodologies in the study of phenomenon".* For the purpose of this study the researcher used the "within method" (Denzen, 1978, p.301), allowing the use of multiple techniques within a given research method (qualitative) to assemble and decipher data (Jick, 1979). The use of multiple sources acts as substantial support by providing a cross section of evidence from each source and not just from the interpretation of the interview findings (Trauth and Jessup, 2000). In effect, each method serves to *'correct out'* erroneous data supplied through the other method, therefore, *"the findings represent only those data that have been shown to be valid in terms of all the methods used"* (Sanders, 1974, p.13). Several researchers have argued that this approach puts the researcher in a much stronger position in terms of claiming validity for their findings (Sanders, 1974; Yin, 1994).

3.4.1.1. Interviews

Interviews are a fundamental data collection technique employed by qualitative researchers with the objective of gathering valid information related to the phenomenon under consideration (Marshall and Rossman, 1989). They define an interview as a reliable data collection method involving interaction

between the interviewer and interviewee (Marshall and Rossman, 1989). One of the key advantages of interviews is that they enable the rapid collection of large amounts of data (Marshall and Rossman, 1989). In addition, there are various modes of interviewing with varying levels of structure and formality. Fontana and Frey (1994) recommend two types of interview: structured and unstructured. Structured interviews pose standard pre-established questions with a fixed set of response categories and are more quantitative than qualitative in nature (Trauth and O'Connor, 1991). According to Yin (1994, p.89) *"interviews will appear to be guided conversations rather than structured queries. In other words, although you will be pursuing a consistent line of inquiry, your actual stream of questions in a case study interview is likely to be fluid rather than rigid"*. This outlook opposes the structured interview approach, advocating a fluid line of inquiry as the most appropriate approach for case study research and the use of an interview guide rather than a rigid questionnaire.

In view of the exploratory nature of this study, semi-structured interviews were deemed the most appropriate data collection technique for the main study. This approach enabled the respondent to answer a predetermined set of questions in the manner of their choice (Stone, 1978), providing a level of flexibility to the interview, because it allowed the respondents to influence and manipulate the direction, order and nature of questions. This technique attempted to capture an understanding of the complex behaviour of managers and decision makers, and allowed the interviewer to uncover aspects that may not be immediately apparent (Burgess, 1982). This was particularly important considering the complex and intangible nature of a cognitive understanding of the decision making process, offering the researcher the opportunity to pursue a probing line of questioning where necessary.

3.4.2. Data Collection Techniques for Exploratory Study

The exploratory study allowed the researcher to collect information on manager's decision activities within their organisations. These practitioner managers provided the data for the exploratory study, which was subsequently

analysed by the researcher. However, in an effort to ensure a high level of rigour with the exploratory study, the requirements for the purposes of internal validity (Campbell and Stanley, 1963) were such that the design of the exercise for data collection can be considered as controlling the main effects of history, maturation, testing and instrumentation.

The assignment formed part of their marking for the overall program and led to excellent work by most groups of students. The students were not aware of the researcher's experiment or research agenda, and in preparation for their field work, all the EMBA students were coached by the researcher in the application of the Humphreys and Berkeley (1985) framework. In this way, multiple-treatment interference is controlled as far as possible. The objective of the practitioner managers involvement was two-fold: Part 1) to develop a comprehensive understanding of decision issues encountered by the participants, in their day-to-day work environment; and Part 2) to understand the relationship between the decision problem identified and the available information sources which were used to facilitate the resolution of the decision problem, for each scenario identified in Part 1. The organisations, which were selected for analysis varied in the extent to which they had adopted and assimilated information technologies and in particular, their Decision Support Systems varied in sophistication in terms of reach and range. The research for each phase of the study is discussed in the following two subsections.

The groups presented their analysis to the researcher in extensive presentations in the class room, with a short question and answer session at the end of each presentation. Each group also produced a detailed written report describing the decision problem scenarios encountered and the decision support systems in use in two organisations. The objective was realised, which allowed the researcher to collect information on managers' decision activities in a number of organisations. After the presentations, the researcher selected the five organisations with the most rigorously produced reports, where the representatives were well informed participants (Johnson, 1990) of the framework and of the decision making process in their organisation. These

reports and presentations were used as research instruments for data collection and led to the analysis of the portfolio of decision levels and decision support available to managers. The five mini case studies are presented in Chapter Four, Section 4.1.

3.4.2.1. Data collection for Phase One of the exploratory study

The results of the Phase One exploratory study provided important evidence that identified two primary findings with regard to the Humphreys and Berkeley (1985) framework, namely: 1) the framework captured the classification of decision problems in an interesting and innovative way, and in particular, in a way that was accessible for the participants; 2) not all levels of the framework are utilised by all levels of management, and there was a deficit of information with regard to decision problems which could be classified at levels 4 and 5 of the cognitive representation under consideration.

When analysing the feedback from the Phase One research data set, including the cases which were excluded (because the researcher was not satisfied with the quality of the data collection carried out by the groups), it becomes evident that the classification of decisions, as described by the managers, can become distorted in a number of ways:

(1) The manager's perception of their own position in an organisation influenced their perception of the level of the decision, and most of the managers overstated the representative level of decisions considered. This was especially true in organisations where 'strategic goal alignment' is part of the day-to-day organisational culture, and managers mistakenly equated their perceived strategic role with the framework levels.

(2) The degree of discretion available to the manager influenced the determination of decision level. Where discretion levels were high, the managers presented a higher decision level classification.

(3) Some managers were swayed by the terminology 'strategic, tactical and operational' which they equated with abstraction levels, and subsequently

reverted to this interpretation when assessing decision problems. This is a related but different bias to the first outlined.

(4) Finally, many managers identified decisions by the IS or DSS that provided the decision maker with the required information to make the decision. Moreover, the classification of representation level, based on the concepts of reporting, scrutinising and discovery, was far more accurate than through any other mechanism.

During a subsequent feedback session the students agreed that, in general, their decision level classifications were overstated by at least one level. Thus, managers find it difficult to measure the degree of abstraction of an idea in conjunction with the degree of formalisation of the solutions they apply to it. This is an interesting observation on the concept of representation level as proposed by Humphreys and Berkeley (1985): it is not spontaneously or intuitively understood by many managers. The feedback session discussions facilitated the realignment of the representation level classification in the Phase One mini cases, such that the data in tables as presented in Chapter Four has been corrected and is accurate as presented.

3.4.2.2. Data collection for Phase Two of the exploratory study

Once again, the results of the Phase Two exploratory study provided similar evidence as identified during the Phase One of the exploratory study. The primary findings with regard to the Humphreys and Berkeley framework, were also similar, namely: 1) the framework captured the classification of decision problems in an interesting and innovative way, and in particular, in a way that was accessible for the participants; 2) not all levels of the framework are utilised by all levels of management, and there was a deficit of information with regard to decision problems which could be classified at levels 4 and 5 of the cognitive representation under consideration.

After the Phase Two presentations, the researcher again selected the most rigorously produced reports, which were used as research instruments for

data collection, and which led to the analysis of the portfolio of decision levels and decision support available to managers in five case studies, which are presented in Chapter Four, Section 4.2. However, on analysing the presentations from the second group of students, it became apparent that the findings were less clearly presented. The biases of the first group persisted, and the representation level classification were even more varied and biased. Two groups of managers "*needed to use all five levels*"[7], and fitted the decisions into a scale of 1 to 5, rather than analytically considering the level of abstraction of the decision.

However, the findings as evidenced in Phase One of the exploratory study are upheld, especially, with regard to the usefulness and accessibility of the Humphreys and Berkeley (1985) framework for capturing the classification of decision problems. Furthermore, the best presentations of the decision problem classifications, as well as the nature of decision support, emanated from managers where a comprehensive range of DSS are in place, i.e. organisations where an almost complete portfolio of information systems have been developed that provide decision support at levels one, two and three and possibly level four, and which are extensively used by these managers.

Peterson (2001, p450) argues that responses from college students *were 'found to be slightly more homogenous than those of nonstudent groups'.* However, this research indicates a level of homogeneity of the findings across organisations where the level and nature of information and decision support availability is similar in its level of sophistication, and not because these managers are students. As discussed in Section 3.3.5, the majority of the student participants are mid-career managers in their own organisations, and the assignment afforded then the opportunity to reflect on their own work environment, their own decision problems and their own sources of information

[7] Quotation by manager of Company F during feedback session

and sources of decision support. This follows the recommendation by Klein and Rowe (2008, p.681) to ensure that student researchers acknowledge and reflect on '*their past life-world experience in terms of the theories they are now learning*'.

3.4.3. Data Collection Techniques for Main Case Study

The most rigorous method of data collection was formal semi-structured interviews with the executives. The interviews were, at a minimum, an hour in duration on average, and one interview lasted for two hours. The primary data were collected during August 2010 and during October 2010 in the BigBank offices in London. Semi-structured interviews were conducted and the researcher observed several rules of interviewing and qualitative data handling (Bourgeois and Eisenhardt, 1987; Yin, 1994), including:

- All interviews were audiotaped and then transcribed verbatim. Two hundred pages of 1.5 spaced text of transcripts was generated.
- The researcher reflected on the interview material and any notes taken, thereby enabling preliminary analysis in accordance with the '24-hour rule' to capitalise on the immediacy of the data.
- Each of the participants were available by phone and e-mail so that interpretations could be clarified and any 'follow-up' questions could be answered and further explanations could be provided.

Interviewees were selected using homogenous sampling to enable an in-depth examination of decision making within an organisation. This strategy facilitated a meaningful comparison of the decision problems identified at the different representation levels (Patton, 2002; Suri, 2011). Theoretical saturation is reached when additional interviews provide little or no new insights. Essentially the last few interviews did not provide any new insights, thus giving the researcher the confidence that theoretical saturation had been reached. The researcher also took part in semi-structured and unstructured discussions with senior executives that, at their request, were not recorded. The researcher took extensive field notes during these sessions, and subsequently recorded reflective

commentaries as soon as possible after each meeting. In addition, most of the participants made themselves available for telephone and e-mail discussion that allowed the researcher to clarify issues during data analysis.

The case data reported, and presented in Chapter Five, were collected over a number of weeks of intensive field research in the organisation. The data were obtained through a series of in-depths interviews with a total of fourteen different participants, all high level executives (Managing Directors, Directors and Senior Vice presidents), of whom ten were Business executives and four were Technology executives. The interview schedule is presented in Table 3.4.

Date	Time	Name	Position	B/T	Duration
16/8/2010	10.00	Ellen	CAO EMEA Equities	B	2 hours
	14.00	Jim	Global head of Prime Finance and Futures technology	T	1 hour
	16.00	Owen	CAO Emea markets	B	1 hour
17/8/2010	09.00	Nick	Head of European equities	B	1 hour
	11.00	Lorraine	Emerging Markets Business Manager	B	1 hour
	14.00	Adrian	Director of global infrastructure	T	1 hour
	16.00	Jason			
18/08/2010	11.00	Richard	Head of European electronic trading	B	1 hour
	14.00	Steve	Global Head of middle office	B	1 hour
	~~16.00~~	~~Adriann~~	~~Planning & Analysis~~	~~T~~	~~1 hour~~
	16.00	Raj	Electronic trading Business manager	B	1 hour
19/08/2010	9.00	Anne	CAO EMEA Markets	B	1.5 hours
	12.00	John	EMEA – head of Electronic trading	B	1 hour
	14.00	Daniel	Prime Finance and Futures Technology senior analyst	T	1.5 hours
	16.00	Steven	EMEA Head of Equities Technology	T	1.5 hours
20/08/2010	14.00	Focus Group meeting		B & T	1.5 hours

Table 3.4. Interview schedule

The four technology executives were interviewed comprehensively, both as executives in their business area, as well as executives in charge of technology for that area. Furthermore, the role of 'Head of Risk and Operations' is a newly

created role. The current appointee, Adrian, had acted as Director of Technology Infrastructure in his previous role. Both roles were discussed during the interview and provided in-depth insights in the technology domain. During the course of three of the interviews, the interviewees recommended other executives in their own business unit, whom they believed would be able to bring further insights to the discussion at hand. The researcher was able to interview these people within the timeframe available. One of the scheduled interviews was not realised as the interviewee was unavailable due to unscheduled business travel to Asia for the week. The interviewee was available a number of weeks later, and the interview was conducted during the researcher's second visit to the UK headquarters. The researcher spent two time periods of approximately one week each, in the organisation, talking to and observing organisational actors until an extensive understanding of the context of the case had been achieved. Further follow up, primarily by e-mail, has occurred since those interviews in order to clarify aspects of the interview discussion or for additional information. Thus, Chapter Five reports on the types of decision problems encountered in the Global Markets Division of BigBank and the information sources that facilitate the resolution of the decision problems.

3.4.3.1. The interview process

The interview guide protocol was employed as it facilitated systematic data collection (Appendix A). The consistent sequence of questions outlined in the interview guide facilitated the breakdown of the longer interviews during the data analysis phase. The interview line of inquiry was focused on the nature of an employee's role and their associated decision making activities in the selected business function. Towards the beginning of the interview, each participant was asked to confirm their position and role within the Global Services division.

A number of schemas were introduced during each interview, which facilitated a consistent approach to each interview, and these are included in Appendix B. The researcher pointed out that the terminology of the schema/diagram was merely indicative, and was by no means either prescriptive

on inclusive. In this way the researcher was endeavouring not to overly influence the substantive nature of the discussion and encouraged the participants to steer the interview towards issues and concepts that they felt best represented their own decision making experiences. The primary objective was to explore the participant's decision making domain and the information sources available.

The first schema (Appendix B, Figure B1) illustrates a typical environment for any executive. The schema facilitated the interviewee to describe the primary sources of decision problems, as well as the channels of communication for discussion and problem resolution. This schema is adapted from Jones, Saunders and McLeod Jr (1988). The second schema (Appendix B, Figure B2) depicts the Humphreys and Berkeley (1985) framework which was presented to each of the interviewees. This schema facilitated an understanding of the Humphreys and Berkeley (1985) framework, and grounded the context of the interview. All of the interviewees used this schema to specify their own decision problem domains, and referred back to it, repeatedly, during the interview. The third schema (Appendix B, Figure B3) is based on the Daft *et al.* (1987) information richness framework. This schema facilitated a wide-ranging discussion regarding sources of information, which the interviewees identified as pertaining to their own decision resolution process.

The three schemas ensured that the researcher did not lead the interviewees in any particular direction, and in many of the interviews, the interviewee notated the schemas which facilitated their elaboration of the discussion as it evolved. Ultimately, the interview transcripts and the notated schema served as the primary data for the study.

When the individual interviews were completed, a group session was conducted, based on the focus group method. The focus group method is useful for obtaining information which would be difficult to obtain using other methodological methods (Kreuger, 1994, Morgan, 1994) and it is also useful for clarification purposes due to a level of reiteration (Eisenhardt and Graebner, 2007). The main area for discussion during the focus group session pertained to the applicability and suitability of the Humphreys and Berkeley (1985) framework

as a means of capturing the different decision problems domains, and which had been discussed during the individual interviews. While not all of the original interviewees attended the group session, the attendees reflected the number of hierarchical levels of the overall group and were a representative body. This type of session contributes to limiting bias, as it is unlikely that the participants will "*engage in convergent retrospective sensemaking and/or impression management*" (Eisenhardt and Graebner, 2007, p.28).

3.4.3.2. Document Analysis

Document analysis was employed as one of the research methods for this study. Marshall and Rossman (1989) state that document analysis is the gathering and analysing of documents produced in the course of everyday events, they refer to it as *'historical analysis"* that may be used to support other data gathering techniques. Document analysis is a method of discovering from records and accounts, what happened in the past. Sources of data include records, reports, questionnaires and documents (Marshall and Rossman, 1989). Archival documents such as various internal reports, business strategy reports, IS strategy reports and internal presentation reports were made available to the researcher. Some of these reports were made available in advance of the interviews and consequently the initial analysis of these reports was used for interview preparation. For example, the organisational hierarchical chart enhanced the researcher's understanding of the participant's role, as well as their scope and domain of responsibilities.

Document analysis employed for this study included publically available information as well as confidential documents pertaining to the organisation's future business strategy, and IT Strategy documentation. Sources of information included the 2008 and 2009 annual reports, the organisation's corporate web site and intranet. Document analysis contributed significantly to the research process supporting and corroborating some of the interview findings by providing information about the organisation's core offerings and in certain cases an insight into projects they had completed.

3.4.4. Synthesising the Data Collection Process

The previous sections outline the data collection process for the exploratory case study and for the main case study. The exploratory study leveraged an EMBA class, whose participants are decision makers and managers in their respective organisations. The exploratory study was the first attempt in applying the Humphreys and Berkeley (1985) framework to categorise organisational decision problems and as such an a priori list of decision problems did not exist. The participants' understanding and interpretation of the representation levels of the framework facilitated the refinement of the presentation of the original Humphreys and Berkeley (1985) framework. The refined version is as presented in Figure B2 (Appendix B), and was part of the data collection mechanism for the main study. This refinement of seed categories is represented in Figure 3.1. and it is further discussed in the following section, where the data analysis process pursued in this study is presented.

3.5. Data Analysis Methods

Data analysis is the means by which conclusions can be rigorously developed in any research study. A step-by-step approach to analysing the gathered data allows the researcher to develop new ideas in the area of research from an early stage. Eisenhardt (1989, p.539) purports that "*analysing data is at the heart of building theory from case studies, but is the most difficult and least codified part of the process*". Miles and Huberman (1994) identify issues of extreme importance in data analysis including: data displays, threats to analytic validity, and 'transparency' and the distribution of data management and data analysis procedures. They identify four distinct but interrelated tasks within the data analysis process: data collection; data reduction; data display; and data verification. These processes are conducted before, during and after data collection. Data reduction is the process of selecting, simplifying, abstracting and

transforming raw case data. Data display is the organised display of information to enable the drawing of conclusions. Drawing conclusions and verification refers to deriving meaning from the data. Data collection for the exploratory case and for the main case has been discussed in the previous section. Data analysis for the exploratory case study is described in the next section. This is followed with a description of the data analysis process for the main case study.

3.5.1. Data analysis for the Exploratory Study

This research project is informed from the outset by a preliminary research framework that is informed by extant theory, and seeks to further refine that framework through empirical investigation. In qualitative research, sampling tends to be *purposive* rather than random (Eisenhardt, 1989; Miles and Huberman, 1994; Patton, 2002). As discussed, this is an instrumental case and examining it requires a synthesis of the frameworks so that an increased understanding of their applicability can be realised (Stake, 2005).

The Humphreys and Berkeley (1985) framework provided a set of useful "seed categories" (Miles and Huberman, 1994) reflecting the underlying constructs of this research. When analysing the data, the seed categories were used to identify and to structure the decision problem formulation and the decision solution evolution. The attributes associated with levels of abstraction were derived from the literature presented in Chapter Two, Table 2.5. These categories provided a set of decisions which were encountered by individual managers in their normal role, and answered Research Question One. The sources of decision support categories were derived from the literature presented in Chapter Two, Table 2.10. These categories provided a set of IS applications is use in the organisation, and represented the primary sources of decision support, which answered Research Question Two. Each of the organisations in Phase One and in Phase Two of the exploratory study was essentially a mini-case. The narrative represents the decision problems

encountered by one manager in the organisation. The ten mini-cases are presented in Chapter four.

3.5.2. Data Analysis for the Main Case Study

The extent of the data collected during the main study allowed for a much more comprehensive level of data analysis. Given the context of the data gathering procedures, the data analysis was conducted as follows. The interviews were analysed using grounded theory building coding procedures (Strauss and Cobin, 1997). The Humphreys and Berkeley (1985) framework provided the primary set of seed categories. However, the widest possible range of meanings for participant's word or phrases was considered by the researcher. This micro analytic coding procedure forces the researcher to break away from their own frame of reference and prejudice to reduce the effect of the researcher's bias. One of the well documented drawbacks of qualitative research is the effect of bias, and the possibility that the researcher will draw premature conclusions during the early stages of analysis.

Coding is a part of the data analysis process, according to Miles and Huberman (1994) and coding requires the researcher *"to review a set of field notes, transcribed or synthesized, and to dissect them meaningfully, while keeping the relations between the parts intact"* Miles and Huberman (1994, p.56) Codes are labels that assign meaning to chunks of data compiled during the course of a study (Miles and Huberman, 1994). Strauss and Corbin (1998) support the use of a 'coding paradigm' that includes the use of open, axial and selective coding techniques. Open coding is the initial process of labelling units of data based on terms and concepts found in the data. Open coding techniques involve microanalysis of the data and the examining of the meaning in each word or groups of words. Based on this, each word receives a label or code (Strauss and Corbin, 1990). Axial coding on the other hand involves identifying the relationships between categories of themes and validating these relationships in the data (Strauss and Corbin, 1998). Selective coding is concerned with

generating theory to fit the data collected (Strauss and Corbin, 1998). This approach is exemplified in the recent work of Olsson *et al.* (2008) and codes are captured in analytic memos as a means of refining data collection.

With coding, researchers must keep in mind that there are two levels of interpretation: 1) first order which refers to the participant's interpretation; and 2) second order which refers to the researcher's interpretation (Miles and Huberman, 1994). A key purpose of microanalysis is to elicit first order concepts that reflect the participant's interpretation. By using the participant's own words, the ideas reflect those of the participant. As the codes build up, the researcher will recognise the groups of codes that can be grouped together. This mechanism will allow for a deeper interpretation allowing for essentially open-coding. The goals during the open-coding stage are: 1) to continue to look for new codes or concepts that may surface as more of the interviews are analysed; and 2) to code around first-order and second-order concepts in order to identify category properties and dimensions.

3.5.2.1. The coding process adopted for this study

During a complete reading of the transcripts, it was possible to build a matrix of codes by isolating relevant text fragments. The coding list was revised several times during the analysis of the data, which, of itself, is not an unusual occurrence (Miles and Huberman, 1994). Table 3.5 provides a sample subset of the open codes and source interview transcripts and documents quotations.

Source	Source narrative	Code
Owen	I guess this is the area - level 4 – expressing it. And this is where I think too much time is spent in this part of the funnel, this is where the blockage is where the slowdown occurs. What you want is getting to this stage of the funnel implementation stage (L2 and 1). Thing get slowed down going from here to here (4 to 3).	Complexity of implementing and actioning strategic direction.
Owen	If I look at my organisation and the people I work with closely, there is no issue with coming up with good ideas. I think they get lost in the day-to day immediacy of our business.	Time taken to make decision on what is possible to implement
Nick	Bonus driven culture and for only a 12 month basis	Short term objectives
Raj	Short time ago we had one place to trade, now we have 10 choices. The trade horizon is a few seconds. Where can I trade fast, and where is the probability of failure or risk highest. How can I optimise my costs but what is (optimised) impact on market signalling.	Complexity associated with day-to-day operations
Steve	Decisions based on eight different sources – promotions and the people side of things, so again he (my boss) may force me to only promote one or two.	Multiple sources of issues. People decisions
Steve	Process trades, to control and reduce the number of exceptions, …. can we deal with new activity.. do we throw more people at it or build some technology to incorporate it or [do] we say no.	Process improvement. People vs. technology decisions

Table 3.5. Sample Open Coding used during Data Analysis

In all, almost 200 codes or labels were identified. During the axial coding process the focus shifted to these labels. The labels were analysed for similarities and clustered into sub-themes. Yin (2009) proposes that data analysis should follow the theoretical propositions which lead the researcher to the study. In this research the Humphreys and Berkeley (1985) framework has been used to ground the context of the interviewees in BigBank, as discussed in Section 3.4.3. Therefore, the higher level categories generated during the 'axial coding' process are matched to the Humphreys and Berkeley (1985) representation levels. In addition a small level of abstraction from the data begins to emerge.

Selective coding refers to the integration of the categories under a single theme to form the initial theoretical framework. Figure 3.1 and Figure 3.2 illustrate a sample of the process of developing the relationship between the Humphrey and Berkeley (1985) representation concepts and the categories

derived from the codes in Table 3.5. Figure 3.1 separates out the categories and the relationships with Levels 5 and 4 of the Humphreys and Berkeley framework, and in particular the relationship as it relates to the Decision Problem Representation in Figure 2.8. Figure 3.2 presents the categories and relationship with Levels 1, 2 and 3 of the Decision Problem Representation in Figure 2.8. In this way, a parsimonious theoretical model that provides the best fit to the data is presented as advocated by (Eisenhardt, 1989). Since the goal is to develop and enrich the emerging theory by looking for patterns, themes and associations across all the participants' interviews, similar coding exercises have been completed for the other elements of Table 2.8.

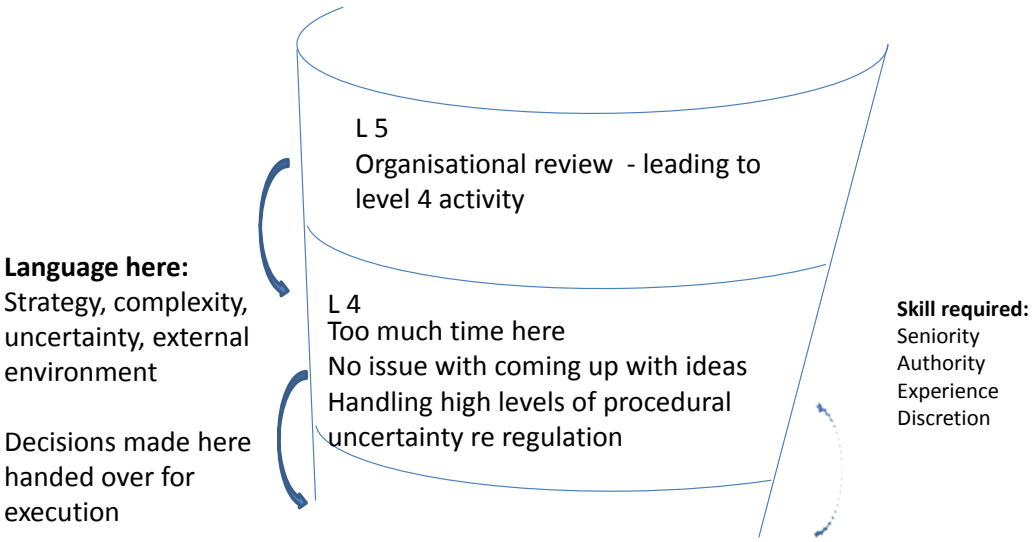

Figure 3.1. Example of Selective Coding and the emerging differentiators for Levels 4 and 5 representation levels of the cognitive framework

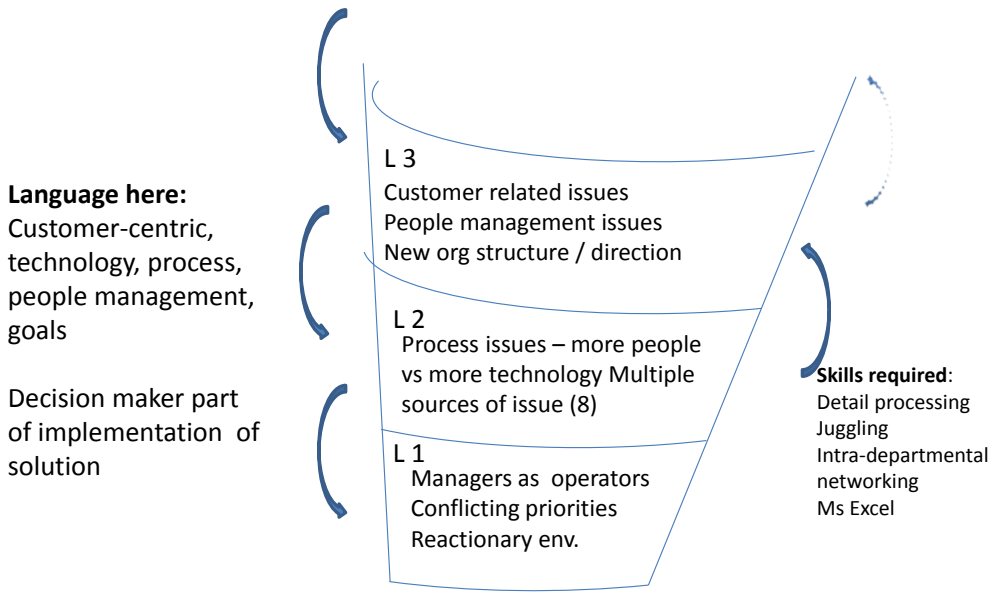

Figure 3.2. Example of Selective Coding and the emerging differentiators for Levels 1, 2 and 3 of the representation levels of the cognitive framework

3.5.3. Synthesising the Data Analysis Process

The previous sections outline the data analysis process followed in this research study. Figure 3.3 illustrates an overview of the data analysis process, leveraged to meet the research objective presented. Figure 3.3 clarifies starting with participants in an EMBA class (1), and coding according to categories derived from the literature. Using the seed categories as a basis for identifying the level of abstraction of the decision problem formation and solution evolution, the decision problems were differentiated and represented at the different cognitive levels of the Humphreys and Berkeley (1985) framework. The DSS systems utilised when resolving the decision problem provided an insight into the nature and the extent of the decision support availability (2). The understanding gained during the exploratory case, facilitated the refinement of the original seed categories and enabled the researcher to incorporate these refinements into the schema which were used during the interview process for the main case (3).

The process associated with the main case starts with interviews at BigBank (4). Using the refined seed categories the decision problems were identified. In Figure 3.3 the analytical memos and the analysis converge, indicating some revisiting of the interview transcripts to clarify and corroborate findings when the need arose. Bidirectional arrows indicate iterative interactions (between the analytic memos and the analysis, and between analysis and data display).

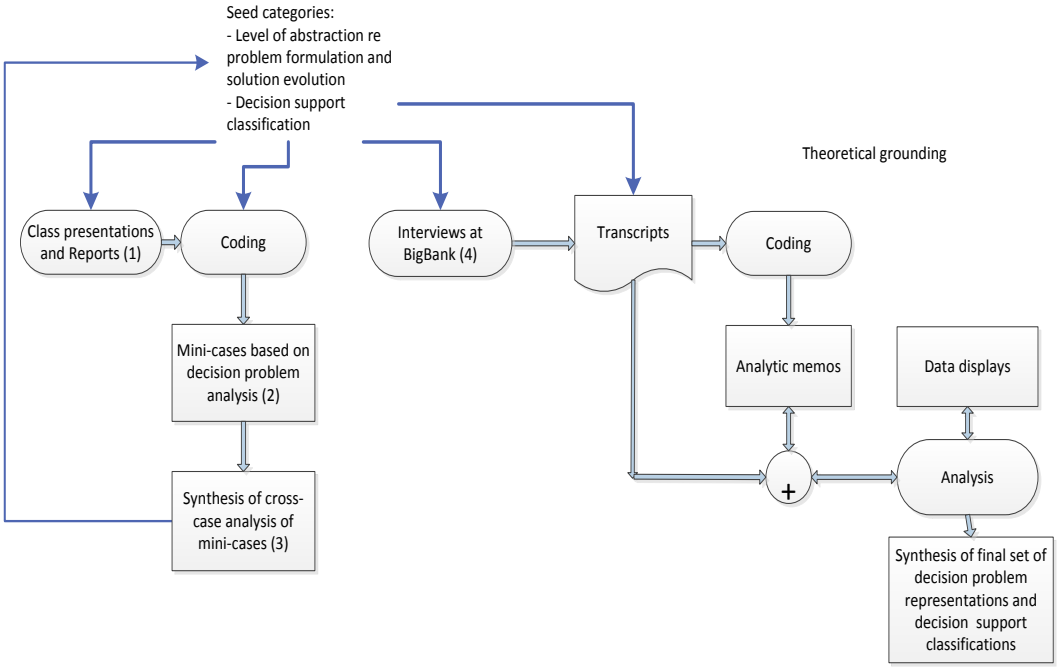

Figure 3.3. Schematic overview of data analysis process (adapted from Agerfalk and Fitzgerald, 2008)

The final section details a summary of the research approach undertaken in order to achieve the research objective outlined.

3.6. Summary of Research Approach

According to Huberman and Miles (1994), an amount of 'anticipatory data reduction' is involved in the process of qualitative data analysis, for example, in the choices of framework, of research questions, of samples, of case

definition itself, and of instrumentation. In this research study this data reduction process was focused on evidence collected from an exploratory study through utilising an EMBA class as well as from the BigBank participants, which provided in-depth insights into a complex phenomenon and facilitated answering the research questions posed. However, the research also embraced the perspective of facilitating 'creative work' (Huberman and Miles, 1994) where the research design followed a 'looser' inductive orientation, due to the inherent complexity in the area under research, and the researcher's own perception of the area under study, based on experiences and observations. Therefore, the researcher's intention was exploratory, using a small number of cases in an effort to induct theoretically sound arguments to further improve our understanding of the area under research. The objective of this research has been broken down into three research questions. These questions culminate in an exploration of the decision problems and decision support maturity in organisations. Figure 3.4 presents the steps that have been taken in order to arrive at answers to the research questions posed.

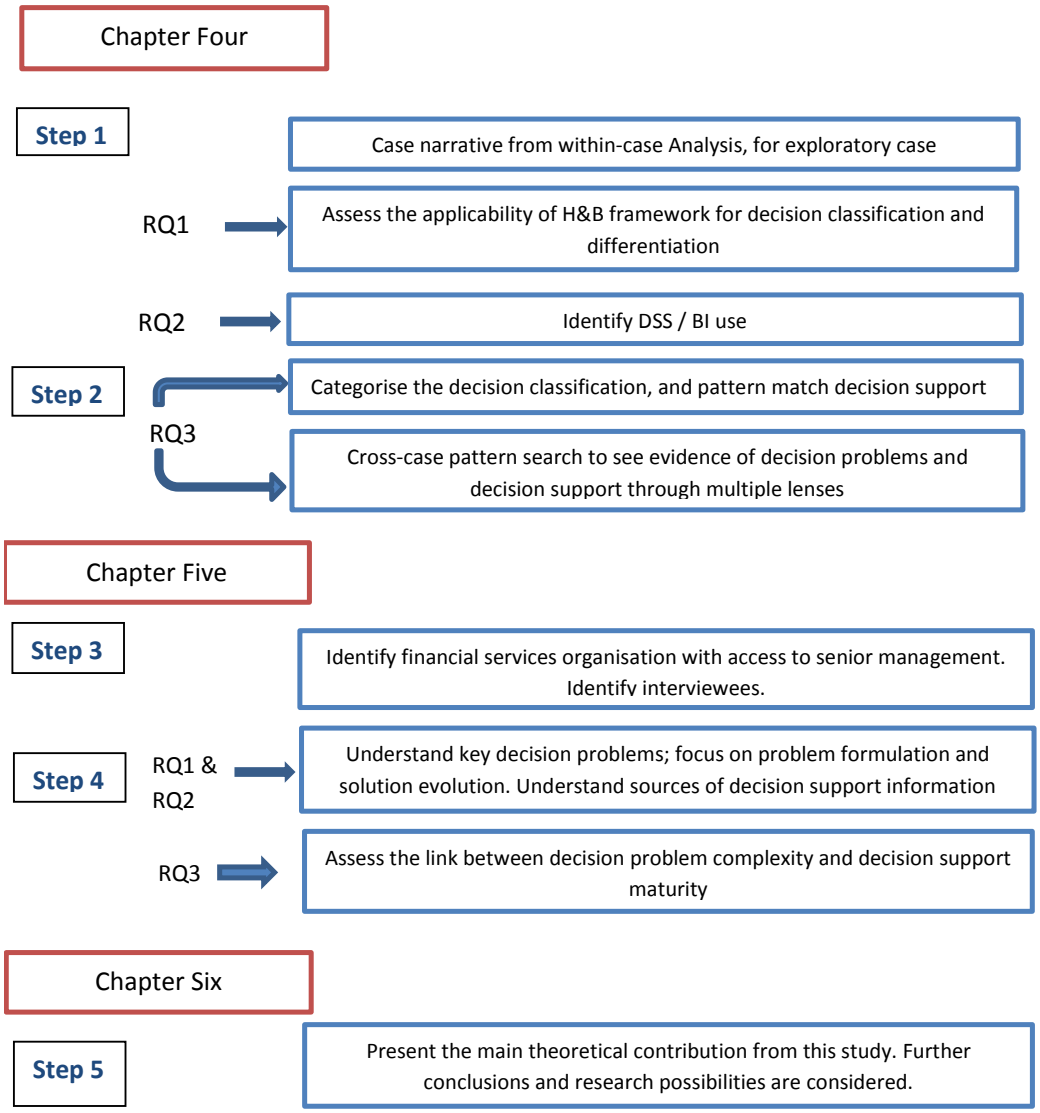

Figure 3.4. Research protocol summary for this study

Step 1 involves the investigation of the feasibility of the Humphreys and Berkeley (1985) framework in representing an understanding of decision problems experienced by decision makers in organisations. The representation reflects the cognitive process associated with the degree of abstraction in relation to the decision problem formulation and its solution. As identified in Chapter Three, the Humphreys and Berkeley (1985) framework has not received an empirical testing in an organisational decision making context. An EMBA class

facilitated the data collection for an exploratory case. The rational for choosing this method of data collection has been discussed in detail in Chapter Three.

Step 2 involves extracting and analysing the data set to facilitate the identification of decision problems at the different representation levels. The decision support systems which facilitated the resolution of the decision problems were analysed and classified according to the Adam and Pomerol (2008) classification. Ten organisations were examined, during two sessions of the University Executive Masters in Business Administration class. Chapter Four presents a within-case analysis for each of the ten organisations. Case narratives are provided for Research Question One, Research Question two and Research Question Three for each organisation. A cross-case analysis is presented for each of the research questions using the displays for each case.

Step 3 involves the selection of a financial services organisation which will facilitate decision making experiences at more senior levels than observed in the exploratory study. The identification of interviewees is also pursued during this step. The selection focuses on choosing key respondents who actively work at senior levels in the organisation.

Step 4 provides the opportunity to construct an in-depth case presentation from the data set derived through Step 3. Chapter Five presents the BigBank case study including tabular displays to support answers to Research Question One, Research Question Two and Research Question Three.

Finally, **Step 5** presents the greater implications for the DSS domain as derived from this research study, as well as future research possibilities.

This chapter has presented the research process pursued to achieve the research questions and objective outlined for this study. The findings and conclusions are presented in Chapters Four, Five and Six.

Chapter 4. The Exploratory Study: Presentation of Cases and Discussion of Findings

This chapter presents the details of the exploratory study. In the following sections, a detailed textual and tabular account of the context of the organisation is presented for each organisation studied. For each firm, the decision problems encountered by managers have been recorded and classified based on Humphreys and Berkeley's (1985) framework. The formal or informal decision support available to managers has been recorded, and identified by inquiry type.

The first research question (RQ1) was concerned with the representation classification of the decision problems identified, determined by the degree of abstraction of the managers representation of the decision problems presented, and the level of understanding of the decision problem solution, based on Humphreys and Berkeley's (1995) work. The question was also concerned with the investigation of what levels of decision problem have not been captured with this method of data capture.

The second research question (RQ2) was concerned with the sources of formal and informal decision support tools available to the decision making, and decision taking managers. By tools the researcher meant systems, routines, procedures and other forms that provide information dissemination. The classification of decision support tools used the topology of reporting, scrutinising and discovering as per Adam and Pomerol (2008).

Aggregating the findings from the first and second questions, provides a clear opportunity to synthesise the data gathered in the first two questions, and to present a composite model of decision support mapped against the cognitive levels of decision problem representation after Humphreys and Berkeley's model for each of the ten organisations. Therefore, Research Question Three (RQ3) provided the opportunity to discuss the scope and quality of decision support availability in the firm at each of the representation levels. This question relied more heavily on interpretation and perception on the part of the researcher. In

addition, while Research Question One and Research Question Two and Research Question Three are presented for each case, Research Question Three is split, whereby analysis is presented at 1) firm level, and 2) at cross-case level. The cross-case analysis permits the consideration of the findings for all ten firms in the study, which provides an overview of the level of maturity across a broad spectrum of Irish firms. Thus, the applicability of the Humphreys and Berkeley (1985) framework can be better understood.

4.1. Introducing the firms in the Exploratory Study

The presentation of the mini-cases selected pursues replication logic in the within-case analysis of the ten firms investigated. A case narrative is presented for each organisation. The case narratives provide the researcher with the opportunity to present the background to the case, and most importantly, characterise each organisation's individual approach to decision making. Each case narrative is followed by synthesised answers to Research Question One in section 4.2. Research Question Two and Research Question Three are answered in section 4.3. This is followed with a cross case analysis for the ten firms, that discusses the notion of decision support maturity across the firms.

Table 4.1 shows the key demographical data for the 10 organisations selected in the exploratory study. It indicates the spread of observations across a range of industries, including manufacturing and services, and a range of sizes from medium to large. The sample covers six indigenous Irish firms and four multinational companies, of which, the Irish subsidiaries were studied. Finally, the ten companies feature different domains of expertise including engineering, health, food and services. Overall, this reflects an attempt to cover many different types of organisational settings and present a broad but representative spectrum of observations. The presentation of the ten cases is in an order determined by the level of decision support richness and quality of each case. Table 4.1 also provides a brief account of the context of the firms and the challenges faced by their managers.

Firm	Activity	Turnover	Ownership	Main Business factors
A	Energy supply	€1.1 bn.	State body	2 main businesses: Gas transportation and Energy supply. Some deregulation of the energy supply market. However operating in a regulated market, with government approval required for all price changes in all customer segments.
B	Private healthcare	€144 m.	Private independent	Primary source of revenue comes from private health insurers. 60,000 patient admissions per year. Changes to funding model for private healthcare in Ireland.
C	Hi-tech manufacture	$6bn. Worldwide	Private US multinational	World leader in information management and data storage products, services and solutions. Recently has enlarged its product portfolio towards cheaper lower end products and also included software and consultancy products which are a departure from its traditional hardware products.
D	Medical Device Manufacture	€144 m.	Private US multinational	Large portfolio of innovative products, technologies and services that advance the practice of less-invasive medicine in a wide range of medical areas. Faces key changes in how healthcare is provided and funded in its core markets in the future.
E	Milk Processing	€200 m.	Irish co-operative	Cheese, food ingredients and flavours manufacturer. Produces 25% of all cheese manufactured in Ireland. Quality of raw materials and securing reliable suppliers are key issues.
F	Bio-science energy generation	€10 m.	Irish private company	Electrical power generation from sustainable fuel sources or "green energy". Start-up company, in a very immature industry segment, with few customers and suppliers.
G	Spirit distiller	€7 bn. worldwide	Irish co-operative	Part of largest wine and spirit company in the world. Extensive use of external market research data including. data on the key drinks companies, their brands, sales volumes etc.
H	Food and Beverage	$ 60 bn. worldwide	Private US multinational	The primary focus of the organisation had become the creation of healthier products and reducing the organisation's negative impact on the environment. Specific goals are handed down from headquarters to local sites for each functional area.
I	Medical device manufacture	$4 bn. worldwide	Private US multinational	7 manufacturing sites worldwide, with Cork plant accounting for 40% of total production. New plant in China will be a source of increased competition for product allocation. Extremely price sensitive market. Key Performance Indicator (KPI) oriented culture, with goals handed down from headquarters to local plant for each functional area and converted into strict targets.
J	Supply Chain management	€120 m.	Private Irish international	Irish supply chain management company with a product portfolio across consumer electronics, personal computers, medical devices and telecommunications. KPIs in use across the organisation. The entrepreneurial founder continues as managing director, operations director and marketing and sales director.

Table 4.1 Demographics of firms in the exploratory study

This shows the general decision environment of managerial decision making in these firms and allows their classification in terms of the dynamism of the environment in which they operated and the pace of change which they face. It is also useful as a backdrop against which, the extent to which Decision Support Systems (DSS) and applications are being used to support managers in these firms in the crucial aspects of their jobs, is evaluated, which is discussed in further detail in section 4.3, when RESEARCH QUESTION TWO and RQ3 are considered.

The detail of the data which has been assembled about the ten firms is presented in Table 4.2. For each firm, decision problems and formal or informal decision support available to managers at each level of the framework have been recorded and classified, based on the degree of abstraction of the managers' representation of the decision problems presented, and the level of understanding of the decision problem solution. Prima facia, Table 4.2 reveals that managers in some firms do not tackle problems at the higher levels of the framework. When no decision problems are identified at a certain level, this level is omitted in the table. Thus, no firm has cells corresponding to level 5; only four firms have cells corresponding to level 4; and two firm has cells relating to levels 1 and 2 only. Table 4.2 also shows that decision problems classified at level one of the framework: those characterised by little ambiguity and low levels of abstraction; are well covered by information systems, which are used extensively for operational control and performance monitoring across all organisations. In other words, the decisions identified at level 1 of the framework are supported by well-developed reporting tools based on ERP-type systems of record, and augmented by industry-standard report generators and Business Intelligence (BI) tools. Level 2 decision problems are also well covered, with "what-if" and "drill-down" type support widely used across most of the cases. The sophistication of such tools varied across the cases, and while MS Excel® is the most favoured tool, and a number of organisations have well established BI type tools implemented.

Conversely, very few decision problems were identified with complex and semi-formed ideas, where outcomes were unclear and ambiguous, even in organisations that are operating in very challenging, highly competitive and uncertain environments. The problems presented as “abstract” were in fact clearly stated. In a number of situations potential solutions were more uncertain, but possible scenarios were entertained. Finally, where no formal decision support was available to managers to support them in the search for solutions at a certain level, cells are coded in *italics*.

The following section provides a more detailed account of the decision making context and the decision problems encountered, in each of the ten organisations, by answering research question one for each firm.

Firm	Level	Cognitive Level Decision Problems	Decision Support Activity
A	4	More competition has been introduced in the residential gas market – must lose market share down to a set level. In the new single wholesale Electricity market, company A is a new entrant - How will it operate in this market? The effect of global warming on energy demand is also a key uncertainty	Regression analysis assesses the relationship between gas demand and degree days, price change and customer segmentation. The dataset represent 60% of the residential and small temperature sensitive Industrial and Commercial customers. The purpose is to discover what the operational environment may be like and the implications for the energy trading business, especially in terms of pricing going forward.
	3	The decisions made based on the projected price of electricity are of material value to the business. In-depth knowledge of the workings of the market is required. An informed view of where the SMP (System marginal price) will be for each half hour of the day is a key strategic asset as well as an operational asset as it helps to determine what contracts should be entered into, and to manage capacity on a day to day basis.	Portfolio modelling applications are used to support the identification/ prioritisation of gas and electricity commercial activities The organisation has invested in 2 market modelling applications to help in its forecasting of the SMP price. SMP price together with the business hedging strategy for the following 12 months determines what contracts are entered into and for what prices and quantities.
	2	The organisation recognises the importance of analytics where optimisation and efficiency are key components to operating in a new energy trading environment	There are a number of systems in use which allow a level of scrutiny. Market-to-market reporting is used to predict the future benefit derived from entering into forward transactions enabling management to optimise purchase contracts, and allowing corrective action should the firm's hedging strategy require amendment.
	1	All aspects of the 'claims management' area must be monitored in near real time	Recent systems developments have replaced Excel spread sheet reporting, and has enabled the capability of data analysis based on data warehouses
B	*4*	*Understand how medical and technology advances and government decisions will change patient care provision and revenue model*	*Some information for contract negotiation with health care purchases in Discovery mode is available, but managers do not have the resources to run scenarios to understand the impact on bottom line and on operations*
	3	Optimising resource utilisation with improved financial performance enabling benchmarking between hospitals is a critical activity	Resource utilisation modelling is available in areas such as outpatient metrics, theatres and bed management across the hospitals. Information derived from level 2 is used to make predictions for

			changes in health sector.
	2	Accurate analysis and tuning of local company performance across complex indicators	Ad-hoc assessment of key business metrics in financial and clinical areas across all hospitals – bed occupancy, theatre utilisation etc. is available
	1	Managers seek to measure all aspects of operational and financial performance to improve services delivered, as well as patient and financial outcomes	Reporting activity is well developed. A Hospital Information System (HIS) enables the management of scheduled admissions, theatre scheduling and staff/consultant workload. A data warehouse has been developed as well
C	3	When increased resolution times are apparent, management can predict the potential impact on service levels based on the volume of service calls, the number of available staff, the introduction of new products and the quality of training.	Each business unit has visibility of specific hardware products' dashboards, with defective attributes flagged.
	2	Improving management ability to investigate the reasons for the outcomes at level 1, where the cause and effect relationship is not as factual or evident is a critical factor. Information from Level 3 in turn, allows the Global Services unit to flag product issues to the engineering organisation, or to roll out further training where appropriate.	Scrutinising the performance of the business units and their ability to meet SLA's can highlight problems – for newly released products for example. This information is derived from level 1 systems, and has been further manipulated manually.
	1	Improving management ability at problem solving, maintaining customer SLA agreements, and tracking compliance of documented processes is essential.	This is presented in Dashboard format with colour coding to indicate if SLA levels are not met.
D	4	What disease are emerging and how to support them. How will US government decisions on healthcare insurance bill influence the product portfolio	n/a
	3	Effects of corporate / market changes on Cork Plant	Manual collation and manipulation of data from external market research

	2	Plant specific strategy aligned to Corporate. Monthly ranking analysis across 23 plants, poor performance trend analysis at plant level, Customer complaint analysis at plant level.	Excel based Ranked League table generated (at corporate level) based on information derived at levels 1 and 2, and analysing performance across the 23 plants – then fed back to Cork. Long term trending difficult to achieve and requires considerable manual manipulation – using Excel.
	1	Analysis of performance based data represented on 9 panel Balanced Scorecard for operational problem solving and quality metrics - resource allocation, project start, project cancellation, issue escalation, customer complaint analysis.	SAP and SAP BW implemented. Very strong on production data capture, but reporting is siloed and manually collated. Quality data captured on Excel showing weekly trends based on customer complaints
E	*4*	*The raw material of cheese is milk, i.e. 90% water but managers do not know how to address the issue of yield and efficiency*	*n/a*
	3	*Dry hot summers mean poor milk yield and low milk quality which increases the cost of cheese but the reasons for these variations are unclear*	*Available systems compute these variations, and report them, but there is no capability for diagnosis through drill-down or what-if, or for corrective actions.*
	2	Controlling fixed costs and managing the milk throughput are critical activities. Understanding the reasons for spoilage, and analysis of the relationship between milk quality and cheese recipe used is problematic.	Critical KPIs at scrutinising level are all produced manually based of various SCADA and forecasting systems. Excel spread sheets are prepared and hand delivered to management weekly, 2 working days after each weekend.
	1	Company D produces cheese more efficiently than any of its competitors. Maintaining that efficiency is a core competency which drives a sustained competitive advantage. Relevant CSFs are based on a system of budget vs. actual variances	Company D excel in dashboard technology to control and monitor all aspects of the production process. KPIs are reported upon in dashboard form and include: Milk cost per tonne of cheese; direct wages cost per tonne of cheese; direct energy cost per tonne of cheese
F	3	How to increase market share and profitability? How to fine tune the setup of the UK operation?	All scrutinising is based on external information – published reports, governments and European "green" strategy policy, waste industry specialists and market analysts, grid connection regulations. Excel is the only tool but staff analytical skills are high.
	2	Contract negotiation – i.e. analysis of what contracts to sign	Excel used by engineering staff to monitor waste tonnage and price charged by waste operators, type of waste gas yields – fed into excel-

			generated financial models for sensitivity analysis..
	1	Day to day operational effectiveness.	SAGE and Excel are the main systems.
G	3	How to increase market share and profitability e.g. launch of product to new market?	Excel the main scrutinising tool using data from the data warehouse plus external market research data and tacit information from marketing specialists.
	2	Weekly review by CEO on all products with emphasis on contribution to bottom line	Business analyst uses Cognos/PowerPlay for weekly report based on Data warehouse updated in Level 1.
	1	Monitoring of production and sales targets and KPIs	SAP used daily to record all transaction. Data warehouse updated once daily. Cognos/PowerPlay BI toll available across enterprise for reporting and drilldown capability.
H	3	Declining demand for carbonated soft drinks Move towards healthier products and lifestyles	n/a
	2	Whether to implement modern manufacturing tools – lean, six sigma. Increase capacity without extra resources.	The only IT system is MS Excel®® at this level, as inquiry and reporting from MAPICS and LMS are transactional and not integrated.
	1	Plant manager responsible for operations and quality. Local area management (not reporting to plant manager) responsible for engineering and supply chain.	Manual input to MAPICS generates production requirement weekly. Interfaces to Oracle (system of record). Quality data based on manually extracting Lab results
I	3	Competition both internally and externally is forcing the Cork site to consider its cost structure	n/a
	2	From the CSF's monitored at level 1, a core set of key performance indicators (KPI's) are produced and reviewed, with the frequency of review being determined both by the criticality of the operation and the availability of information.	Little drilldown capability is available to managers to facilitate scrutinising. Reports are mostly static.
	1	The Cork site has a number of critical success factors (CSF's) that if	Current reporting systems monitor day-to-day operations and the ERP provides some data. However manual systems generate most of the

		managed effectively can ensure the site is a success.	weekly reports prepared by Finance. An "equipment effectiveness" dashboard allows drilldown in each machine's downtime but it is not integrated with any other system
J	1	Matching supply with customer demand through tight inventory management, control over purchasing etc. Effective cash-flow management. Better control of operations through managing a core set of KPIs available to staff, customers and third party vendors	ERP system provides fast and reliable financial reporting and analysis. KPI portal provides data in report and dashboard format on predefined KPIs...

Table 4.2 Decision problem and decision activities for ten firms in exploratory study

4.2. RQ1: Utilising the Humphreys and Berkeley (1985) framework to represent managerial decision problems

Research question one seeks to explain decision problems as identified by organisational decision makers. The Humphreys and Berkeley (1985) framework reflects a cognitive representation of manager's thinking based on the degree of abstraction of the decision problem formulation on the one hand, and on the degree of formalisation of the proposed solution, on the other hand. The use of the Humphreys and Berkeley (1985) framework facilitates the separation of what is essentially a continuous process into separate representations of the decision problem based on the manager's handling of the decision process and on their support needs. The next sections present the data which was collected for the exploratory study, in narrative and tabular format. The managerial decision problems are discussed for each of the ten firms, on which data has been collected and analysed.

4.2.1. FIRM A

FIRM A is a commercial State Body operating in the energy industry. FIRM A was set up in 1976, when the Gas Act (1976) was approved by the Oireachtas (Irish Government), establishing the company as the state Gas Development Company. The company is wholly owned by the Irish Government and consists of 2 main businesses – Gas Networks and Energy Supply. The residential gas market is the primary area of business, and FIRM A controls approximately 50% of the total gas sales market, and almost 100% of the residential market. A new wholesale electricity market has come into operation in Ireland since November 2007. FIRM A entered the retail electricity market in 2006, and in 2008 held 15% of the electricity market in Ireland. In 2008, FIRM A is set for a period of major growth and development as it establishes itself as a leading energy supplier on the island of Ireland, with plans to double its value and grow its customer base to one million by 2014. Externalities which will influence the demand for energy in

the future include the effects of global warming / climate change and improved housing insulation standards.

- Decision Problems representation

FIRM A is an interesting site from a Decision Problem viewpoint, as outlined in Table 4.2. Working within a regulated framework, but extending its business model to the supply of electricity as well as gas, due to a more liberalised market, the suitability of the current organisational structure is under review as European Community Directives require a clear separation between Energy Supply and Networks. FIRM A Energy Supply is the customer-facing organisation, while FIRM A Networks procures, transmits and distributes gas.

Cognitive Level	Decisions Problems
5	How will global warming affect energy demand in Ireland
4	Competitive influences: How to retain residential gas market share – currently holding 100% of market. How to compete in deregulated electricity market and grow market share. Consideration as to whether the current organisational structure and competencies are sufficient to deal with new opportunities and challenges.
3	The decisions made based on the projected base Price (the price of electricity) are of such material value to the business that in-depth knowledge of the workings of the market is required. An informed view of where the SMP (System marginal price) will be for each half hour is a key strategic asset as well as an operational asset as it will help to determine what contracts should be entered into, as well as help to manage capacity on a day to day basis.
2	Optimisation and efficiency are key components to operating in a new energy trading environment
1	The more traditional areas of business - Planning and prioritisation of the day's activities.

Table 4.3: Decision Problems at cognitive representation level for FIRM A (Humphreys and Berkeley,1985)

Complex and uncertain decision problems can be represented; (Table 4.3) which have been clarified over time, and can now be stated as a result of continued and evolving cognitive thinking on the part of managers, as well as improved knowledge acquired over time, for example, the effect of global warming on energy consumption. For most of the aspects of decision making at level 5, FIRM A is not able to explicitly define the models that may provide answers.

4.2.2. FIRM B

FIRM B is a private healthcare provider, with operations in five locations in Ireland. While individual patient admissions can be in the region of 60,000 per year, the primary source of revenue earned by the group is the private health insurers. Current government initiatives present a challenge for the organisation – the move towards co-located hospitals (mixing private and public facilities under the same roof) and the negotiation of new contracts for hospital consultants may mean substantial changes as to how healthcare is provided and funded in Ireland in the future.

The mission of the organisation is stated as: "*Our hospitals have as their mission care for the sick, the dying and their families within a Catholic Ethos ….. seeking to provide high quality holistic care characterised by compassion, respect, justice and hope*"[8].

- Decision Problems representation

As profit margins are tight, providing for the on-going investment required in the hospitals, is difficult. Moreover return on investment is lower in FIRM B than in similar private health care providers in Ireland. Tight profit margins are a key concern in both the chairperson's and Group Chief Executive Statement, in the Annual reports of 2005, 2006, 2007 and 2008. Increased profitability, while at the same time, maintaining the mission of the organisation is a core decision problem.

There is considerable uncertainty in health care provision due to Government initiatives concerning medical consultant remuneration and work practices, for example, the abolition of a "Category II post" which would prevent consultants practicing in both Public and Private Hospitals. This could have a serious impact of FIRM B's ability to recruit and retain high calibre consultant medical staff. A number of scenarios are being considered as possible outcomes.

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[8] From FIRM B 2007 Annual report

These decision problems would be representative of Level 4 on the Humphreys and Berkeley (1985) framework, as the problem can be clearly represented, but not the solution.

In contrast, it is clear that the health insurance providers make a considerable profit. The dominant player in the medical insurance market reported profits of seventy million Euros (€70 million) with premium income more than one billion Euro (€1 Billion) in 2007. This represents a profit margin of seven per cent (7%) as against a profit margin of 2.7% reported by FIRM B. Negotiating the best possible contract with the health insurers, so that the re-imbursement rates reflect the true operating and capital costs of the group's facilities, is of the utmost importance as this is the primary revenue stream for FIRM B. This decision problem would be represented at Level 3 on the Humphreys and Berkeley (1985) framework, as both the problem and the solution can be clearly represented.

Decision problems were clearly stated when there is little ambiguity, where there is a minimum level of abstraction, and where the issues relate to the day-to-day operational control and performance monitoring across all locations across the organisation, i.e. decisions identified at level 1 of the Humphreys and Berkeley(1985) framework. Likewise, Level 2 decision problems were also clearly stated and are a progression of evolution of thought identified at level 3 of the framework for FIRM B, and are a result of further analysis of requirements and better information availability. "*Full visibility and analysis of drugs dispensed to patients allows better clinical understanding and better cost control*"[9].

There was a complete lack of decision problems identified at Level 5 - complex and semi-formed ideas, where outcomes are unclear and ambiguous. FIRM B is operating in a very challenging, highly competitive and uncertain environment, and it is reasonable to assume that decision problems of this

[9] Extracted directly from Group assignment report on Company FIRM B

nature exist. Table 4.4 reflects some of the decision problems identified when analysing FIRM B.

Cognitive Level	Decision Problems
5	No Problem identified
4	How to improve profit margin. Understand how medical and technology advances and government regulatory decisions will change patient care provision and the revenue model.
3	Optimise resource utilisation with improved financial performance. Positive contract negotiation with the health care insurers, and other health care purchasers.
2	Continuous Benchmarking of hospitals, by the assessment of key business metrics in financial and clinical areas across all hospitals, especially resource utilisation. How to improve services delivered and improve financial performance.
1	Enable day to day management activity such as scheduled admissions, theatre scheduling, staff and consultant workload scheduling, unbilled accounts minimization.

Table 4.4: Decision Problems at cognitive representation level for FIRM B after Humphreys and Berkeley (1985)

The evolution of cognitive thought as presented by Humphreys and Berkeley (1985) is evident, and coincides with the natural progression across the levels of the framework going from level 4 to level 1, and indicates the richness of FIRM B from the point of view of the potential for a complete portfolio of decision problem identification at all 5 levels of the framework.

4.2.3. FIRM C

Company FIRM C is a world leader in products, services and solutions for information management and data storage. In recent years FIRM C has expanded from developing hardware platforms that provide data storage to developing software and providing services to help companies of all sizes to keep their most essential digital information protected, secure and continuously available. Global Services is FIRM C's customer support organisation, with almost 10,000 technical/field experts located in 35 locations globally delivering "follow-the-sun"

support in over 75 countries. Access in the case allowed us to study a global unit, rather than a local manufacturing unit.

- Decision Problems representation

Global Services is an integral part of the FIRM C product delivery process, providing support on the full hardware, software and services products range. Exacting Service level agreements (SLAs) must be adhered to, and monitoring support service is a basic element of Global Services management. FIRM C Global Services holds Support Capability and Performance (SCP) certification. Dashboard reporting is part of the audited requirement of certification, which in turn is marketed as a quality differentiator. Each business unit has visibility of specific hardware products dashboards, with defective attributes flagged, representative of decision problem resolution at level 1. This in turn allows Global Services to flag product issues to the engineering organisation, and to ensure further training where appropriate, which at level 2, indicates further analysis and more scrutinising type inquiry that facilitates management ability at solving problems on a more long term basis, as well as. at an overall perspective for Global Services. Call handling process compliance is tracked in a similar way.

"*A spike in the "calls closed in 24 hours" metric may indicate that support staff members are leaving open cases in their queues at the end of their shift*".[10]

The highest level of decision problem classification identified, falls under Level 3, where both the decision statement and a solution can be clearly stated. Time is a significant factor for call resolution. When increased resolution times are apparent, management can predict the potential impact on service levels based on: the volume of service calls; the number of staff; the introduction of new products; and the quality of training delivered. Table 4.5 reflects some of the decision problems identified when analysing FIRM C.

[10] Extracted directly from Group assignment report on Company FIRM C

Cognitive Level	Decision Problems
5	No Problem identified
4	No Problem identified
3	When increased resolution times are apparent, management can predict the potential impact on service levels based on the volume of service calls, the number of staff, and the introduction of new products and the quality of training delivered.
2	Improving management ability to investigate the reasons for the outcomes at level 1, often where the cause and effect relationship is not correlated
1	Improving management ability at problem solving, maintaining customer SLA agreements and tracking compliance of documented processes

Table 4.5: Decision Problems at cognitive representation level for FIRM C after Humphreys and Berkeley (1985)

The natural progression of business problem resolution transfers to each business unit, which has visibility of specific hardware products dashboards, with defective attributes flagged. This in turn allows Global Services to flag product issues to the engineering organisation, and to ensure further training where appropriate, i.e. providing the solution to the decision problem identified.

4.2.4. FIRM D

FIRM D is a worldwide developer and manufacturer of medical devices, and is part of an US multinational corporation. FIRM D has advanced the practice of less-invasive medicine by providing a broad and deep portfolio of innovative products, technologies and services across a wide range of medical specialities, in the belief that less invasive medicine can help clinicians improve patient care by reducing risk, trauma, cost, procedure time and the need for aftercare.

Current (2010) US Government initiatives in regard to the US healthcare bill present a challenge for the organisation, and the move towards universal health insurance may mean substantial changes as to how healthcare is provided and funded in the US in the future, which in turn will influence funding in Europe. FIRM F operates in a highly competitive environment, where product quality must meet U.S. Food and Drug Administration (FDA), European and other regulatory body requirements. The Cork plant was set up in 1998 as a

manufacturing site for all Neurovascular products worldwide. Within this context, RQ1 will consider the decision problems identified at the Cork plant.

- Decision problems representation

FIRM D's mission is to improve the quality of patient care through the development and advocacy of less-invasive medical devices and procedures. This is accomplished through the continuing refinement of existing products and procedures and the investigation and development of new technologies. The Cork site's senior management team manage and control the plant, within the overall strategy framework called the "Strategic Quality Process" (SQP). Each site is measured on a nine panel Balanced scorecard metric based on operational and quality metrics which are integrated with the corporate goals and objectives. A league table generated by corporate, ranks the twenty three plants in terms of performance and alignment with corporate goals. This could be classified as level 3 decision problem classification, as senior management can clearly state the problem/requirements, and know what options are available to them in order to execute the requirements. This researcher found little evidence of level 4 or 5 decision problems being considered with a view towards their resolution.

All other decision making is at levels one and two and is of the nature of resource allocation, resource hiring, project cancellation and new project starts, and escalation of issues to external (outside of Cork) resources depending on severity. Table 4.6 provides a tabular representation of decision problems in FIRM F classified after Humphreys and Berkeley (1985) framework.

Cognitive Level	Decision Problems
5	No Problem identified
4	What disease areas emerging and how to support them. How will US government decisions on healthcare insurance bill influence the product portfolio. How to maintain product pipeline and quality.
3	Plant specific strategy aligned to Corporate. Monthly ranking analysis across 23 plants, poor performance trend analysis at plant level, Customer complaint analysis at plant level.
2	Decisions based on Level 1 data – resource allocation, project start, project cancellation, issue escalation. Customer complaint analysis and follow through.
1	Providing quantitative fact based data for operational problem solving and quality metrics based on 9 panel Balanced Scorecard

Table 4.6: Decision Problems at cognitive representation level for FIRM D after Humphreys and Berkeley (1985)

A performance measurement culture prevails, and managers are continually monitoring trends, with immediate corrective decisions being made in reaction to negative trends or poor performance. The balanced scorecard metrics are displayed in dashboard format, and are based on a traffic light system (green, yellow, red) and are a combination of graphical and spread sheet format. Research Question Two will now consider the systems in place in FIRM D, which generate the information for the metrics.

4.2.5. FIRM E

FIRM E is a major international cheese manufacturer, headquartered in Cork, producing 25% of the total cheese manufactured in Ireland, and has been the largest manufacturer of cheese in Ireland for the last 20 years. They also manufacture food ingredient and flavours. The dairy industry can be very volatile, with milk[11] prices varying by up to fifty per cent in any one year. Over the last ten years, FIRM E has pursued a strategy of diversification with an

[11] The main raw material

international focus, thereby reducing their dependence on the volatile indigenous dairy industry.

- Decision Problems representation

FIRM E is recognised as highly efficient producers of cheese. With profit levels at less than 4%, maintaining that efficiency must remain a core competency. The dependency on the plant's operational efficiency is deemed as critical, and the company excels in the use of dashboard technology to control all aspects of the production process. The production of cheese is a capital intensive activity, with fixed costs contributing a significant percentage of the overall manufacturing costs. Relevant Critical Success Factors (CSFs) are based on a system of variances between budgets and actual. Key Performance Indicators (KPIs), reported in dashboard format, allow operational management to monitor all aspects of the production process e.g. Milk cost per tonne of cheese, Direct wages cost per tonne of cheese, Direct energy cost per tonne of cheese etc.

A core competency which drives a sustained competitive advantage for FIRM E is its ability to produce cheese more efficiently than any of its competitors…… *"the use of information and monitoring of statistics on the production process is a key requirement to improve efficiency"*[12]. *Considering the five cognitive levels for decision problem representation,* FIRM E Decision Problem activity can be classified as outlined in Table 4.7.

[12] Extracted directly from Group assignment report on Company FIRM E

Cognitive Level	Decision Problems
5	
4	How to address the issues of yield and efficiency when the raw material of cheese is milk, i.e. 90% water.
3	The production of cheese is difficult to perfect and reject production can be high. To understand the reasons for spoilage, analysis of the relationship between milk quality, cheese recipe used, production run and cheese storage is undertaken.
2	The production of cheese is a capital intensive activity, with fixed costs a significant percentage of the overall production cost. Controlling fixed costs and managing the milk throughput are critical.
1	Maintaining efficiency is a core competency which drives a sustained competitive advantage. Relevant CSFs are based on a system of variances between budget and actual, which are rigorously persued

Table 4.7: Decision Problems at cognitive representation level for FIRM E after Humphreys and Berkeley (1985)

While the more abstract decision problems at level 4 of the framework are recognised, management cannot define a solution. An extract from the researcher's documentation includes the following example:

"*Dry hot summers mean poor milk yield and low milk quality which increases the cost of cheese. Management don't understand the reasons for these variations although available systems compute these variations*."[13]

The inconsistent nature of the primary raw material indicates that the formula for cheese production will require management attention, for every batch produced, which suggests a resource intensive process. Moreover, the production of cheese is a difficult science to perfect, with the result that downgrade volumes are high, and the financial cost of same is a major burden on the business. It may be possible to establish a number of best practice rules from the trends recorded to minimise the level of downgrade cheese, considering issues such as optimum cheese recipe, optimum production procedure, optimum temperature for milk of different quality levels. However, senior management seem to have more trust in their managers' knowledge than in any potential IT technology scenario.

[13] Extracted directly from Group assignment report on Company FIRM E

4.2.6. FIRM F

FIRM F is an Irish-based bio-science company which focuses on electrical power generation in Ireland and the United Kingdom, based on sustainable fuel sources such as "green energy" technologies, for example: gasification, and dry fermentation. The company established in 2005, was floated on the London Alternative Investment Market (AIM) in 2008, and has recently set up operation in the UK where the company hopes to expand its customer base and achieve higher electricity prices. FIRM F is a start-up company, in a very immature industry segment, with only a few customers and a few suppliers. Within this context, the decision problems identified and represented on the Humphreys and Berkeley (1985) framework.

- Decision Problems representation

FIRM F is an engineering firm and has a highly skilled analytics ethos in place, similar to FIRM A in the study. Expansion to new markets, preferably where higher electricity prices are available, is a key decision in the pursuit of increased shareholder value. In a start-up environment, senior managers are continually scanning for opportunities, and FIRM F is the only organisation within the study where the organisation agenda has not been completely set. Table 4.8 provides a tabular representation of decision problems in FIRM F.

Cognitive Level	Decision Problems
5	No Problem identified
4	What opportunities are available? Trends because of regulation etc
3	How to increase market share and profitability. Should the company set up operations in UK?
2	Analysis of what contracts to sign
1	Day to day operational effectiveness.

Table 4.8: Decision Problems at cognitive representation level for FIRM F after Humphreys and Berkeley (1985)

One of the most interesting findings during the study was how decision making in FIRM F revisits higher decision problem levels as the decision making progressed, i.e. decisions made at level 3 progressed for sensitivity analysis at

level 2, but went back to level 3 or even 4 for further refinement. The recursive nature of decision problem formulation and problem solution evolution is in marked contrast to all the other companies in the exploratory study, all of whom followed a top-down type progression.

4.2.7. FIRM G

FIRM G is part of a French wine and spirit company since 1988, which is one of the largest wine and spirit companies worldwide. However the Irish company was formed in 1966 when three distilleries amalgamated, and all whiskey production transferred to one site. The Group distils and distributes internationally a range of Irish whiskey, gin and vodka brands. FIRM G intends to continue its international development, strengthened by an enriched portfolio of brands, an increased global presence and an efficient decentralised organisation. Decentralised decision making constitutes a key principle of the FIRM G parent organisation. The Group's Holding company defines the Group's strategy and its main policies, but local management adapt this strategy to their local markets. Within this context, the decision problems identified at the Cork plant are now considered.

- Decision problems representation

The CEO of FIRM G constantly reviews the sales figures of all products in the FIRM G portfolio, with particular emphasis on each product's contribution and growth profiles. Trend analysis is considered, and for the purpose of this research, trend analysis was the starting point for the decision to expand the market for one specific product. Table 4.9 provides a tabular representation of decision problems in FIRM G, classified after Humphreys and Berkeley (1985) framework.

Cognitive Level	Decision Problems
5	No Problem identified
4	No Problem identified
3	How to increase market share and profitability e.g. launch of product to new market - UK
2	Weekly review by CEO on all products with emphasis on contribution to bottom line
1	Meeting production and sales targets and KPIs

Table 4.9: Decision Problems at cognitive representation level for FIRM G after Humphreys and Berkeley (1985)

FIRM G is quite similar to FIRM D, already discussed in this study, whereby a culture of decentralisation allows the Cork site CEO some level of autonomy and level 3 decision problems are identified and resolved. Level 1 and level 2 decision problems focus on efficiency and product competitiveness issues.

4.2.8. FIRM H

FIRM H is the fourth largest food and beverage organisation in the world, and is a world leader in convenient foods and beverages, with revenues of over $27 billion. In recent times, FIRM H has changed its strategy in response to a changing market, and since 2006 the primary focus of the organisation has been on the creation of healthier products and the reduction of the organisation's negative impact on the environment. The focus on healthier foods and lifestyles is part of a "performance with purpose" philosophy.

Although a large US multinational firm, FIRM H reflects a narrow range of decision problems. The analysis is of a local manufacturing site of a highly integrated multinational which manufactures and supplies soft drink concentrate to worldwide markets. Firm H (Ireland) employs over 500 people at its three locations in Cork. The business activities located in Cork include: the manufacture of concentrate (exported to 105 countries worldwide); laboratories; financial shared services (supporting 65 countries); IT providing support to global

operations; and Research and Development (R&D). Within this context, the decision problems identified at the Cork plant are now considered.

- Decision problems representation

FIRM H operates within a very hierarchical structure, and with autonomy only in day-to-day activities. The plant manager is responsible for manufacturing operations on site but this excludes the management of the supply chain and Engineering, which are managed by local area managers. The role of the plant manager is to lead manufacturing operations and to ensure product quality. Plant maintenance and plant compliance with reference to EHS (environmental, health and safety) targets, are also part of the plant manager's responsibility. The main site objective is to manufacture concentrate product of high quality, made safely with minimum net impact on the environment, and shipped on time to the customer. However a long term goal set by FIRM H corporate is to develop the Cork plant as a centre of excellence within the organisations World Wide Flavours group (IWF).

A structured problem identification and analysis approach to decision making had been adopted in FIRM H, known as DMAIC, (Define problem clearly, Measure impact of alternatives, Analyse root cause, Improve and Control). This approach serves level 2 and level 3 decision problems well, and examples would include corrective action where necessary to ensure the quality of the product, or managing within budgetary constraints. Decisions considering the implementation of modern manufacturing tools, including lean and six sigma, are also on the manager's horizon. At the time of the research, there is a need to increase production capacity, but without increasing headcount. All decisions regarding capital spend or operational spend must adhere to corporate sustainability policy, or as close as possible to a zero net environmental effect, and within budgetary constraints. Table 4.10 provides a tabular representation of decision problems in FIRM H, classified after Humphreys and Berkeley (1985) framework.

Cognitive Level	Decision Problems
5	No Problem identified
4	No Problem identified
3	Healthier products and lifestyles, declining demand for carbonated soft drinks
2	Implement modern manufacturing tools – lean, six sigma. Increase capacity without extra resources.
1	Plant manager responsible for operations and quality. Local area management (not reporting to plant manager) responsible for engineering and supply chain.

Table 4.10: Decision Problems at cognitive representation level for FIRM H after Humphreys and Berkeley (1985)

Day to day operations are managed so as to ensure a quality product produced in an efficient a manner as possible. Standard operating procedures (SOPs) are in place for all aspects of production, and are adhered to.

4.2.9. FIRM I

FIRM I is a worldwide developer and manufacturer of medical devices and is a subsidiary of a US multinational. This company has seven manufacturing sites around the world, with a new facility currently being built in China. The Cork site is the largest manufacturing facility, accounting for approximately forty per cent of total production. In the medical devices market, gaining additional market share is largely dependent on price competiveness and there is, at this point, significant competition in the market where FIRM I is operating. The new facility in China will significantly change the balance of the organisations production, implying an increased competition between FIRM I and its sister sites. Within this context, the decision problems identified at the Cork plant are now considered.

- Decision Problems representation

With the introduction of manufacturing in China, it is unclear how manufacturing will be allocated across sites in the future. With increased competitiveness both externally and internally within the organisation, management in the Cork plant are focused on achieving improvements in

productivity, space utilisation, operational efficiency and an overall realignment of their cost structure. From the Critical Success Factors (CSFs) monitored at operational level, a core set of key performance indicators (KPI's) are produced and reviewed, with the frequency of review being determined both by the criticality of the operation, but also based on the availability of information. Typically the KPI information is reviewed weekly, based on reports generated by Finance department personnel. Considering the five cognitive levels for decision problem representation, FIRM I Decision Problem activity can be classified as outlined in Table 4.11.

Cognitive Level	Decision Problems
5	No decision problems identified
4	No decision problems identified
3	Need for supply chain and inventory optimisation – 388 days inventory held
2	Competition is forcing the Cork plant to push for huge gains in productivity, space usage and operational efficiency, forcing the Cork site to consider its cost structure
1	The Cork site has a number of critical success factors (CSF's) that if managed effectively can ensure the site is a success.

Table 4.11: Decision Problems at cognitive representation level for FIRM I after Humphreys and Berkeley (1985)

While FIRM I operations remain in reactive mode, the systems capability to allow management to operate in a more proactive mode, is only partially in place. A performance accountability culture could be achieved with improved reporting and dashboard capability. At level 3, management are aware of issues, which, if resolved could have a positive effect on efficiency. The cost of inventory is extremely high, largely due to the business model, as well as the supply chain model in place, but also because of the competitive nature of the market. The supply chain model means that FIRM I holds on average 388 days inventory. This is further complicated because fifty per cent of the inventory is held on hospital sites. Moreover, it remains unpaid for, until it has been used (surgically inserted). However, management are not able to present a solution, not because they cannot devise and formulate a solution, but because of the lack of integrated

information. Integrated information could inform decisions on suitable inventory holding values per hospital, as well as within their own warehouse.

4.2.10. FIRM J

FIRM J is a supply chain management company with a product portfolio across consumer electronics, personal computers, medical devices and telecommunications. FIRM J offers a wide range of services from product design through to fulfilment direct to the hub or to the end client. The company was founded in 1996 in Ireland, and maintains its company headquarters there, while its operations headquarters is in Shenzhen, China. The entrepreneurial founder continues as managing director, operations director and decision maker. FIRM J has amongst its customers some of the biggest telecom and Networking companies, PC companies, and electronic device companies. Within this context, RQ1 will consider the decision problems identified at the Cork plant.

- Decision problems representation

From a starting position in 1996, the emphasis for FIRM J has been growth. Some twelve years later, management have great difficulty getting consolidated group information necessary for due diligence, which was required as part of a venture capital partnership. In the last five years, management has sought to standardise business processes in line with industry best practice. The company remains extremely customer focused, and recognised at a very early stage, that providing their customers with accurate information as to the status of their orders could provide a competitive advantage. Table 4.12 provides a tabular representation of decision problems in FIRM J, classified after Humphreys and Berkeley (1985) framework.

Cognitive Level	Decision Problems
5	No Problem identified
4	No Problem identified
3	No Problem identified
2	Effective cash-flow management. Better control of operations through managing a core set of KPIs available to staff, customers and third party vendors
1	Matching supply with customer demand through tight Inventory management, control over purchasing etc.

Table 4.12: Decision Problems at cognitive representation level for FIRM J after Humphreys and Berkeley (1985)

At an operational level, management have recently introduced a core set of KPIs across all functions in the organisation to ensure better control of operations, and more effective cash-flow management. Matching supply with customer demand is an integral part of the business, and requires tight inventory management and control over purchasing. Other than operational decision problems which can be categorised at levels 1 and 2 of the Humphreys and Berkeley (1985) framework, there was no evidence of any other decision problems being discussed within the organisation. The founder and Managing director makes all decisions and seems to do so, without consultation with any of his staff.

4.2.11. Conclusions to Research Question One

The objective of this exploratory study was to gain an understanding of the application of the Humphreys and Berkeley (1985) framework, as a mechanism to represent decision problem formulation and the associated decision problem solution, concurrently. For the purposes of the exploratory study, Research Question One identified the challenges being faced by managers, and analysed them according to the representation levels of the Humphreys and Berkeley (1985) framework. The overall purpose of analysing the ten cases is to better understand the differentiating of decision problems as per Humphreys and Berkeley (1985) classification. The managers in each of the ten firms were successful in applying the Humphreys and Berkeley (1985) framework as a mechanism to represent a cognitive perspective and representation of the

decision problems encountered on a daily basis. Decision problems up to and including level 4 were recognised, even when any thought process towards a formulation of a potential solution was outside the capability of the participants. Decision problems in the lower three levels of the framework were readily identified by most of the organisations. A synthesis of the overall findings of the exploratory study is presented in Section 4.4 when the decision problems and the associated solutions have been discussed.

Importantly, the representation of the decision problems at each of the levels of the framework enabled the data collected with respect to decision support to be analysed and to provide the answers to Research Question Two, and Research Question Three. For the purpose of the exploratory study, the data analysis with regard to the decision support tools is discussed in tandem, because these two research questions analyse decision support.

4.3. RQ2 and RQ3: Understanding the nature and scope of decision support availability

Research Question Two seeks to explain the availability of the formal and informal decision support tools that are available to decision makers. In this research question, the classification of decision support tools uses the topology of reporting, scrutinising and discovering (Adam and Pomerol, 2008). The data collection process for the exploratory study is discussed in detail in Chapter Three, and focused primarily, on decision support in relation to the available support at the representation levels.

Research Question Three attempts to analyse decision problem classification and the associated decision support, in order to understand the applicability of the Humphreys and Berkeley (1985) framework as a mechanism to represent decision problem formulation and the associated decision problem solution, concurrently. Thus, the relationship between the supply of decision support and the demand of the decision problem formulation is being examined. Therefore, for the exploratory study the case narrative and analysis will be

presented for Research Question Two and Research Question Three for each of the ten firms.

4.3.1. FIRM A

The first observation that can be made is that the engineering vocation of the firm has helped the creation of an “all-knowing” dashboard for reporting in real time on all security elements of the network. Flow, pressure, consumption etc. are monitored in real time and reported accordingly. The reporting on maintenance activities and the occurrences of accidents is also very advanced. On the commercial side, FIRM A is extremely mature in its development of highly complex models for planning for consumption and justifying the price per cubic meter charged to the different categories of customers (which the Department of Finance must approve once a year and whenever price changes are requested). This has been largely based on spread sheets of a highly complex nature, developed by specialists in econometrics and business modelling. For example, managers in the transportation department, run simulations based on generic scenarios, which are then used for price setting or for justifying capital expenditure when network extensions are proposed. Furthermore, regression analysis assesses the relationship between gas demand and degree days, which is used for price changes and customer segmentation. The dataset available represents 60% of the residential and small temperature sensitive Industrial and Commercial customers. The outputs are considered as a base case for 2012. The purpose is to discover what the operational environment may be like and the implications for the energy trading business, especially in terms of pricing. The decision support availability is summarised in Table 4.13

4.3.1.1. RQ2: Decision support availability

Inquiry type	Decision Support Sources
Discovery	The organisation has invested in 2 market modelling applications to help in its forecasting of the SMP price. Portfolio modelling applications are used to support the identification/prioritisation of gas and electricity commercial activities
Scrutinising	There are a number of systems in use which allow a level of scrutiny. Market-to-market reporting is used to predict the future benefit derived from entering into forward transactions
Reporting	Daily trading and operations reporting. Recent systems developments have replaced Excel spreadsheet reporting. Decision support tools are in the realm of 'claims management' system, and extracts from sophisticated 24-hour SCADA systems

Table 4.13: Decision Support in FIRM A.

Altogether, this portfolio of applications, as summarised in Table 4.13, adds up to a complex set of decision support covering the reporting and scrutinising side very comprehensively, and making a definitive contribution at the discovery level, even if not in an organised and formal way.

4.3.1.2. RQ 3: Scope and Quality of Decision Support for Decision Problems

Considering the five cognitive levels and the three core types of support, FIRM A provides the most comprehensive example of an organisation where decision problems are identified at almost all levels, and where a portfolio of applications have been developed that provide information at each level. Moreover, applications have been developed that provide very sophisticated reporting and scrutinising capability, and applications are being developed with discovery level inquiry capability in mind. This is unique to this company in the exploratory study, and will be discussed in the conclusions of the study (Section 4.4). Table 4.14 presents the scope and quality of decision support in FIRM A, interpreted at cognitive representation level after Humphreys and Berkeley (1985) classification.

Cognitive level	Decision Support Scope and Quality
5	No formal systems in evidence
4	Discovery type modelling developed and being enhanced
3	Scrutinising well developed and sophisticated
2	Reporting and scrutinising well developed
1	Reporting well developed and sophisticated

Table 4.14: Decision Support Scope and Quality in FIRM A

However even in FIRM A, it must be acknowledged that for some of the aspects of decision making at level 5, FIRM A is still not able to define the models that may provide answers, reflected by the absence of shading at this level and the lighter shading at level 4.

4.3.2. FIRM B

Traditionally, IT has been deployed in a standalone fashion, with each hospital implementing different IT systems. This has created difficulties with preparing routine management and financial reports at an operational level as well as for strategic planning. An unacceptable latency was specifically noted: *"time between request and delivery of reports currently (being) one to three months"*[14].

Since 2006, systems consolidation and standardisation has been a priority, with enterprise applications being centralised to headquarters. A Hospital Information System (HIS) provides a broad range of functionality based around patient administration, and financial administration. More recently a Business Intelligence Data Warehouse (BIDW) has been implemented during 2007 and 2008, based on inputs from the main HIS modules. The BIDW consists of 11 data marts, spanning operational, clinical and administration aspects of the company, operating at a multi hospital level.

[14] Extracted directly from Group assignment report on Company FIRM B

4.3.2.1. RQ 2: Decision Support Availability

Table 4.15 summarises the Decision Support Systems in use at FIRM B.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	Utilising information derived from the Reporting activities, analysis tools show performance across the 5 hospitals. However there is no system to assist with considering trends and predictions for changes in health sector.
Reporting	Reporting activity is well developed, based on the BIDW data marts. A Hospital Information System (HIS) provides timely and accurate information regarding scheduled admissions, theatre scheduling and staff/consultant workload.

Table 4.15: Decision Support in FIRM B

While the BIDW project was clearly focused on providing robust and comprehensive visibility on operations, it has become the platform for the full spectrum of managerial decision support from reporting to scrutinising to discovering. BIDW data and ad-hoc external data sources are used in Discovery mode to deliberate on potential trends.

4.3.2.2. RQ3: Scope and Quality of Decision Support for Decision Problems

Considering the five cognitive levels and the three core types of support, the BIDW has provided decision support activity classified as outlined in Table 4.16 below.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	Manual Scrutinising based on BIDW
2	Reporting and scrutinising based on BIDW
1	Reporting based on BIDW

Table 4.16: Decision Support Scope and Quality for FIRM B

Levels 5 and 4 have absolutely no sources of information for supporting decisions at these levels. The lack of shading reflects the delivery of support at these two difficult levels was still largely an aspiration at the time of the study. Whilst level 2 is well covered by the implementation of the hospital benchmarking concept, level 3 still presents specific design difficulties as managers seek to understand how the data warehouse can provide the inquiry base which will allow them to manage the challenges of the future. The lack of a model to capture the essence of decisions in this domain remains a problem. Furthermore there is no evidence that specific systems for discovery use for problems identified at levels 4 and 5 have even been considered.

4.3.3. FIRM C

An Oracle Customer Relationship Management (CRM) and workflow system provides key operational data, including product installed base data, time tracking and parts usage recording. Proprietary BI tools, Business objects and Crystal reporting software are used for querying and reporting as required by management. Dashboard displays are used to show SLA compliance or non-compliance on a daily basis adhering to the compliance standards and audited certification requirements. Dashboard displays are also used to track progress on internal Global Services projects for process change projects implementations.

4.3.3.1. Decision support availability

Table 4.17 represents Decision Support Sources in FIRM C.

Inquiry type	Decision Support Sources
Discovery	There are no formal tools available. MS Excel used by individuals.
Scrutinising	Crystal reporting inquiry facilitates scrutinising in an automated and in a manual inquiry capability.
Reporting	This is presented in Dashboard format with colour coding to indicate if SLA levels are not met based on Corporate ERP and CRM systems data.

Table 4.17: Decision Support in FIRM C

While the development and use of Dashboard displays has been driven by the requirement to comply with audited certification, FIRM C has a good database of key operational data. However, there are still a number of activities that are recorded on MS Excel®® for scheduled review activities, despite the fact that the relevant base data is recorded on enterprise systems, and formal Business Intelligence tools have been implemented in the Global Services unit, as well as, in the Sales and Finance departments.

4.3.3.2. RQ3: Scope and Quality of Decision Support for Decision Problems

FIRM C presents a profile of a large US multinational, where access in the case allowed the researcher to study a global unit, rather than a local manufacturing unit. Considering the five cognitive levels and the three core types of support, FIRM C presents a comprehensive and interlinked set of decision problems at levels 1, 2 and 3, where production problems and training needs can be anticipated before anyone has considered training to be a problem. This illustrates the natural progression of all decision problems over the levels of the framework over time, from the stage where managers cannot even express them properly, to the stage where they become part of the normal scrutiny activity of the firm, and, given time, fall into the general reporting area, based on well-defined models that capture the essence of the decision problem. Considering the five cognitive levels and the three core types of support, decision support activity for FIRM C is classified as outlined in Table 4.18 below.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	Manual Scrutinising based on Level 1 and 2 dashboard display
2	Reporting and scrutinising based on automated trend analysis
1	Reporting based on Dashboard displays well developed

Table 4.18: Decision Support Scope and Quality in FIRM C

FIRM C Global Services is structured along product lines, referred to internally as 'platforms', with all dashboard display reporting by product line. Therefore consistency of support level across the various platforms is difficult to deliver, and more difficult to report on, as there is no real time system to monitor activity at customer level. The zero to light shading reflects the delivery of consistent support at customer levels was still largely an aspiration at the time of the study. This should reflect a scrutinising activity, but the relevant information is not available without a considerable manual effort. Whilst level 1 and 2 are well covered by the implementation of the dashboard reporting and scrutinising capability, level 3 still presents specific design difficulties as managers contend with a product centric database to achieve customer-centric support service. Furthermore there is no evidence that specific systems for discovery use for problems identified at levels 4 and 5 have been considered, reflected by the use of the light shading on Table 4.11. Since Global Services is used as a differentiator by Sales and Marketing, managing the customer experience is currently supported using MS Excel®® spread sheets, generated by individuals within the department.

4.3.4. FIRM D

Most of the information provided to managers for decision making is in the form of dashboards of balanced scorecards. The data is manually extracted though specific inquiries, onto MS Excel®® spreadsheets, and manipulated and formatted as required. This inquiry and transformation is completed by FIRM D financial analysts and administration personnel who have specific expertise and training in the process. Management use this information for the full spectrum of managerial decision support from reporting to scrutinising to discovering. The metric reporting interval varies and can be hourly, daily or even weekly.

A SAP ERP and SAP BW (Business Warehouse) provides key operational data, including all production and quality data. Business Objects reporting software is used for querying and reporting as required. There is very little

integration between systems, particularly between the main transactional SAP system and other bespoke in-house developed systems which also record business transactions.

4.3.4.1. RQ2: Decision support availability

Table 4.19 is a representation of the decision support sources of information available to managers a FIRM D.

Inquiry type	Decision Support Sources
Discovery	No evidence of formal tools available. Manual collation and manipulation of data from external market research.
Scrutinising	MC Excel based Ranked League table generated (at corporate) based on reporting level information, showing analysis of performance across the 23 plants – then fed back to Cork. Long term trending difficult to achieve and requires considerable manual manipulation – using MS Excel. Extensive analytics skills in place across many departments
Reporting	SAP and SAP BW implemented. Very strong on production data capture, but reporting siloed and manually collated. Quality data captured on Excel showing weekly trends based on customer complaints

Table 4.19: Decision support in FIRM D

4.3.4.2. RQ3: Scope and Quality of Decision Support for Decision Problems

FIRM D seems remarkably close to FIRM C in the study, from a decision support perspective. This is more than likely due to the examination of a local manufacturing site, rather than the corporation overall. Managers are aware of decision problems that would be classified at levels 4 and 5, where the uncertainty of the business environment would impact the day to day business decisions. However, at a local manufacturing site level, environmental uncertainty has been removed, and achieving a high performance ranking relative to the other plants, is essential for the overall and continued success of the local plant. Table 4.20 presents an interpretation of the scope and quality of

the decision support available to managers represented across the five levels of decision problem.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	Manual Scrutinising based on Excel generated reports
2	Reporting and scrutinising based on Excel generated reports
1	Reporting based on sophisticated Dashboard displays

Table 4.20: Decision Support Scope and Quality in FIRM D

Managers are very well equipped at reporting type inquiries which provide quantitative fact based data based on a nine panel Balanced Scorecard for operational problem solving and quality metrics. However, generating reports that indicate trends over a period of time is difficult to achieve and requires considerable manual manipulation – using SQL queries as the basis for MS Excel®® correlation and number crunching of data. Extensive analytics skills are in place across many departments, but especially within Finance, which allows a high level of scrutiny capability for managers. This is reflected by the very dark shading in Table 4.20 at levels 1 and 2 which are well covered from both decision problem classification and identification, and the delivery of information support. Level 3 support is currently based on further manual extraction of Level 2 data. In contrast, the zero shading reflects the lack of decision problem identification and delivery of support at levels 4 and 5 at the time of the study. Furthermore, there is no evidence that specific discovery type systems, that could facilitate decision problems identified at levels 4 and 5, have been considered within the Cork plant, although these are available to some extent at Corporate. However, the corporate systems are not available at local level, but are the source of the ranking and league table reports, identified within section 4.2.4 on RQ1.

4.3.5. FIRM E

With efficiency considered a core competency, and cost control of the utmost importance, FIRM E have invested heavily in SCADA technology, and have developed a suite of dashboard displays to monitor and control all aspects of the production process.

4.3.5.1. RQ 2: Decision Support Availability

Table 4.21 is a representation of the decision support sources of information available to managers a FIRM E.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	Critical KPIs at scrutinising level are all produced manually by Finance department personnel based on manual extracts from SCADA and forecasting systems. Excel spreadsheets are prepared and hand delivered to management weekly, 2 working days after weekend.
Reporting	This organisation excels in dashboard technology to control and monitor all aspects of the production process. SCADA process control tools implemented extensively.

Table 4.21: Decision support in FIRM E

The Key Performance Indicators (KPIs) required to measure the Critical Success Factors (CSFs) are developed as variances, which are calculated as the difference between budget and actual. However, while this generates an intense level of reporting activity, as well as some limited scrutinising activity, very little is available to management or executives outside of the control room location. All management reports are prepared on spread sheets, with manual preparation from disparate transactional systems and SCADA type process control systems, as well as some paper based log-sheets maintained by plant operators. This MS Excel® based reporting is produced by the Finance department personnel on a weekly basis. It is presented to management on the second working day of the following week.

4.3.5.2. RQ3: Scope and Quality of Decision Support for Decision Problems

Overall, FIRM E shows the Decision Support profile of a less advanced organisation, where managers, for a variety of reasons, do not have the time or the incentive to seek to develop the models that could capture the essence of more abstract levels of decisions. Table 4.22 presents an interpretation of the scope and quality of the decision support available to managers represented across the five levels of decision problem.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	Critical KPIs at scrutinising level are all produced manually by Finance department personnel based on manual extracts from SCADA and forecasting systems. Excel spreadsheets are prepared and hand delivered to management weekly, 2 working days after weekend.
Reporting	This organisation excels in dashboard technology to control and monitor all aspects of the production process. SCADA process control tools implemented extensively.

Table 4.22. Decision support Scope and Quality in FIRM E

As discussed, FIRM E does not have any DSS to support upper level management decision making. Thus, FIRM E shows a very different decision support foot print in comparison to companies FIRM A and FIRM B. In this site, the failure to support higher level decision activities is very evident and this researcher could not identify any significant attempt to instigate systems which might attempt to provide a resolution for any decision problems at levels 3, 4 or 5, as reflected by the lighter shading at these levels. While management understand the financial cost of downgraded batches, the progression of a possible solution will only evolve when management begin to ascribe some best practice and some experimental variables, and follow the natural progression of all decision problems over the levels of the framework, over time.

This lack of discovery tools and top level scrutinising tools, is in sharp contrast with the research findings at level 1 and 2, which clearly show intense reporting, as well as some limited scrutinising activities. A substantial body of mature DSS applications have been developed over a number of years, in the shape of dashboard type applications. Moreover a significant amount of manual preparation of data used for scrutinising purposes is regularly undertaken, in relation to the production activities.

4.3.6. FIRM F

As a start-up company, in a very immature industry segment, and with only a few customers and a few suppliers, FIRM F has minimal traditional type IS systems, and use personal type applications for transaction recording. All of the scrutinising type reports are MS Excel® spread sheet based, and are of a highly complex nature. These are developed by specialists in econometrics and business modelling. FIRM F has limited economies of scale, including knowledge, and extensive use is made of external information from sources such as: published reports, in particular government strategy reports on green policy; and the EU regulatory framework for electricity price setting and for grid connection. Additionally policies and regulatory frameworks in relation on waste management and waste utilisation are also pertinent. Various non-government agency (NGO) reports are relevant and influential in this area.

4.3.6.1. RQ 2: Decision support availability

Table 4.23 is a representation of the decision support sources of information available to managers a FIRM F.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	All scrutinising is based on external information – published reports, governments and European "green" strategy policy, waste industry specialists and market analysts, grid connection regulations. Excel the only tool but staff analytics skill high.
Reporting	SAGE and MC Excel are the main systems tools. Excel used by engineering staff to monitor waste tonnage and price charged by waste operators, type of waste gas yields – fed into excel generated financial models for sensitivity analysis..

Table 4.23: Decision support in FIRM F

With just thirty employees, manual scrutinising of both qualitative and quantitative information is completed by highly skilled engineers who perform sensitivity analysis of models and information, and employees have extensive analytics skills, which are utilised across many departments. There is considerable evidence of discovery type activity in place in FIRM F, but there are no tools available. This is a company where an understanding and knowledge of the company's strategy in conjunction with the industry and environmental factors is fundamental.

4.3.6.2. RQ3: Scope and Quality of Decision Support for Decision Problems

Table 4.24 presents an interpretation of the scope and quality of the decision support available to managers represented across the five levels of decision problem.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	Manual Scrutinising based on analysis of external reports
2	Reporting and scrutinising based on Excel generated reports
1	Reporting based on SAGE and Ms Excel

Table 4.24: Decision support scope and quality in FIRM F

There are very few industry databases available to FIRM F, as the organisation operates is in a very new industry segment. Furthermore the governmental regulations are evolving all the time, as the industry matures. Therefore both the scope and the quality of decision support are meagre. The companies' internal information suffices for its current purpose. But this company is at the forefront of a technology revolution, and is part of creating the standards and proposing best practice in green energy procedures and processes.

4.3.7. FIRM G

FIRM G has a very sophisticated portfolio of systems which are utilised extensively in the organisation. A SAP ERP system and COGNOS PowerPlay BI tools are implemented enterprise wide. FIRM G makes extensive use of external market research data including the International Wine and Spirit Records (IWSR), which maintain data on the majority of drinks companies, such as their brands, sales volumes by brand and other relevant information.

4.3.7.1. RQ 2: Decision Support Availability

Table 4.25 is a representation of the decision support sources of information available to managers at FIRM G.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	Excel the main scrutinising tool using data from the data warehouse plus external market research data and tacit information from marketing specialists.
Reporting	SAP used daily to record all transaction. Data warehouse updated once daily. Cognos PowerPlay BI toll available across enterprise for reporting and drilldown capability.

Table 4.25: Decision support in FIRM G

FIRM G employs some very skilled analysts who combine internal and external data for scrutinising and reporting. However there was no evidence of higher level discovery type analytics available, but extensive use is made of external drinks industry information, by the CEO and by analysts. Considering the five cognitive levels and the three core types of support, decision support scope and quality can be classified as outlined RQ3.

4.3.7.2. RQ3: Scope and Quality of Decision Support for Decision Problems

FIRM G operate in a very mature market, with an abundance of external information providers based on trading and export figures, consumer surveys and other market intelligence. FIRM G has access to, and makes extensive use of this intelligence. Moreover, the information available is downloadable to MS Excel® which can be merged with internal data. Therefore, the quality of decision support can be classified in a very positive way. However, the decision making requirements are once more indicative of operating in a subsidiary, where the primary objective is to ensure the adherence to corporate strategy as well as to meet the objectives as set out by corporate. Table 4.26 presents an interpretation of the scope and quality of the decision support available to managers represented across the five levels of decision problem.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	Manual Scrutinising based on Excel generated reports and external data
2	Reporting and scrutinising based on Excel generated reports
1	Reporting based on SAP data, Cognos extracts

Table 4.26: Decision support scope and quality in FIRM G

FIRM G is a company where decision support more than adequately matches the requirements of the manager's decision making problems. The light shading reflects the delivery of support at levels 4 and 5, which is still largely an

aspiration at the time of the study. Whilst levels 2 and 3 are well covered by reports produced by the skilled analysts employed in the company, these are not automated, and are reflected by the mid-level shading on Table 4.26. The lack of a model to capture the essence of decisions at level 3 remains a problem. Furthermore, there is no evidence that specific systems for discovery use for problems identified at levels 4 and 5 have been considered.

4.3.8. Firm H

FIRM H has a number of systems available. The production plant has a very low level of automation. The hierarchical structure of the organisation highlights the lack of systems integration, and this results in a disconnect between the plant manager and the functional local area managers. The local area manager for supply chain compiles the production schedule weekly, based on customer orders and raw material availability, which are maintained on a MAPICS inventory system. The production schedule reports are "hand delivered" to operations, who then schedule the following week's production. Even though all the data is MAPICS based, the report is generated on MS Excel® for production. Time-in-motion studies are all manually recorded.

4.3.8.1. RQ 2: Decision Support Availability

Table 4.27 is a representation of the decision support sources of information available to managers at FIRM H.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	Manage within budgetary constraints using MS Excel. All decisions re capital spend or operational spend must adhere to corporate sustainability policy – control via MS Excel spreadsheets
Reporting	Manual (by supply chain based on customer orders) input to MAPICS generates production requirement weekly. Interfaced to Oracle, which is system of record for production. Quality data based on manually extracting Lab results.

Table 4.27: Decision Support in FIRM H

The version of MAPICS that is implemented is a customised add-on to the corporate Oracle ERP system. The Oracle ERP system is the system of record for the organisation. MAPICS is the main tool used to report on historical data, for example, batches produced by period, inputs used by batch, monthly shipments, all of which provides FIRM H managers with comprehensive reporting mechanisms. Reporting on product quality is based on manually extracting laboratory results data. However, any scrutinising activity is based on manually captured and recorded data used as the basis for MS Excel® models for scenario testing. Considering the five cognitive levels and the three core types of support, decision support scope and quality can be classified as outlined RQ3.

4.3.8.2. RQ3: Scope and Quality of Decision Support for Decision Problems

In FIRM H managers are well equipped at level 1 reporting only. Even at level 2, the plant manager seems to have his own reporting mechanisms through MS Excel® and his own knowledge and 'gut feel' for what is happening in the plant, which facilitates scenario testing or root cause analysis. However, the plant manager in FIRM H has considerable decision making discretion, albeit with a narrow remit. The Local area manager who has responsibility for quality has somewhat better reporting tools in place. Based on laboratory monitoring and testing results, with a focus on "right first time" metrics, the laboratory analysts maintain extensive databases. These can be queried on an ad-hoc basis, but would be at reporting level, with no evidence of scrutinising activity.

4.3.8.3. RQ2: Decision support availability

Table 4.28 presents an interpretation of the scope and quality of the decision support available to managers represented across the five levels of decision problem.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	Manual Scrutinising based on Excel generated reports
2	Reporting and scrutinising based on Excel generated reports
1	Reporting based on sophisticated Dashboard displays

Table 4.28: Decision support scope and quality in FIRM H

The zero shading reflects the total lack of decision problems identified at levels 4 and 5 and no evidence of and support at these two difficult levels. As discussed Level 1 day to day decisions are well covered, reflected by the deep shading. Any reporting and scrutinising at levels 2 and 3 are based on individual managers own reporting capability created using MS Excel®. This reflects the non-KPI-oriented culture, and while specific goals are handed down from headquarters to local sites for each functional area, the plant manager manages in his own style.

4.3.9. Firm I

While FIRM I operations remain in reactive mode, the systems capability to allow management to operate in a more proactive mode, is only partially in place. A performance accountability culture could be achieved with improved reporting and dashboard capability. Little drilldown capability is available to managers to facilitate scrutinising. Current reporting systems monitor day-to-day operations and the ERP systems provide some data. Many different ERP systems are in use, with no integration, and no data warehouse in place. Therefore Finance personnel manually generate most of the data in the weekly reports. While some SCADA systems are implemented, for example machine performance tracking and maintenance, and the data is reported in dashboard format in real time, it is not integrated with any other system.

4.3.9.1. RQ 2: Decision Support Availability

Table 4.29 is a representation of the decision support sources of information available to managers in FIRM I.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	Little drilldown capability except for machine performance.
Reporting	Reporting activity for management on weekly basis, prepared by Finance personnel based on centralised ERP systems and local machine performance extracts.

Table 4.29: Decision support in FIRM I

The limited level of systems integration restricts the managers at the Cork plant to do little more than operational reporting. Little drilldown capability is available to managers to facilitate scrutinising, which means that management are managing budgets, but are not considering possible efficiency improvements. There is no evidence of discovery type inquiry reflection. Research Question Three discusses how these systems deficiency impacts decision support in FIRM I.

4.3.9.2. RQ3: Scope and Quality of Decision Support for Decision Problems

Although a large US multinational firm, FIRM I seems remarkably close to FIRM E in decision support terms, despite having a totally different profile in general terms. This is more than likely due to the examination of a local manufacturing site, rather than the corporation overall. In other research, it has been observed that there was a tendency for a reduced scope of decision making at local level in highly integrated multinationals (particularly US multinationals). This pattern seems to be repeated in FIRM I where managers are very well equipped at level 1, where KPIs are clearly identified, but where decision making tools for scrutinising in general terms and for discovering are totally absent.

4.3.9.3. RQ 2: Decision Support Availability

Table 4.30 presents an interpretation of the scope and quality of the decision support available to managers represented across the five levels of decision problem.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	None
2	Limited scrutinising available
1	Weekly Reporting – manually generated

Table 4.30: Decision Support Scope and Quality in FIRM I

This reflects the KPI-oriented culture of many multi-national corporations (MNCs) where specific goals are handed down from headquarters to local sites for each functional area, and converted into strict targets by each manager. This culture means that the incentive and the time to develop specific DSSs at the higher levels of decision making are low because local managers have little autonomy of action. This in turn means that management remain in a reactive state, rather than taking a more proactive view of the business.

4.3.10. FIRM J

FIRM J has a very sophisticated portfolio of enterprise systems in place. The value of information and the ubiquity of the internet have been leveraged to provide customers with up-to-date and accurate information on their (customers) orders at all stages of the delivery process. From the company's inception, FIRM J has had an in-house applications development team based in South Africa, and information systems providing online order status over a robust network were the first to be prioritised. However the lack of systems ensuring an accurate and comprehensive system of record for the company proved a major drawback when the managing director needed fully consolidated accounts for a joint venture due diligence exercise. Following this, an

organisation-wide fully integrated ERP system was implemented in 2009. However none of the historical data was migrated. The emphasis has been on providing their customers and third party suppliers traceability on their (customers) orders from a logistics perspective.

4.3.10.1. RQ 2: Decision Support Available

Table 4.31 is a representation of the decision support sources of information available to managers at FIRM J.

Inquiry type	Decision Support Sources
Discovery	There are no tools available.
Scrutinising	KPI portal provides data in report and dashboard format on predefined KPIs. Excel remains the tool for any scrutinising activity, but staff analytics skills are poor.
Reporting	ERP system provides fast and reliable financial reporting and analysis. Excel used for further selective reporting

Table 4.31: Decision Support in FIRM J

The ERP implementation has coincided with the roll out of Key Performance Indicators (KPI's) across the organisation. Currently the ERP system is perceived to provide fast and reliable financial reporting and analysis. MS Excel® is used for further selective reporting and scrutinising, but staff analytics skills are poor. Considering the five cognitive levels and the three core types of support, decision support scope and quality can be classified as outlined RQ3.

4.3.10.2. RQ3: Scope and Quality of Decision Support for Decision Problems

In FIRM J managers are well equipped at level 1 reflected by the deep shading on Table 4.35. Levels 2 and 3 rely on MS Excel® for reporting and any scrutinising activity which relate to the KPI's are as a result of MS Excel® extracts from the ERP system, and subsequent manipulation of the data into required formats. Table 4.32 presents an interpretation of the scope and quality of the

decision support available in FIRM J represented across the five levels of decision problem.

Cognitive level	Decision Support Scope and Quality
5	None
4	None
3	Manual Scrutinising based on Excel generated reports
2	Reporting and scrutinising based on Excel generated reports
1	Reporting based on sophisticated Dashboard displays

Table 4.32: Decision support scope and quality in FIRM J

The light shading reflects the total deficit of decision problems and delivery of support at the top two levels is non-existent.

4.3.11. Conclusions to Research Questions Two and Three

For each firm studied, the types of systems relied upon for decision support, have been considered. In some cases, the case data is factual and outlines specific applications used by managers in the firms, whereas in some cases, it is aspirational in that little is known about how to design the support applications, although the decision problems are known.

Table 4.33 presents a collated view of the levels of decision support across the ten firms, which has been identified at each of the representation levels. As discussed in Chapter Two, the relative level of decision support maturity is suggested as the size of the footprint of decision support mapped against the decision problems. The presentation order of the firms in the table, represents the level of decision support maturity observed during the research, with FIRM A on the left of the table showing the highest levels of maturity. The deep shading reflects the availability of formalised decision support. The light shading reflects where decision problems can be identified, but where there is no formalised decision support available. When a cell remains unshaded, decision problems can be identified, but there is no suggestion as to any

solution. The table indicates that the broad spectrum of firms included in the study is matched by a broad spectrum of findings with respect to the use of decision support tools.

Cognitive Level	FIRM A	FIRM B	FIRM C	FIRM D	FIRM E	FIRM F	FIRM G	FIRM H	FIRM I	FIRM J
5										
4	X	X								
3	X	X	X	X	X	X	X	X	X	
2	X	X	X	X	X	X	X	X	X	X
1	X	X	X	X	X	X	X	X	X	X

Table 4.33: Decision support by cognitive level across firms in the exploratory study

Prima facia, we observe that no company has formalised support for level 5 problems, a fact compounded by the observation that many managers could not describe level 5 problems that they were facing. Furthermore, only thirty per cent of the companies in the research sample have formalised level 4 decision problems. Ninety per cent have considered decision problems at level 3, whilst one company appears to be concentrated on lower level problems only. In this case, it may be that the nature of the firm's business has a bearing on the problems that managers face. Clearly finding new contracts and new customers would rank at level 3 and 4 in the table. However the data collection was restricted to the class participants' experiences and a thorough examination of decision problems within an organisation was outside the remit of this exploratory research.

Another key finding is that a company can be at a given level for different reasons, notably; lack of expertise as in FIRM E, where some variances could be computed in available systems, but where the skill set required to complete more advanced analytics was missing; or lack of incentive as in FIRM I, where managers did not seem to be empowered to conduct inquiries into problems which they could see, and which is quite different to FIRM E. Firm F is noteworthy as it displays better systems and more advanced analytics at level 2 of the framework, than at level 1. Thus, the existence or absence of decision

support at the scrutinising and discovery levels is about more than just the abilities of the managers and the IS developers of the firm to properly model the issues facing them. Managers must also recognise the need to perform such activities, and they must acknowledge that the amount of autonomy that they have, warrants the significant efforts required in conceptualising the problems. Otherwise, they may prefer to concentrate on levels 1 or 2, which allows them to manage the narrow indicators handed down to them by top management, where there is little or no discretion in the choice of procedures used to structure the decision problem and to formulate a policy for action. In firms where the context facing managers provides clear incentives to (1) attempt to formalise level 3 and level 4 problems and (2) to seek the help of systems analysts and systems developers in taking their decision support tools beyond simple end-user developed spread sheets, then organisations may display a very complete portfolio of decision support applications spanning three levels (companies FIRM A, FIRM B, FIRM C and FIRM D). However, even in these firms, it will remain that, few organisations ever achieve a complete portfolio spanning 4 levels, let alone 5 levels on a permanent basis. In other words, reaching level 5 is not like reaching a threshold at which one is certain to remain. Quite the opposite, it is a matter of reaching a certain level of understanding of the problems facing the firm, at a particular point in time, where the environment is presenting a new, identifiable pattern of competition or regulation, for example, until Nature's next move changes the state of play again and managers shift their focus on other, newer ideas, as they become aware of new challenges facing them. Yesterday's level 5 problems become level 4 or 3 problems, or drop off the agenda altogether. Tomorrow's level 5 problem, of course, will take time to crystallise.

4.4. Learning from the exploratory case study

As discussed in section 3.3.5, this is an instrumental case study in that the actual case is of less importance than gaining a better understanding of the particular issues under investigation (Stake, 2005, p. 445). Therefore the details pertaining to the individual firms play a supporting role, and these details have

facilitated an understanding of the nature and extent of decision support when applied to the cognitive representation framework. This instrumental case has been successful in applying existing frameworks to develop a method for evaluating the maturity of organisations with respect to their use of decision support tools. It confirmed the usefulness of the Humphreys and Berkeley (1985) framework in measuring decision support maturity.

The observations across 10 case studies of Irish firms confirm that the higher levels of abstraction in decision making are not covered by decision support, either formal decision support by Decision Support Systems or decision support by other softer mechanisms. None of the 10 firms has any concrete decision support above level 3 in the Humphreys framework and only three firms have conclusively considered what issues could be supported at level 4. Reasons for this lack of engagement at level 4 have been identified and discussed in the case narrative, and are different for each of the firms, but include: lack of discretion on the part of the managers due to the subsidiary nature of the operation, or lack of motivation on the part of the managers due to a singular focus to manage within a CSF/KPI type culture. The agenda has been set by a management team who are not available for inclusion in this study, and any further extension of the agenda is not considered. Level 3 decision problems formulation and problem solution have been identified in all except one of the firms researched. However formalised decision support has been identified in just forty per cent of the case sample at this level. Decision support at level 1 and at level 2 of the framework is well represented across almost all organisations in the study.

Another important finding of the exploratory case is that it is difficult to engage with managers on the topic of decision making and decision support. Even in the relatively controlled environment of the class room, discussing real life organisations and the problems they face, on the basis of a well explained grammar (the Humphreys and Berkeley (1985) framework), discussions with managers on the topic still reveal the possibility of important bias and misrepresentation. Furthermore, in the exploratory study, the best

understanding and presentation of the decisions levels was from managers in firms where a comprehensive range of Decision Support Systems are in place, i.e. organisation where an almost complete portfolio of information systems have been developed, up to level 3, and where these are extensively used by managers. Managers seem able to understand the outcome of decision problems and solutions based on their interaction with their information systems, rather than through conceptualising levels of abstraction of decision problem formulation and solution formation. This phenomenon could reflect the characteristics of the managers who undertake the EMBA program – middle managers who understand the day-to-day activities of their organisation, and who rely on information systems for their information used when monitoring and controlling the structured KPI type scenarios that reflect their role.

However, the study of Firm A, which represents the most DS mature organisation of the study, identified complex, uncertain and unstructured decision problems which were refined over time, to the point where the decision problem can be stated. Furthermore decision support has been enabled over many years, and now represents a sophisticated portfolio of applications of the reporting and scrutinising nature, and where discovery type applications are being prototyped and further enhanced. Therefore, in order to achieve the objective of this research project, access to a more senior level of management is required, and ideally, in an organisation which has a history of IT adoption.

Chapter 5. The main case: Understanding decision support in a financial services organisation

This chapter is concerned with presenting and exploiting the data collected in the study of the main case. In this case, the research focuses on a group of executives and managers involved in complex decision making in a financial services organisation. The objective is to gain an understanding of the decision problems encountered by executive managers on a daily basis, and to capture the essence of the information that is available to them during the decision problem formulation and solution evolution.

This chapter begins with a presentation on the background to the case, and then proceeds to answer research questions one, two and three. The first research question will facilitate the representation classification of the decision problems identified, based on the degree of abstraction of the managers representation of the decision problems presented, and the level of understanding of the decision problem solution, based on Humphreys and Berkeley's (1985) work. Research question two will describe the sources of formal and informal decision support tools available to the decision making and decision taking managers. By tools the researcher investigated IS systems, formal and informal, as well as routines and procedures that provide information dissemination (Simon, 1977). The classification of decision support tools uses the topology of reporting, scrutinising and discovering (Adam and Pomerol, 2008) as discussed in chapter two.

As a conclusion to the first and second questions there is a clear opportunity to synthesise the data gathered in the first two questions, and present a composite model of decision support mapped against the cognitive levels of decision problem representation after Humphreys and Berkeley's (1985) framework. Research Question Three provides the opportunity to consider what a derived vision of decision support maturity across representation levels would suggest. This question relies more heavily on

interpretation and perception on the part of the researcher. This case presents a high-level view of decision support maturity in the Markets Division of BigBank[15].

5.1. BigBank

BigBank's history dates back almost two hundred years. BigBank is now a global diversified financial services holding company whose businesses provide customers, corporations, governments and institutions with a broad range of financial products and services, including consumer banking, credit cards, corporate and investment banking, securities brokerage and wealth management. BigBank has approximately 200 million customer accounts and does business in more than 140 countries. BigBank reduced headcount by over 100,000 to approximately 265,000 between 2007 and 2010.

The BigBank group currently operates via two primary business segments consisting of BigBankcorp and BigBank Holdings. BigBankcorp consists of the Institutional Clients Group and Regional Customer Banking, and is considered the core client-driven business of the organisation. BigBank Holdings consists of Brokerage and Asset management and Local Consumer Lending. While the BigBank group reported a net loss of $1.6 billion in 2009, BigBankcorp remained profitable with $14.8 billion in income. The organisational structure is reflected in figure 5.1, as extracted from the 2009 annual report.

[15] Not the real name of the organisation

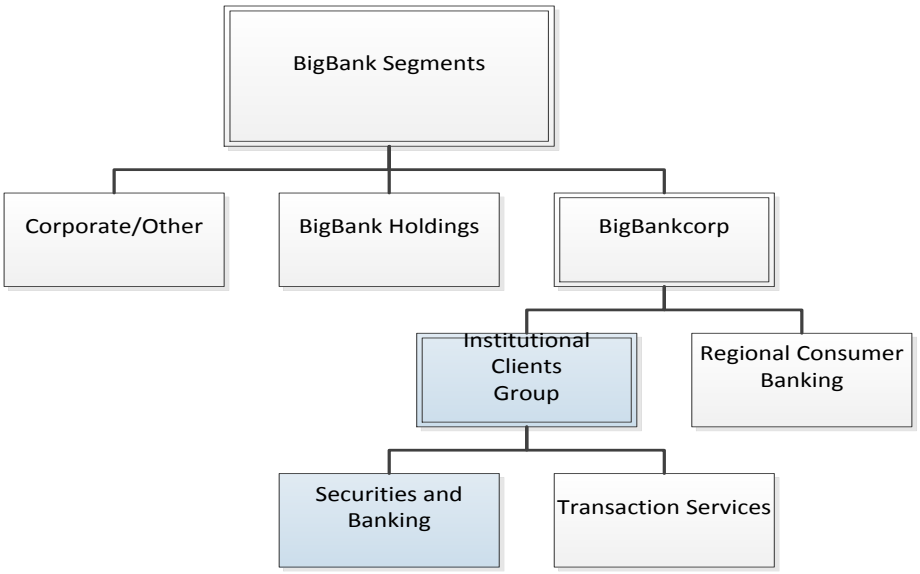

Figure 5.1. BigBank organisational structure

The Institutional Clients Group (ICG) includes Transaction Services and Securities and Banking. ICG provides corporate, institutional and high-net-worth clients with a range of products and services, including cash management, trading, underwriting, lending and advisory services around the world. BigBank Global Transaction Services unit is a leading provider of integrated cash management, trade and securities services for corporations, financial institutions, intermediaries and governments around the world. Many Global Transaction Services customers are multinational organisations that do business in dozens of countries and have hundreds of bank accounts around the world. Managing these accounts is a challenge for the treasury officers in such companies, who use BigBank Global Transaction Services to gain visibility and control of the information and processes around their cash, trades and investments.

BigBank Securities and Banking includes Global Banking, Global Markets, BigBank Private Investment Bank and BigBank Capital Advisors divisions. Securities and Banking offers a wide array of investment and commercial banking services and products for corporations, governments, institutional and retail investors, and ultra-high-net worth individuals. Securities and Banking includes

investment banking and advisory services, lending, debt and equity sales and trading, institutional brokerage, foreign exchange, structured products, cash instruments and related derivatives, and private banking. Securities and Banking revenue is generated primarily from fees for investment banking and advisory services, fees and interest on loans, fees and spread on foreign exchange, structured products, cash instruments and related derivatives, income earned on principal transactions, and fees and spreads on private banking services. "*The core mission is to be the global bank for institutions and individuals and to serve our clients with distinction*" (Annual report 2009).

This research was carried out in conjunction with executives in the Institutional Clients Group (ICG), specifically in the Global Markets division. The Global Markets division includes Equity markets and Fixed Income Markets. BigBank, through its Global markets division trade and execute over one billion shares per day, making markets in approximately seventeen thousand stocks. Retaining existing customers and cross-selling additional products to them, is a core objective for management. Thus, this chapter reports on the types of decision problems encountered in the Global Markets Division of Citicorp and the information sources which facilitate the resolution of the decision problems. Figure 5.2 presents an overview of the organisational actors in the Global Markets Division of Citicorp. The participants to this research are those actors as are highlighted in blue. While not all functional areas are represented on the organisational chart, all management hierarchy levels are represented for the functional areas relevant to this research. The 'Operations and Technology' (O&T) functional areas are on the left of the organisational chart, with the business functions of ICG are on the right hand side of the organisational chart, as represented on Figure 5.2.

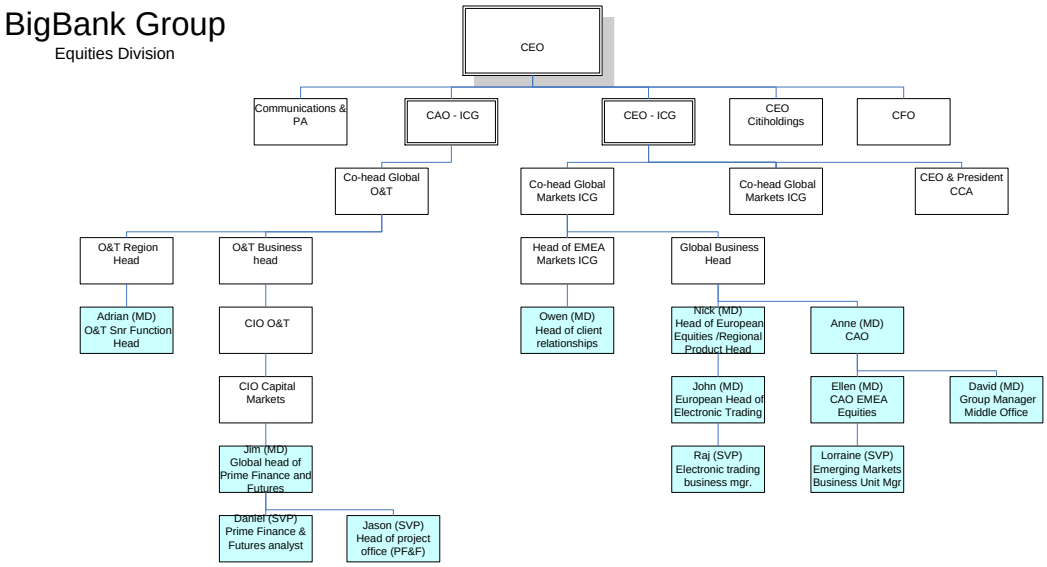

Figure 5.2. Organisational chart for BigBank, Equities division.

Table 3.3 in Chapter Three, section 3.4.3 presents an overview of the participants who were interviewed for this study, and identifies the participants' name, their current position and management level, the number of direct reports as well as their length of employment in BigBank. Table 5.1 further summarises Table 3.3 identifying the seniority of the interviewees, and their area of expertise: business or technology. The business environment for financial services is highly competitive and continues to be challenging in 2010 and into 2011, providing a rich background for the interviews with senior executives.

Position	Number	Officer Title	Area of Expertise
Global market Head	2	MD	Business
EMEA market head	3	MD	Business
CAO role	2	MD	Business
Global SVP role	1	SVP	Business
EMEA Business Manager	2	SVP	Business
Global Head of Technology	2	MD	Technology
EMEAl Head of Technology	1	MD	Technology
Global Technology role	1	SVP	Technology

Table 5.1. Summary of research participants in BigBank

The following sections focus on answering the research questions posed for this study. The decision problems identified and classified is presented in the next sections. The classification is represented using the Humphreys and Berkeley (1985) framework, and is presented in decreasing order, i.e., level 5, the most abstract level of representation is analysed firstly.

5.2. RQ 1: Representing and analysing decision problems at BigBank Global Markets

The seniority of the participants to this research realised the researcher's objective of focusing on complex problems where there is considerable uncertainty about what is involved in the formulation of the problem and where there may be many possible ways of structuring a solution, and where the implementation of any solution has critical and often unintended consequences.

In discussion with executives in the Markets Division, two main decision themes are dominant – decisions pertaining to a) customer related trading issues and b) people management and people performance management. However the Securities and Banking division, and specifically Global markets, is organised by product or product area, as in Equities, Prime Finance, Foreign currency, and RSP etc. and not by customer. Moreover, all technology platforms are product based, and organised within that structure, which will be discussed in detail in section 5.3. when Research Question Two is addressed. This apparent dichotomy provides an interesting and rich background for the researcher when considering complex decision problems.

5.2.1. What is on the horizon - Level 5

Based on the interviews conducted, there is little evidence of any activity which could be regarded as representative of level 5, where the description is beyond language (Humphreys, 1989). The closest to level 5 decision discussion is in relation to the organisational review which occurred some two to three years prior to this study. Two of the most senior informants, were involved in that review. In 2008 the future for BigBank was very uncertain, with no guarantee of

its very survival. The uncertainty which prevailed at that time meant that an *a priori* understanding of where the organisation was, and how it had gotten into such difficulties, was difficult (Philips, 1984; Ilmola et al, 2006; Hiltunen, 2008; Davenport et al, 2010). One of the MD's succinctly indicates the difficulty, even after some time has passed, of grappling with ideas and the lack of precision in verbalising problems of that time.

> *We spent a huge amount of time … we used a lot of external consultants to help us in terms of defining, yeah, defining, what we wanted to be as a business, what we therefore needed to do as a business; to be leading, competing … changing the businesses model, it meant exiting certain parts of the business, building up certain others, moving along.*

The research informants who were involved in that organisational review reflected on how the initial sense of bewilderment with the problems faced by the organisation, had, over time, given rise to decision making experiences which can now be classified as Level 4 decision problem formulation activities, and, furthermore, towards more structured solutions at level 3 and beyond. However, as the Humphreys and Berkeley (1985) framework stipulates, managers, whether at the individual level or as a group, are not able to dispel the sense of unease with the situation and with the analysis of the problem that was presented (Philips, 1984; p. 29). Finding solutions to the problem requires the dissipation of this unease and the statement of an explanation that seems plausible to everyone. Philips (1984) has eloquently described this process as "*unlike the varied perceptions of a distant mountain brought about by differences in vantage point*" (p. 33) in that the reality that is being modelled by managers is not an objective reality that can be perceived by the naked eye. The interviews bore this out, insofar as the informants were aware that the shared understanding they ultimately arrived at, as a management team was their own: a different team may have come to a different interpretation, as "*each person creates an internal representation of the problem (...) bringing to bear on the initial problem statement any experience and knowledge that seems relevant*" (Philips, 1984: 33). The implication of this construction of the truth for the development of

decision support for decision problems that are at this high level, will be discussed in section 5.3, pertaining to research question two. Let us just note that this process of emergence of the truth rules out certain types of decision support, insofar as consensus has not yet emerged amongst managers regarding problems at this level, even when it (the problem) is on the managers' radar.

5.2.2. Expressing the problem – level 4

The research informants provide a rich, but limited set of decision scenarios which would be consistent with a level 4 representation. Four of the informants identify the level 4 area as where most of the discussion or "*the thinking process*" of decision problems would begin, the real start of all decision making processes. The difficulty of expressing a decision problem is identified as a significant issue in its own right. Themes associated with global environmental drivers, changing regulatory policies, industry competition and overall changes to the financial services industry, are recognised as significant drivers for the complex and fast changing internal environment which has become the norm within BigBank. Decisions identified at this level are recognised as significant and complex, and there is considerable time spent in evaluating the complexities and ambiguity associated with these problems. There is a palpable sense of frustration associated with working in this space, arising from the uncertainty and difficulty associated with the expression of the problem and the time elapsed during which the evolution of the expression occurs (Ilmola et al, 2006; Hiltunen, 2008). Owen, who is one of the most senior and long-serving BigBank MD, expresses it well:

> *Senior people see level 4 as the problem area - that is absolutely right in big organisations….. This is where I think too much time is spent in this part of the funnel, this is where the blockage is, where the slowdown occurs. What you want is getting to this stage of the funnel – implementation stage. Things get slowed down going from 4 to 3.*

The time taken to establish a clear "expression" of an issue and the decision to resolve it was recognised as a further complication and often the cause of not following through with good ideas.

> *There is no issue with coming up with good ideas. But they get lost in the day to day immediacy of the business. And therefore, for them to get through from a good idea to actually work out what to do about it and to then get to the next level of structuring a business plan around it - a good idea, this is where it gets jammed up and therefore too much time is spent at level 4.*

Seniority, authority, experience and discretion are all identified as key personal attributes necessary for the success of the decision making process at level 4. Anne summed it up as follows:

> *what I can bring to the table, with the experience in the background, is being able to articulate an issue, flesh out by asking the right questions, what the issues are, so that we can determine what are the relevant issues.*

A number of policy type decision problems were identified by senior executives and are classified as level 4, as the essence of the problem is a high level of procedural uncertainty and lack of consistency in the application of regulation across products and geographic locations. There is a new emphasis on 'guaranteed consistency' which will provide documented evidence of conformance with all regulatory compliance policies. An understanding of the requirements regarding the application of the regulation, as well as its current operation, requires a considerable level of experience and organisational knowledge, and proficiency in the regulatory frameworks and standards as pertaining to the financial services sector. While a decision on adherence to regulatory compliance is unambiguous and unequivocal, the regulatory framework can be ambiguous in its implementation, especially when regulations and their interpretation are changing, as in the current fiscal environment. Issues arise on a regular basis in relation to conformance with regulatory standards from many external bodies, and the resolution of the issue is not always as clear-cut and precise as managers would like (Chae et al, 2005). Abdullah, Sadiq and Indulska (2010) maintain that financial services is the most highly regulated

industry, and that the high rate of business rule changes increases the complexity associated with managing the business processes.

Furthermore, a number of the business executives commented on the management experience required to drive towards more long term solutions. Investment banks operate on a one year cycle, with a considerable emphasis on annual bonus compensation. External influences associated with the financial services industry are having an unsettling and uncomfortable effect on the internal activities on the organisation due to: uncertainty associated with the direction of the business; what products should be focused on; the need for technical innovation versus the allocation of more people to perform operations on a more manual perspective; and a requirement to become customer focused in an organisation where the structure and culture are product driven. It is unclear how this uncertainty is affecting organisational actors, each of whom is aware of the current economic environment. Subsequent to the recent banking collapse, the industry is changing. The requirement to reduce costs and to invest in technology is paramount, while maintaining the strategic perspective of the overall organisational direction, at all times.

Again, the discussion pertaining to the provision of decision support at this level is left for the next section, it is nonetheless important to note that the structuration expressed by top managers in relation to their own speed in bringing problems from level 4 to the lower levels provides a clear incentive to seek to imagine that kind of dedicated decision support could be provided at level 4, which would cover the efficiency aspect: where decision support processes can be accelerated, without prejudice to their outcome. At the same time, it is important to recognise that the frustration felt by managers is also a consequence of the complexities they face and are not, prima facia, able to comprehend.

Decision problems identified at level 4, and the proposed solutions are significant for the business. Solutions formulated by senior executives form the basis for the implementation of structures at the next level – normally at the next lower organisational hierarchy level. The interviews indicate that, once

decisions are made here, the expectation is that the next management level will take responsibility for the implementation of the proposed solution. However executives who identified with decision problem formulation at level 4 of the framework would typically give consideration to possible solutions, taking account of certain high level constraints such as budget resources and timelines. In a number of examples, the perception is of a decision solution being handed over to managers who then have autonomy as to how to implement the preferred solution. This provides complete validation of the Humphreys (1989) framework where the progression through the stage of the framework is depicted as the introduction of increasing levels of constraints in designing solutions (Humphreys and Jones, 2006). However, the concept of the decision solution being handed over to managers who then have responsibility for its implementation will be explored further in section 5.5.

5.2.3. Structuring the problem solution – level 3

The greatest level of discussion concerning decision problems and decision making across all the interviews, the core of decision making processes, is associated with this level of representation. It is heavily influenced by one important contextual element: BigBank is extremely goal-driven as an organisation. Each area has a daily goal for revenue and profit, which is measured and reviewed on a daily basis. This emphasis on daily goals leads to certain behaviour patterns which influence Level 3 problem decisions activities, and the impact of goal measurement is most in evidence at levels 3 and 2.

Insofar as the design of core objectives (e.g.: daily performance goals and matching incentive schemes) is part of the design of solutions to organisational problems, it is an important observation of this case study that constraints exist on the solution of new problems that are inherited from other problems. The daily review of performance for instance, constraints the managers deliberation and assessment for a broad category of problems, some of them not yet solved. In fact, it frames the thinking of managers on a broad scale. This is an empirical validation of Earl and Hopwood's warning about the possibility to reduce

managerial margins of manoeuvre too early in the decision making process, although one not discussed in their paper. It shows that firms routinely place managers in situations where alternatives cannot be considered, quite apart from any reasoning or reflection about the nature of these constraints. This is all the more important because of the pivotal role of level 3 in the decision making process, as discussed next, in the case of customer related issues.

Customer related trading issues regularly concern the larger customers and their requirements. The focus on customer retention means that decisions made can be very tactical, and resources are deployed to satisfy the immediate trading requirements of even one single major client with one single product transaction. Major clients are the main driver for many decisions, in an environment where eighty per cent of the revenue is derived from twenty per cent of the clients. This fundamental driver must be balanced with the need to reduce the cost base, while working with incomplete information for decision making. The adhocracy inherent in this situation, where a case-by-case approach is adopted, is characterised by the lack of consensus: such situations will slow down the emergence of specific rules and routines. To-date, an individual product offering created for a customer, referred to as '*customerization*' (Wind 2001) has been achieved through augmenting staff resources, as distinct to devising an automated customised IS solution.

The requirement to understand which of the other business divisions are impacted by changes to procedures within one function area is another key factor in all interviews. The issues relate to a requirement for consistency in approach when communicating with customers, as well as the need to add value to other parts of the business where possible. While the decision maker's goal is currently product oriented, the focus must be client-centric, and operating in a client-centric environment requires knowledge of all client activity across all divisions in the whole organisation. Moreover, all IS systems are product-centric. In this, the BigBank case study is quite representative of other types of businesses where cross-functional awareness and the emergence of an effective cross-functional orientation are critical to future performance (El Amrani et al,

2006). The on-going design of decision making processes, decision rules and decision routines is a vital enabler of such performance (Davenport et al, 2010; Carte et al, 2005; Piccoli et al, 2008).

Many of the managers who operate within Level 3, are quite senior, and have extensive experience of investment banking, gained both internally at BigBank and in other investment banks. The overall focus is on efficiency. But structuring the problem, and setting up the frame within which the manager is comfortable, requires understanding the resource allocations and resource capabilities from both a personnel and technology perspective.

A number of the research informants discussed the need for more structure and more focus, but unlike at level 4, structure and focus refers to the choice between, on the one hand developing a more technical innovative solution, and on the other hand, deploying more staff to perform manual transactions faster. In the current environment, there is recognition that deploying staff in this manner is a costly and inefficient way to process client transactions, and is in direct conflict with the organisational goal of reducing headcount. Thus, the goals are well understood, although managers disagree on the shape of the preferred solution (Earl and Hopwood, 1980).

The critical impact of the current situation is that senior executives are regularly involved in what should be simple and automated transactions, thereby spending too much of their time “micro-managing” transactions, instead of rising above the day to day clutter to concentrate on high level tasks. This illustrates the barriers to the emergence of reliable, repeatable organisational decision making processes, not because of incorrect behaviour, but because of fundamental operational contradictions that require arbitration that top level managers are slow to get involved with, decisively.

As discussed, a number of the decision problems reflect resource constraints, and while the underlying information gathering is a Level 2 activity, the final decision requires senior business executives to make ‘the call’. Thus, the mapping of managers against representation level follows hierarchy to an incomplete extent. Top level managers have a tendency to hand over problems

when their complexity is deciphered, but in some cases, upper level managers remain connected to the implementation of problems even where they have delegated the implementation to other managers reporting to them. The concepts pertaining to framework level boundaries will be explored further in section 5.5.

5.2.4. Understanding the implications of the proposed solutions - Level 2

Executives working at this level all characterised their work in terms of a bombardment of decision issues coming their way from multiple, more senior sources. The research informants for level 2 decision activities are working at Senior VP level and spend a considerable proportion of their time considering possible process issues and matching solutions for those. The main problem areas identified during the interviews are: client issues, process issues, people issues and systems issues. Information gathering and analysis at this level involves grappling with reasonably fine grain detail, before the final solution to be implemented is decided upon. Most of the informants are adept at maintaining their own information stores, and being successful at this activity is a rite of passage for career progression. Without doubt, the complexity of the myriad of activities those executives are engaged in at level 2, makes working in this space very challenging. If level 4 is the root of the decision making process and level 3 is their core, then level 2 is the engine room of decision making processes.

Research informants individually are readily able to identify up to eight individual sources of issues for their attention. These include their immediate superiors as well as superiors in other departments, many of whom assign issues with very sketchy and partially defined requirement sets. Sometimes, a low level of coherence is observed, most frequently reflecting cross-functional scenarios where a precise understanding of the *status quo* does not exist. Subordinates are also a source of decision issues at an operational level. Senior VPs have prior first-hand experience of most of the issues encountered and must leverage their

experience in real time to ensure that all the issues are addressed in a timely fashion. This is an interesting scenario where residual uncertainty is allowed to rear its head at a low level of the decision making process, highlighting the possibilities for underlying conflict in the organisation (Brunsson, 1989). Thus, at level 2, managers are fire fighting and, although not on the front line with clients, keep the whole organisation ticking over.

Existing information systems issues also play a very large part at this level, and each of the informants provided examples of recent issues with information systems, where a lack of consistency in the treatment of trading processes for a client, or across clients, would have been uncovered, requiring more or less immediate 'fixes' to be implemented. Without pre-empting the discussion pertaining to Research Question Two and the role of decision support, it must be observed, that from level 2 down, the problems facing managers and especially their solutions, are hard to distinguish from the decision support layer, illustrating the close integration of information systems with the most formalised side of the decision making processes. Most operational decision making is supported by systems, and any description of a decision making process at this level, relies, at least in part, on an IT artefact. This can be taken as a validation of the choice of this case study as suitable for the study: BigBank is close to the leading edge when it comes to the integration of decision support to decision making processes.

However, the research identified a notable exception: people management is a critical and resource intensive activity in BigBank. In its most basic form, the demands of being a supportive manager, in the current time of turmoil are extremely time consuming, as commented upon by almost all research informants. The managers, who spend a considerable amount of their time working with levels 3 and 2 type scenarios, in the engine room of the business processes of the firm, also happen to have large numbers of people reporting to them – seven or eight direct reports, and up to four hundred under their direct remit. Staffing and prioritisation decisions are common topics for these decision makers, due to resource conflicts and shortages. For these

decision problems, there was no evidence whatever of decision support, as decisions are made in an improvised manner and often under enormous pressure. This resulted in conflicts, and in frequent escalation of comparatively low level decisions up to division heads.

5.2.5. Implementation and execution – Level 1

While all of the research informants were at senior vice president level, or higher, many of them spent considerable time working at level 1 type activities. This is due, in no small way, to the lack of standard decision making processes in place for many seemingly routine activities. Conflicting priorities and the complexity associated with the day-to-day activities makes for a fire-fighting type work environment. By all accounts, this is where the rubber meets the road.

Of course there are areas where procedure and process are well established. One such area is the 'middle office' (a separate cross asset group, which handles all trades for all products), where the main objective is to provide flawless communication to all actors in a trade. Metrics and best assessment checks are in place and continuously monitored. A well-established protocol has been implemented for ensuring the correct communication to the client, to all relevant parts of the organisation and to external bodies. A resolution protocol ensures that disagreements can be resolved in a timely fashion, and a full reconciliation of the various systems is established, facilitating current legislation requirements.

5.2.6. Conclusion to Research Question One

The Humphreys and Berkeley (1985) framework proves very successful in identifying and recording the different decision problems which are encountered by managers at the different representation levels in the life of the organisation, notwithstanding its level 5 may be difficult to observe in reality. The activities pursued by the different actors are fundamentally different when engaging in the formulation and resolution of decision problems at the different cognitive levels as presented in Table 5.2.

Cognitive Level	Decisions Problems
5	Environmental uncertainty. Financial markets collapse in 2008: future of the organisation in doubt.
4	Decision problems significant and complex, but difficult to express. Policy type decisions due to procedural uncertainty and lack of consensus in regard to solution.
3	Managing goals. Managing resources. Managing customer related trading issues.
2	Managing workload. Multiple sources of issues ensure an underlying dynamic and conflicted environment.
1	Managing in a fire-fighting environment with many conflicting priorities.

Table 5.2. Decision problems identified at each of the cognitive representation levels (Humphreys and Berkeley, 1985)

While all actors suggested that in the course of thinking about and structuring a problem, they progressed from higher levels of abstraction to lower levels of abstraction, the process does not appear to be as continuous as could be expected. This will be discussed further in section 5.5. Firstly, there is a fundamental abstracted decision making process that can be observed in the case, from level 4, where the roots of all processes can be found, to level 3 where a critical process of emergence of the truth takes place, to level 2, where the bulk of the analysis and design work is carried out, resulting in formalised decision making processes. Thus, the Humphreys and Berkeley (1985) framework gets an empirical validation: it has excellent discriminating power and can form the basis upon which information systems can be designed that provide tangible support to managers and to the decision making processes of the organisation. The decision support availability is explored in the next research question.

5.3. RQ 2: Decision support classification

The next sections consider the availability of the formal and informal decision support available to decision makers. Firstly an overview of the IT function in BigBank is presented and a very brief description of some of the core transaction processing systems is provided. This is followed by a detailed description of the decision support that is available at each representation level.

5.3.1. Information Technology Function overview

Information Technology is diffused across all areas in BigBank and is referred to as the 'Technology' function. Even within the Markets division, there are a number of Technology units, all working in an autonomous manner. Technology is a core element of the organisation and represents approximately forty per cent of the total workforce. Technology is embedded in the business organisation structure and is 'business product' based. While the majority of the staff members are located in New York and London, there are growing numbers of staff in China, Hong Kong, and in India. Technology has grown organically over the lifetime of the organisation through many acquisitions of financial institutions, whose technology platforms and systems have been retained to enable the new customer base transactions. Consequently in 2008, some 90,000 individual applications and 16 different database standards have been identified, as a result of the combination of the strategy of non-integration of platforms and systems, as well as the customer centric trading focus discussed in the previous sections. The objective for the technology group is to reduce this number to 50,000, and ideally to 30,000 applications over the coming five years. Every one of the research interviewees acknowledged the criticality of IT in the organisation. Equally, the lack of coherence and the lack of availability of consistent information is a major concern for all of the research interviewees. The next sections outline some of the existing data capture systems as well as the many initiatives undertaken to provide better executive information.

5.3.1.1. Current trade capture systems.

BigBank operates in a highly regulated industry. Equity trades are subject to regulation, and the trades are the primary source of income for the organisation. Many of the trade capture and reporting systems are some of the first information processing systems which were implemented, and many continue to operate on legacy platforms which were built 20 to 25 years earlier. All application systems modifications require regulatory approval. In recent years, there have been on-going initiatives to amalgamate applications, with the initial focus on trade capture applications, so that an integrated approach for cross-product global transacting could be achieved. However this is a complex task, and one of the research informants recounted that retiring just one 'Trade Management System' has taken four years, due to the difference in standards and processes in the main market areas. The initiative to amalgamate applications is focused towards a greater level of standardisation and less once-off routines either automated or manual, but it is essentially endeavouring to "*do the same thing better*". The involvement of business and technology is required to ensure the continued amalgamation of applications. This illustrates that the BigBank case study is very representative of the general trend in modern business towards global standardised processes. It also confirms the complexity attached to implementing such changes, as well as the far reaching impact on processes; including decision making processes, when high level managers increasingly manage processes that are remote from them, and involve complex business processes (Lee et al., 2003; Markus et al, 2000; Holsapple, 2005; El Amrani et al., 2006; Leidner, 2010).

The automation of client trades is accomplished through the use of Algorithms. These are computer programs developed to perform all the transactions associated with the daily trades. In common with other technology applications, there are numerous algorithms in use. The trading environment has become very complex, and many trades need to happen within a time horizon of a few seconds, rather than a few hours, or even a day as was appropriate when the initial algorithms were developed. Thus, the current IT infrastructure is

perceived as a barrier to the achievement of finely tuned performance for this category of systems.

Complexity is a fundamental axiom of the working environment. From a management perspective, this means that control and monitoring information is a key component of the day to day focus on performance and growth. Reporting and inquiry systems and information availability is examined in the following sections. It is also a daily topic of discussion amongst managers at BigBank, further validating the choice of this organisation as a case study in this research.

5.3.2. Baseline decision support – at the lower levels of the Humphreys framework

With 50,000 applications, it is clear there are many reporting systems in place in BigBank. However there is very little positive recognition of the value and usefulness of these systems amongst interviewees. Most of the research informants in the business area were critical of existing systems, and regularly spoke of the inadequacy of available reporting systems, especially in terms of providing the information which can truly facilitate the complex and fast moving decision making requirements, facing managers on a day to day basis.

The primary source of reporting is the 'Worldwide Management Reporting System' (WMRS) which generates all Financial Trading Reports. These reports are considered to represent the 'system of record' for the organisation, and are the basis for all senior executive reports. This is a batch system, and all updates to WMRS are from a 'twenty year old mainframe system' where all trade transactions are processed overnight. The batch financial reports are on a T+1 (trade date plus one) basis, and are the primary set of management reporting received on a daily basis. This set of reports is emailed to senior executives each morning and forms the basis for all management reconciliation of trading status.

Clearly there is a need for real time reporting also, so that the activities are tracked during the day (Burstein et al, 2011). Real time reporting is the responsibility of the Front Office reporting systems. These reports, on the current positions for 'Cash', 'Derivatives' and 'Risk', are available at all times

during the day. At the end of the trading day, a separate set of real-time reports are generated based on T (trade date). These include risk management reports, trading profit and loss reports, commission reports and the 'delta position' for the day. This second main set of management reports is referred to as the 'trader's flash reports'. These are also emailed to all senior executives on a daily basis. However, this second set of management reports must be reconciled to the T+1 reports of the following morning, sometimes tediously so, and merely provide a real-time indication on the day's trading position.

This indicates that there is an abundance of reporting mechanisms available to executives, which is utilised at all levels of management right up to the most senior executives in the organisation. Jim, one of the senior technology domain interviewees, summarised this dilemma:

> *We certainly have no shortage of data to review – a horrific volume of data, we probable miss things because we have so much data; the reverse of the purpose of providing people with accurate information becomes the truth.*

It is a surprise to note that, in a world class organisation with this scale of leading edge investment in IT, including dedicated BI spending, a manager in the technology domain could still be found to agree with Ackoff's 1967 assessment of MIS systems as "MIS-informing" managers. Although the conclusion that this is a badly organised firm is an easy one to propose, it is preferable to consider that, such case studies are indicative of the size of the challenge faced by Business Intelligence and decision support designers, when they seek to provide even simple level reporting tools to managers in a complex business setting. It is worrying that such comparably simple BI tasks are still problematic in the golden age of BI (Davenport et al, 2010).

The next section considers the decision support available to executives pertaining to the higher levels of the Humphreys framework. By and large, these inform executives on numerous aspects of operational performance, and crucially shed light on the deviations that occur between the two sets of management reports generated on the basis of T and T+1 respectively. These discrepancies have their roots in the different sources of raw data used to

compute the reports, and in the different latencies that afflict these two categories of information systems. Needless to say, these discrepancies are a topic of intense conversation amongst users.

5.3.3. At the core of decision making – levels 2 and 3 of the Humphreys framework

There is ample evidence of scrutinising decision support, pertaining to levels 2 and 3, being available to executives. The tools available for such stages in decision making processes vary from 'official' Technology-developed systems to the versatile MS Excel®. The WMRS system discussed in the precious section is the basis for all official MIS reporting. 'Proper' is the term used to designate the status of WMRS derived reports, as opposed to those developed by business managers based on multiple other sources of the 'same' data.

As already mentioned, there are many criticisms of the MIS reports which are based on WMRS in terms of the lack of granularity of the information they provide, and the lack of certified information until the T+1 reports are available. From a managerial perspective, the lack of granularity is a source of major frustration because considerable manual effort is required to unpack from the aggregate data, the full detail required to reconcile the differences between the daily flash reports and the 'proper' MIS reports. The granularity of data capture is as it was twenty years ago. This means that certain trade categories cannot be extracted, as they are aggregated when being processed. Therefore, further segmentation is not possible for more recently introduced product and trade type categories. Electronic trading and segmentation of electronic trades, which is considered a potential growth area, is aggregated under the 'Cash' category, for example, and has no visibility on the MIS reports, other than as part of 'Cash'. Furthermore the emphasis on product information also means that the organisation has failed to achieve the coveted "single view of the customer". From these observations, it is evident that a rift opens up between the reality of managerial discussions and the picture of the organisation captured and displayed in the information systems. This represents a failure of information

systems to track the decision making processes of managers, and reduces the level of support that can be attained from applications. The next sub-section discusses how the business executives compensate for the lack of 'official' decision support, as well as their sources for the support they need.

5.3.3.1. User developed decision support

At individual level, MS Excel® is used extensively by almost all the informants, whether in the business area or in the technology area. There is an abundance of examples of extracting information based on more than twelve spreadsheets which have been developed by the executive's subordinates. The executives in CAO roles seem to spend an inordinate proportion of their time extracting and filtering data for control, monitoring and rationalisation purposes with regard to their own decision making or that of their director. Even with this level of filtering and personalised presentation, the overriding perception is a sense of executives being overwhelmed by the volume of information, and the lack of clarity and conciseness of specific decision support needs.

The impact on having an overabundance of information is recognised as problematic by many of the research informants who point out that ideally

> *its about making a decision based on the information that you want, rather than decision making based on what you have.*

Technology staff are very aware of the lack of support offered in certain areas, and they point to developments under way in an attempt to rectify the current scenario. However the abundance of user developed decision support applications confirms an observation made in section 2.5.2: the intentions of managers are just as important as the intentions of developers when it comes to decision support.

5.3.3.2. Recent Technology developed decision support

There have been some official systems developed in recent years, which are focused on level 2 and 3 type decision problems, with the development of a 'Sales Dashboard'. The data for the Sales Dashboard are based on the real time

trading entry systems, which are also the basis of the 'trader's flash reports' (T based) discussed in the previous section. The Sales Dashboard was designed as primarily, a commission reporting system for the front office, but it also shows trade positions - volumes and value by client category, risk positions and stress points, as well as commission information. It has drill down capability for platinum and gold status clients, and by product groupings. The Sales Dashboard is a corporate strategic initiative, and will encompass all markets, once completed. Each trade transaction is also fed to a real-time data base called RTDB, which has similar levels of drill down capability as the Sales Dashboard provides. RTDB is being built with a more flexible inquiry type in mind, and is being made available to senior executives and their CAO staff.

These two examples illustrate how far the new frontier of decision support still is, in 2011. Whilst these two applications provide the level of support expected by managers, the fact that they are on-going recent developments, and the perception that they hide a large backlog of similar applications as yet undeveloped, can be looked upon as a cause of worry for IS researchers and IS practitioners. It could also be argued, that an incomplete portfolio of such applications is inherent in the provision of decision support.

5.3.3.3. Collaborative developments for decision support

One of the most senior research informants in the business area admitted to developing stand-alone decision support to capture the trade data for the top clients. However, the Technology people in his area were quick to point out that this project was partially covered by a RAD (Rapid Application Development) front end, for a very narrow trade and product set. This is a business driven initiative, which has taken two years to complete, using fifteen Technology staff who have been allocated to the area, and where the development was outsourced. This expedient approach indicates the frustration of senior business management with the weakness of information management and inquiry capability, which the internal Technology divisions can provide. Moreover the

fact that this initiative may be at best a short term and a partial solution, points to the mismatch between business requirements and technology deliverables.

All in all, the reliance on end user development, even in collaboration with Technology is not encouraging, particularly in a regulated environment, where it carries additional risks (Vile, 2007). Even if one acknowledges the successful support derived by managers from their self-service systems, it remains a critical imposition on their time as managers, when, arguably, the information should be at their fingertips (Rockart and Delong, 1988), whether it is provided by systems or by dedicated support staff. The BigBank case study does not display a systematic approach to delivering decision support to managers for level 2 and 3 type problems.

5.3.4. At the root of decision making processes – level 4.

There are also some Technology driven initiatives in place to develop a 'complex event processing' capability, which will have a degree of intelligence built into it. Three FTEs have been assigned to the project, which indicates that the initiative is exploratory and it will be some time before anything meaningful is available for senior executives. The current inadequacy of data mining capability is apparent during every interview, and every one of the research informants agree that new initiatives are urgently needed.

At level 4, people are recognised as the source of information. The most senior research informants rely on their people for all of their information inquiry requests. A number of these very senior directors believe that even the technology used to capture information is inadequate. Expertise and experience are highly valued attributes. Anne refers to the significance of these people as follows:

> *In this environment, subject matter experts and the 'ten year experience' people are vital when new initiatives, or new and changing regulatory policies are being investigated.*

Senior directors are aware that the information provided is filtered, and for the most part they require further filtering, and ideally, they require more

targeted information provided to them, which will help them to deal with the most critical and pressing of internal issues in a timely fashion. Owen, surmised that in an ideal world, a set of actions would be presented to him at the beginning of the week. His dream entails

A report with the ten things that have come from the data – based on client management and from business management that have been through all the data… which can then be discussed at meetings.

Essentially, senior executives could then concentrate on higher level issues. The acceptance that public relations (PR) is recognised as warranting its own budget was presented as an analogy as to the merit of employing people who are recognised for their capability with information and IS. This is in keeping with Murphy's (1994) conclusions that the actions of Decision Support staff are more likely to have an impact than any information systems at this level of abstraction. Despite the most optimistic claims of current literature and their concentration on very positive case studies of organisations, which, for a variety of reasons have managed to develop high impact decision support applications (Carte et al, 2005; Piccoli et al, 2008; Davenport et al, 2010), there is still a long way to go to the new frontier of IS for Decision Support.

5.3.5. Conclusion to Research Question Two

Research question 2 has enabled the discussion and the presentation of the information and inquiry systems which are available to managers and decisions makers at each level of the cognitive representative framework, identified in Research Question One. At the end of Chapter Two, decision support is considered from the perspective of the inquiry classifications of Adam and Pomerol (2008), which are examined in conjunction with Sage's (1981) hierarchical structure of decision rules. These are: Reporting inquiry systems, which provide information which can be used when resolving well-structured decision problems; scrutinising inquiry systems, which facilitate explorative

heuristic activity; and discovery inquiry systems, which assist managers to engage with unstructured problems.

The system of record reporting systems in BigBank, are based on twenty year old legacy systems, and they are limited in their capacity to deliver the current level of reporting granularity which is required in a complex and dynamic business environment. These systems were developed to process daily transactions globally, within a highly regulated industry. The more recently developed real-time front office systems are designed to enable the tracking of trading activities during the day. While there are numerous reporting type systems available, the system of record reporting systems experience latency issues, and the front office systems lack verifiable reporting accuracy, until substantiated when the system of record reports are generated. CAO staff compensate for this dichotomy by providing reports that filter the discrepancies and that provide information which is the basis for managers' explanations of the current status of goal realisation, as well as their justification for decision outcomes. The answer machines of the 1980's as described by Earl and Hopwood (1980) are very much in evidence.

The source of 'proper' information is the WMRS. The rigidity and batched nature of this system is significant when any degree of scrutinising activity is required. The rigidity associated with the database structure means that any level of analysis, based on product or customer segregation, is reliant on all data being regenerated, at different levels of granularity, by individual staff members, and in particular by CAOs and their staff. Therefore, most scrutinising inquiry outputs are based on information derived from MS Excel®. Table 5.3 summarises the information systems which have been discussed in relation to Research Question Two and presented to correspond with the Adam and Pomerol (2008) classification.

Inquiry type	Decision Support Sources
Discovery	Ten-year-experience people the primary sources of decision support. These are domain knowledge people and also highly skilled in MS Excel. 'Complex event processing' system in exploratory development.
Scrutenising	MS Excel used extensively especially by CAO staff. Sales Dashboard in development. While Sales Dashboard is a commission system, a real-time database is also generated, which will be the basis for a more flexible and more available inquiry system for senior executives and CAO staff. End-user RAD inquiry system for narrow trade and product set.
Reporting	Standard reports include risk management reports, trading P&L, commission and 'delta position'. System of record "T+1" reports generated overnight and disseminated next morning to all levels of organisation, based on WMRS legacy applications. Trade granularity based on business of 1980's. Daily trading reports in real time "T", based on 'Front Office' systems, but lacking validity until reconciled with T reports.

Table 5.3. Sources of Decision Support at BigBank. (Based on Adam and Pomerol (2008) classification)

The business executives recognise the 'ten-tear-experience' people as their source for discovery type information, especially for new initiatives or for new and changing regulatory policy investigation. The senior technology executives acknowledge that support for the senior business executives is neither consistent nor cohesive. Jim, who is the global head of technology in the prime finance and futures markets, summed it up as follows:

> *Senior executives have lost out most, in the cohesiveness and conciseness of the reporting requirement they need.*

Electronic trading is a growth area for the business, and as already discussed, it does not have a separate categorisation within the legacy WMRS. Richard, who is the global head of Electronic Trading, demonstrated the difficulty that he encounters on a daily basis when he is managing the traders' portfolios of those who report to him. Executives, at this senior level find themselves locating information from twelve different MS Excel® spread sheets, with no agreed upon columnar formats, with inconsistency of data on the different spread sheets, for example, "Brau Olive; Brauet Olive; Ollie Brauet" all denoting trader name, and with summary information on some spread sheets only. The

data is derived from the many transaction processing systems that have been developed to support electronic trading, with data input by the clients and by the traders.

In summary, reporting type systems are prevalent across all business areas. However, scrutinising type systems are not systematic for all the business areas, and discovery type inquiry is provided for by decision support and CAO staff exclusively.

5.4. RQ3: Analysis of decision support supply and decision maker demand: towards a concept of Decision Support Maturity

Research Question One addresses the different decision problems which are encountered by managers in BigBank. These are categorised at the different representation levels of the Humphreys and Berkeley (1985) framework in BigBank. Research Question Two considers the availability of the formal and informal decision support available to decision makers, at each of the representation levels. Decision support has also been classified by inquiry type of reporting, scrutinising and discovery (Adam and Pomerol, 2008). Using these elements, Research Question Three seeks to characterise the scope and nature of decision support maturity in BigBank. A model of Decision support maturity is presented in Chapter two (see Table 2.8), that suggests that the availability of all three inquiring classifications, as per Adam and Pomerol (2008), would indicate a highly mature level of decision support in an organisation. Therefore Research Question Three is a synthesis of the findings in relation to the first two research questions, and offers the researcher the opportunity to discuss the scope and quality of decision support provided in the organisation across the cognitive representation levels. At the end of Chapter Two, it is proposed that a level of decision support maturity can be understood based on the size of the footprint of the decision support and Business Intelligence applications and on the inquiry capabilities of the decision makers (managers and specialists). Thus, the relationship between the supply of decision support and the demand of the

decision problem formulation is being examined. When decision support is available up to and including Level 4 (and even Level 5) of the Humphreys and Berkeley (1985) framework, then reporting, scrutinising and discovery inquiry is facilitated, and this would represent a high degree of decision support maturity.

Research Question One provides an understanding of the nature of the management decisions at the different representation levels, and in turn, it highlights the nature of the decision support requirements at each level. Research question Two has facilitated the researcher to identify the range and extent of the decision support available, and ultimately, a decision support maturity level for the organisation.

Table 5.4 presents a summary of the researcher's observations in terms of the level and nature of decision support observed at BigBank. Clearly, reporting systems are well represented and they fulfil the criterion for decision support when the information requirement is associated with the operational control and performance monitoring of the daily trading activities. Therefore, decision problems classified at level one of the framework: those characterised by little ambiguity and low levels of abstraction; are well covered by information systems and Decision Support Systems were used extensively. In other words, the decisions identified at level 1 of the framework are supported by well-developed reporting tools based on the systems of record.

Cognitive level	Decision Support Scope and Quality
5	No formal systems in evidence
4	Discovery type modeling dependent on 'ten-year-experience' people.
3	Scrutinising activity largely based on MS Excel and CAO expertise
2	Control and monitoring based on individual managers maintaining multiple MS Excel based spreadsheets. Data is extracted from official sources (WMRS and front office system) and their own individually maintained databases.
1	Extensive Reporting available, but manual reconciliation required for T and T+1 validation and trade analysis.

Table 5.4. Decision support maturity in BigBank

However, when any level of reconciliation or investigation is required, then there is a dearth of automated reporting availability, which would be a normal expectation in an organisation of the size and cadre of BigBank. As discussed in section 5.3, scrutinising type information is mostly provided by CAO staff based on sophisticated but individual MS Excel® activity. There are some initiatives that will provide scrutinising type inquiries for executives and senior managers. The RTDB initiative is an example of one such initiative.

BigBank managing directors rely on their senior domain experts for all discovery type information. In discussion with senior executives, there was a fundamental assumption that people are the one and only true source of information of this nature. During interviews with technology domain executives, the development of systems with potential discovery capability was deliberated upon. However, it was agreed that the benefactors will be the CAO staff, who will have a greater degree of confidence in the relevance and accuracy of their efforts, rather than influencing the decision makers' activities, directly.

BigBank is an organisation that has application systems that are crucial to the daily trading and performance and governance operations that were developed more than twenty five years ago. BigBank was an early adopter of IS, and has consistently relied on technology over the last twenty five years, evidenced by the considerable technology investment over the years. It could be argued that, without a doubt technology in BigBank is not a significant enabler for senior managers in achieving their goals. However, the subject matter experts, who are now the cornerstone for all new initiatives under consideration, are completely dependent on technology for the information requirements of senior executives. Therefore, it must be acknowledged that decision support based on DSS, merely leverages the concept of DSS in BigBank. However decision support based on information provided by subject matter experts is mature, with a sophisticated and an individual level of information provided to senior executives.

5.5. Discussion on the decision process in BigBank

Research Question One identified the different decision problems encountered by executives at BigBank. The decision problems were represented at the different levels of the Humphreys and Berkeley (1985) framework, and the framework proved successful in identifying and recording fundamentally different activities of managers when engaging in the formulation and resolution of decision problems at the different cognitive levels as presented in Table 5.2. The progression of cognitive thinking, whereby, the level of abstraction is reduced as the decision maker's ability to formulate and express the decision problem is refined, is also reflected in the research. The achievement of abstraction reduction coupled with solution definition is interesting, and it is not consistent at each level of the framework. In some situations, the progression follows a largely linear model of thinking, and it other situations there are many actors involved, and the interaction between these actors is significant to the understanding of the decision making process. The framework facilitates the full decision process, as essentially it acknowledges the separate elements of a continuous process.

5.5.1. Progression from Level 4 to Level 3

Decision problems identified at level 4, and the proposed solutions are significant for the business. Solutions formulated by senior executives form the basis for the implementation of structures at the next level – normally at the next lower organisational hierarchy level. The research interviewees indicate that, once decisions are made here, the expectation is that the next management level will take responsibility for the implementation of the proposed solution. On some occasions, these managers were part of the decision making process, (as in the regulation policy example), but normally these managers had not been involved in the formulation of the problem or the search for the decision solution, such that these problems were being *handed over* to

them. However executives working at level 4 of the decision problem would typically give consideration to possible solutions, taking account of certain high level constraints such as budget resources and timelines. In a number of examples, the perception is of a decision solution being handed over to managers who then have autonomy as to how to implement the preferred solution. This provides complete validation of the Humphreys and Berkeley (1985) framework where the progression through the stage of the framework is depicted as introducing an increased degree of constraint in the designed solutions (Humphreys and Jones, 2006). Moreover when there is inter-departmental involvement, the handover process can involve peers in other departments, as well as direct reports within one's own department, giving this process a truly organisation-wide dimension. Thus, a broad consensus emerges that represents the organisational perception of the truth.

The concept of working in a feedback loop type scenario between levels 3 and 4 was not really apparent, except in the assurance of regulation compliance decisions, as discussed in the previous section. This gives some support for the notion that the progression down the levels of the Humphreys framework is, in many cases, a matter of a tipping point rather than a slow slide. Furthermore, while the "how" of implementing is not yet a major consideration for the executive's thinking in terms of level 4 activity, building up of knowledge and its applicability in the implementation stages is already a consideration. It forms part of the material that is handed over.

5.5.2. Handovers from Level 3 to Level 2

As discussed in the previous subsection, handovers from Level 4 to Level 3 represent a transfer of duties, in so far as a decision is made as to what decision problems will be investigated. The transfer is regularly completed with little follow through on the part of the decision maker at the higher decision level. This is in marked contrast to the level of involvement of the decision maker when moving through levels 3 and 2 activities. In all cases, the handover was to a subordinate, and normally a direct report. There was also a high level of

feedback involved, which an executive referred to as a "*two way feedback process*". Moreover, the executive remained involved in the evolution of the solution, and in some cases this involvement persisted all the way through levels 2 and 1. Executives whose normal domain was within level 3 type decisions were very aware of their relative organisational status when reporting decision requirements upwards, to Level 4 decision makers. The general approach was to present a proposed 'best' solution wherever possible, as well as the decision problem, and a number of executives filter the amount of information provided to the more senior executives, when authority or knowledge is required to achieve decision problem resolution and authorisation.

A number of the decision problems reflect resource constraints, and while the underlying information gathering is a Level 2 activity, the final decision requires senior business executives to make 'the call'. Thus, the mapping of managers against representation level follows hierarchy to an incomplete extent. Top level managers have a tendency to hand over problems when their complexity is deciphered, but in some cases, upper level managers remain connected to the implementation of problems even where they have delegated the implementation to other managers reporting to them.

5.5.3. Handovers from Level 2 to Level 1

Although communication was very intense between managers operating at level 2 and those at level 1, there was very little evidence of any actual handover scenarios from level 2 activity to level 1 activity. Involvement at level 2 implies ensuring the operationalisation of the solution. As many activities are client focused and urgent, managers assume an operational role on a regular basis, rather than incurring the time cost of handing over the decision solution, which can often be difficult and time consuming, However, the more experienced Senior-VP level informants understand that developing reliable handover processes for operational type activities to appropriate staff would free up precious time for them. Over time, and given successful implementation of handover procedures, not only would time be freed for higher level managers,

but execution time would also accelerate without the current need for constantly seeking decision clearance from senior managers at SVP or even director level. The complexity of the decisions themselves will remain, and in the current environment it is not clear how the handover procedure could be implemented. There are no information systems in place that could support the transition from level 2 to level 1.

In summary, the presence of handover activities between the levels is highly significant, and it is remarkable that these activities are very different between levels 4 and 3, between 3 and 2 and between 2 and 1. While the observations are very tangible, they pertain only to the BigBank case, and as such, a much larger body of observations needs to be built up to theorise more conclusively on this fundamental decision making process.

Ultimately, the concept of representation levels, as presented by Humphreys and Berkeley (1985) and Humphreys (1989) and as applied in this study is very important for research on decision support, because it provides a tangible basis for discriminating between the informational and decisional needs of different actors in the organisation, based on the level at which they operate in, when facing decisional problems of various grades of complexity. In places, it correlates well with hierarchy as the handover of problems down the levels of the framework can be mapped onto hierarchical levels. There are exceptions however, as for example, when managers decide to remain closely associated to their "pet" problems, or when they do not want to incur the time required in executing a clean handover to a subordinate.

5.6. Conclusion: BigBank findings

The theoretical framework presented in Figure 2.8 in Chapter Two correlates 1) reporting type decision support with level 1 of the Humphreys and Berkeley (1985) framework; 2) scrutinising type decision support with levels 2 and 3 of the Humphreys and Berkeley (1985) framework; and 3) discovery type decision support with level 4 of the Humphreys and Berkeley (1985) framework. The findings of the research indicate that support provided by the official IS and

DSS will (and should) satisfy the requirement of reporting and scrutinising activity. Figure 5.3 is derived from Table 2.8, and indicates the overall findings of the research study for BigBank. Some of the interesting aspects include:

- While the resolution of decision problems has a top-down approach, it is not a linear process. The selection of decision problems that are considered, as well as their choice alternative is typically determined at level 4 of the framework. However, in most scenarios, the implementation process is the remit of lower level managers, who operate at level 3 and below. Typically a handover of a ready-made and a restricted solution occurs, whereby level 4 executives dictate the solution. Revisiting the selected solution is rare, unless it proves problematic.
- However the same level of absolute handover or delegation is not apparent at the lower levels of the framework. Where delegation occurs at the lower three levels, there is an evident two-way communication flow, until implementation is complete.
- Technology delivered decision support is a mixed bag in BigBank, with an overabundance of information and applications available. However it could not be termed comprehensive or mature. The negative impact of legacy systems in a regulated industry generates a continuous workload for the majority of the staff who operate at levels 1, 2 and 3. Moreover, while senior business executives are very critical of the IS systems, the restrictions associated with operating in a regulatory environment were not identified by these executives, as a contributing factor to the lack of technology driven decision support. Rather, the impact of regulation was observed in relation to the handling of procedural uncertainty, as discussed in section 5.2.2, and necessitated senior executive involvement, and a requirement for human resources rather than technology enabled support.
- This empirical study identified the over-reliance on subject matter experts, who remain the key source of domain insights. In BigBank, employing and retaining people with analytic and domain expertise is critical for the

organisation. This underlines Davenports (2006) assertions regarding the organisational benefits gained through analytics.

Decision making					Decision Support	
Cognitive representation Level and abstraction level (max to min)	**Decision Problem Focus**	**Problem solution constraints**	**Communication and Handovers**		**Information requirements**	**Delivery Strategy People or technology**
5	Future organisational strategy. Complex uncertain external environment	Not applicable	Organisational review set the agenda for future direction		Business overview: reconciliation of T and T+1 reporting	Not applicable
4	Procedural uncertainty and complexity	Time taken to devise solutions	Solution handed over to Level 3		Customer profiling. Validation of external signals	'Holistic judgment' * and Discovery type outputs achieved by CAO role
Disconnect between level 4 and level 3 handover, with a fundamental change in objectives at levels 3, 2 and 1						
3	People management, product-centric-tech and customer-centric demand	Organisational structure & objectives in conflict with urgency of implementation requests	From 3 to 2 and 1. Rarely to 4 unless solution unresolved		Customer profiling to ensure business objectives are realised	Office automation tools and domain experts. 'Heuristic elimination' inquiries and scrutenising outputs achieved through once-off RAD system. But narrow focus.
2	Multiple process issues	Solution process dilemma – more people or more technology	From 2 to 3 From 2 to 1		Customer centric focus required from product centric data	
1	Conflicting priorities	Reactionary process	From 1 to 2		'Holistic evaluation' based on verifiable T reports	System of record reports from legacy systems on a T+1 timeframe and product classification

Figure 5.3. Synthesis of research findings in relation to BigBank

*Holistic evaluation, heuristic elimination and wholistic judgement after Sage (1981).

5.7. Conclusion: Analysis of propositions

Research Question One and research Question Two have each been explored in sections 5.2 and 5.3. Due to the exploratory nature of the research, some propositions were suggested that would underpin the operationalisation of the research project, and in particular the operationalisation of Research Question One and Research Question Two. This section examines the seven propositions. Propositions 1, 2, 3 and 4 sought to establish some key elements of decision problem formulation, so that utilising the Humphreys and Berkeley (1985) could be facilitated. In a similar way, propositions 5, 6 and 7 sought to establish some key elements of decision support that could enable the identification of the nature and scope of the inquiry classifications and the decision support maturity proposal as presented at the end of Chapter Two.

Proposition 1 sought to confirm that the Humphreys and Berkeley (1985) framework, was a meaningful and operational platform for classifying the evolution over time of managers' understanding of the firm's decision problems – the fundamental decision making process of all organisations. The Proposition is supported in this study and it was surprising to see how readily managers understood and engaged with the concept. They found it easy to comprehend, and meaningful in describing their endeavours. This is a call for more research in DSS which leverages the concept of representation levels.

Proposition 2 sought to establish the dynamic nature of the process of emergence of some form of organisational truth, as problems become increasingly well-defined and solutions become attached to them over time. Again, this proposition receives much support in this research study with managers ready to provide examples of problems they faced in the past, for instance, the perception of grave threats facing BigBank back in 2008, without any specific observation to back up the claim, let alone any potential solutions with which the crises could be resolved. In the observations as described, the

Humphreys and Berkeley (1985) framework leads to a grand scheme to study decision making processes. The dynamic process described in section 5.2, progresses from the root of decision making at level 4, to its core at level 3, to enabling the solution from the engine room at level 2 and finally, to when the rubber meets the road at level 1. To a degree, all decision making processes are shaped in this broad organisational forum, coming in as ideas and emerging at level 1 as routines. One key feature of this grand scheme is the concept of hand-overs, where managers at the higher levels develop ideas to a certain extent, formalise them by placing constraints against their solutions, as theorised by Humphreys and Jones (2006), before handing them over, increasingly "packaged" to lower level managers.

Proposition 3 sought to confirm the specialisation of the different hierarchical levels at the different levels of the framework, where top managers handle the higher levels of abstraction, middle managers design processes and lower level managers implement and execute the plan. This proposition receives partial support, in the sense that managers basically behave in the way that the proposition is stated, with notable exceptions where managers decide to follow their "pet projects" and become involved (by choice it seems in this case study) in lower levels of implementation, thereby by-passing the usual hand-over scenarios of the organisation. In other words, the proposition is basically true, but may be normative in certain cases.

Proposition 4 sought to validate that the process described in the first 3 propositions provided an increasingly stable platform for the development of decision support for managers, in the shape of help provided by support staff or dedicated decision support systems. In broad terms, this proposition is supported, not least by vast segments of the DSS literature, and also partially in the case of BigBank. Our observations do indicate the more formalised decision support systems of the firm provide dedicated support for levels 1 and 2, and definitely, no support systems are available to reflect on problems at levels 4 and

5. The issue of whether the quality of support provided is a good match to the types of problems, or whether managers are more satisfied by the applications available to them at the lower levels is best left for discussion of the subsequent propositions on decisional support.

Proposition 5 sought to establish the extent of extended use of decision support, whereby managers come to be highly reliant on the decision support they receive and are generally very satisfied with that support. The validation of this proposal comes in different shapes, insofar as decision support at BigBank is a patchwork scenario. The formal T+1-based applications provide high levels of support, but the level of managers' satisfaction is very low. For instance, the granularity of the data is criticised, and only the reliance on further manipulation of the data increases the level of satisfaction of managers. In other words, managers at BigBank are supported by a multi-speed system, which involves them to a large extent, such that the data they need is rarely at their fingertips. Extended use of decision support is evidenced in the 50,000 mostly end user developed decision support, but this runs somewhat against the spirit of proposition 5, whereby, managers' frustration leads to them taking matters in their own hands, in collaboration with their support staff. These observations give much support to Alter's notion that decision support is more interesting than decision support systems. Proposition 5 is validated in that decision support and the guidance that managers build into it are critical to the decision making processes of the firm, but the support is not provided in the way that DSS theory proposes. Extended use is prevalent and BigBank is heavily reliant in IS in its decision making processes, but the DSS portfolio is incomplete and the role of the Technology function is controversial and uncertain.

Proposition 6 sought to establish that, over time, the reliance on decision support in a firm increases and reaches higher levels of sophistication within specific domains of managerial complexity. This proposition receives some support, with clear examples of scenarios where older systems are retired and

replaced by support systems that satisfy managers to a greater extent. The examples of the Sales Dashboard and the RTDB provide illustration of the embodiment of increasing levels of managerial understanding in representing problems, and in solving them through the development of applications for everyday use. These systems involve high levels of decision support and guidance and fit well with the propositions with regards to what the theory says should happen with level 2 problems. However, the speed of the Technology function response to the decision support needs is inadequate, and the case does not provide any indicators as to how this scenario can be resolved, even is such a large and powerful firm, with a very well-resourced technology function. The proposition, therefore, is not supported when it comes to the emergence of sophisticated systems.

Proposition 7 sought to measure the impact of decision support on the decision making of managers and its level of fit with organisational objectives, and with the context in which manages operate. There is only partial support for this proposition, as there is clearly an abundance of decision support available at BigBank, and most of it is very pertinent to the work of managers: risk management reports, trading profit and loss reports, commission reports and the 'delta position' for the day are all in place. The over-abundance of data, the lack of real time information and the latency in the formal *system of records* of the firm are clear weaknesses, but the informational guidance seems to be evident all the way up to level 3 type decision problems. The failure to be able to display the business data to the right level of granularity and to present a customer-oriented rather than a product-oriented view, are big limitations, however. Informal, user developed applications have greater impact across the board but their lack of validation and the need for very labour intensive reconciliation, limits the quality of these systems. Thus, both official and unofficial DSS / BI applications suffer in terms of their quality and in terms of the impact they can make on decision making.

Broadly speaking, the propositions were validated. In particular, the propositions further highlighted the merits of the Humphreys and Berkeley (1985) framework in providing clarification of the decision support requirements at the different representation levels on the one hand, and in proposing the development of the informational and decisional guidance and support applications and inquiry facilities, on the other hand. Ultimately, the processes described in this research, both on the emergence of the truth side and on the decision support development side, are collaborative processes, leading to negotiated outcomes: they embody the combined intentions of managers, technologists, support staff and any other stakeholders in the decision support arena. This gives shape to the existence of an organisational capability for decision support, helping researchers to bridge the gap between the individual level and the organisational level in the study of decision making.

Chapter 6. Research Study Conclusions

This chapter presents the overall conclusions of the research study. The chapter begins by outlining the research objective and the research questions for the study. This is followed by a discussion on how the research objective was addressed, by leveraging the observations made within each of the research questions. Following on from this, the theoretical contribution of this research is discussed, and the implications of the findings for research and for practice are also considered. The limitations of the study are considered and the chapter concludes with recommendations for further research.

6.1. Restating the Research Approach of this Research study

The overall goal of this research was to investigate the nature and extent of decision support that is available to organisational decision makers, at all levels of an organisation; and the nature of the decision problems which must be supported. The research project leveraged the Humphreys and Berkeley (1985) framework to facilitate an understanding of organisational decision problems and decision support from a cognitive perspective. Therefore, to achieve the aim of this research, the attributes of particular interest for the research model employed in this dissertation are the complex decision problems which occur continuously in organisations, and the decision support, in the broadest sense, that define the nature and the level of decisional guidance and support available to decision makers, such that, decision solutions are devised based on high-value information that is easily accessible and is of relevance to the decision maker. In order to achieve this goal, a research objective was proposed and three research questions were formulated to address the research problem.

6.1.1. The Research Objective and Questions

The research objective of this study was stated as follows:

An investigation into organisational decision support for decision makers, through the application of a cognitive framework that characterises decision

problems based on their level of abstraction of problem representation and on their level of formalisation of the proposed solution.

The following research questions were formulated to enable the achievement of the research objective.

Research Question One: *How can complex decision problems, which managers encounter, be represented and analysed from a decision support viewpoint, by using the Humphreys and Berkeley (1985) framework?*

Research Question Two: *What level of decision support and decisional guidance is available to decision makers, individually and in groups, within the organisational decision environment, with respect to the different category of problems facing managers?*

Research Question Three: *How does the level of availability of a decision support portfolio to match the decision support needs of managers, reflect the decision support maturity of an organisation?*

The findings of this study are based on the findings of each of the three research questions, and they are presented in the following section.

6.1.2. The role of the Research Questions in reaching the conclusions of the study

Figure 6.1. captures how the three research questions serve to answer the objective by providing an overview of the interconnectedness of the research questions. The figure shows an abstracted view of the type of findings harvested in the BigBank case study, which is the case study most thoroughly examined in this research.

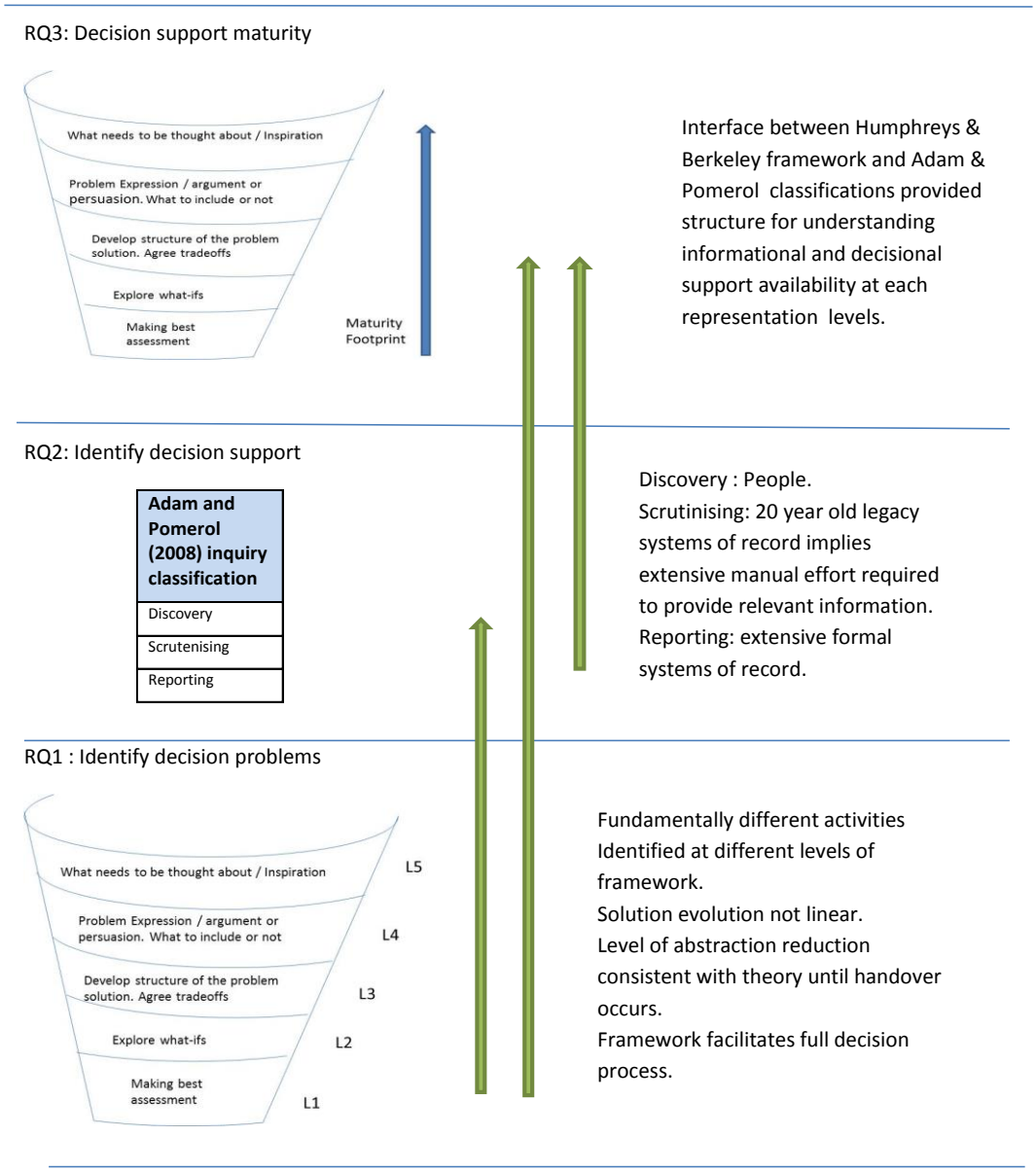

Figure 6.1. The role of the research questions in answering the research objective for the BigBank case

As illustrated in Figure 6.1, the insights gained from Research Question One and from Research Question Two combined to form the inputs to Research Question Three. While Figure 6.1 provides an overview of the researcher's approach to analysing and to organising the empirical materials collected throughout the research (in answering each of the research questions), it also highlights the theoretical contributions to the research questions. The next

section presents a synthesis of the findings under the heading of the three research questions.

6.2. The contribution of this research study

The exploratory study, which was conducted prior to the BigBank study, afforded the researcher the opportunity to assess the applicability of the Humphreys and Berkeley (1985) framework. The exploratory study was successful in applying the framework to represent a cognitive perspective to the representation of managerial decision problems encountered by organisational decision makers, even though there were very few examples of issues that could be categorised as pertaining to level 4 of the framework during the study. This reflects the middle management positions held by the study participants and the narrow focus of their observations. Therefore, the theoretical contribution discussed in the following sections relates to the findings from the main study for the most part. Where findings from the exploratory study are included, the researcher's intention is to provide context and clarification in a more substantive manner that is possible through the abstraction of just the main case study findings.

6.2.1. Research Question One: The representation and analysis of complex decision problems, using the Humphreys and Berkeley (1985) framework

Research Question One examined the applicability of the Humphreys and Berkeley (1985) framework to the identification, representation and analysis of decision problems encountered by managers in an organisational setting. This empirical investigation leverages the framework to capture the cognitive processes of decision problem formulation and decision solution evolution from the point where the decision maker is aware of a problem, but not able to express the problem, to a point where requirements are clarified and therefore, a solution to the decision problem is articulated and can be implemented. Moreover the framework, proved to be very accessible to managers, and from

the earliest stage of many of the interview sessions, the framework representation (Figure B2) was adopted by the interviewees to describe their own decision making process, and to portray the many examples of decisions problems that were discussed.

While all decision problems are reflected as being elusive and abstract when first encountered, this research established that the constraints that are determined by senior managers when they define the scope of what will be implemented, means that elucidation and understanding happens very quickly for managers at level 3, but, especially so at levels 2 and 1. Therefore, the framework reflects the decrease of abstractedness that happens when decision makers refine the problem, based on an evolving understanding of their requirements as the decision solution is being formulated and communicated. The decision problems presented to managers at level 3 and below, are problems with a high probability of implementation of a solution. Moreover, the characteristics normally associated with delegated operational tasks were evident, for example, tasks that are repeatable and that have imitable processes in place.

However, at level 4, there is difficulty in the expression and in the analysis of the decision problem. The resultant delay in the decision process is significant and it hinders the implementation of a solution. Managers whose normal domain is within this representation level, identified experience and seniority as significant assets at this level, because diagnosing and developing the representation of the problem is dependent on an understanding based on previous experience, as well as their expectations and preferences, which are closely aligned with the long-term objectives of the organisation. However, the findings in the BigBank case highlight some instances where the lack of accessible information based on DSS and IS, hinders the efficient processing of the decision scenario, because the lack of reliable information frustrates the process of cognitive reasoning on the part of the manager, who is further stymied due to the regulatory nature of the Financial Services industry. During the exploratory case study, FIRM A and FIRM B identified decision problems at level 4, and the

evolutionary nature of the cognitive process was recognised, and the potential influence of available modelling and informational tools acknowledged. At the same time, it is important to appreciate that the frustration felt by managers in BigBank is also a consequence of the complexities they face and the associated ambiguity, which makes comprehension difficult, especially in a dynamic sense, where situations evolve too quickly to allow solutions to crystallise.

The findings of this research highlight the fundamentally different activities engaged in by different levels of management, during the resolution of decision problems in BigBank (presented in Table 5.2, Chapter 5). The analysis of these activities considers the forward progression of the representation of the decision problem as it evolves, and simultaneously, as the decision support requirements are being understood. However, the framework, in its original form does not represent the forward progression of the decision process when multiple actors are involved and when hand-over or delegation procedures are necessary. The original framework was developed as a representation of the cognitive process of an individual decision maker, and the managerial requirements of communication and delegation are not represented. This aspect of the applicability of the framework is discussed in further detail in section 6.3.

6.2.2. Research Question Two: the classification of decision support

Research Question Two identified the decision support and the decisional guidance available at all hierarchical levels in BigBank. The findings from this research question ascertains that decision support at level 1 and at level 2 of the Humphreys and Berkeley (1985) framework is well represented across the BigBank organisation, as well as, across almost all of the organisations in the exploratory study. Moreover, the systems that support decision makers at level 1 of the framework are of a reporting nature. A combination of reporting type systems and scrutinising tools and inquiries are used to provide the information required by managers who manage level 2 and level 3 type decisions. The emphasis on office automation tools, such as MS Excel®, for scrutinising activity

highlights the lack of structured and formalised enterprise-wide models and applications.

This research identifies decision support of the discovery type as relevant for those decision problems at level 4 (and possibly level 5) of the framework. Unequivocally, discovery type decision support and decisional guidance was delivered by people, most notably those in CAO (Chief Administrative officer) positions. This research highlights that while, reporting type systems outputs are presented to senior management, the lack of automated reconciliation applications, requires the involvement of domain knowledge experts on a regular basis, for what should be regarded as mundane tasks. Without doubt, the inappropriateness of reporting type outputs for executives is well known and is discussed in both academic and practitioner literature. Moreover, the use of human subject matter experts for reconciliation purposes points to a poor use of their time and expertise, and represents a high cost to providing this type of reporting in a more suitable format. The exploratory study highlighted two organisations (FIRM A and FIRM B) with a comprehensive portfolio of decision support that can be classified as reporting and scrutinising. Moreover, FIRM A has developed modelling tools of a discovery nature, that facilitate executives in scenario planning and other high level cognitive processes. This research underscores the significance of Alter's (2004) suggestion that decision support, rather than DSS, should be the focus for research in the decision making and decision support domain, as well as Murphy's (1994) contention that the actions of decision support staff is as vital as systems development.

The choice of the BigBank case study was motivated by the scale of investment in IT, as well as the high information intensity of firms in this industry. In addition, BigBank is considered to be a leader in its field. The BigBank case gives a mixed picture of the impact of decision support at the level of the division studied. It suggests that the best match to managerial decisional guidance needs comes from the less formal (less "proper") decision support. This is understandable given the high level of direct participation of managers in developing the most informal decision support. However, the isolated

development of DSS type solutions makes the emergence of standardised and integrative solutions more difficult. Ultimately, the processes of DSS development described in this research, both in terms of the emergence of the organisational *truth* side and on the decision support development side, are highly collaborative processes, leading to negotiated outcomes: they embody the combined intentions of managers, technologists, support staff and any other stakeholders in the decision support arena. This suggests the existence of an overall *organisational capability* for decision support, based on discourses between participants which lead to better systems *within a suitable timeframe*.

6.2.3. Research Question Three: Understanding the relationship between decision support supply and decision maker demand

Research Question Three explores the concept of decision support maturity, which is defined as the relative level of the representation of decision problems identified in the framework when decision support applications and models are available that will satisfy the requirements of the decision maker. The relationship between the supply of decision support and the demand of the decision problem formulation is being examined. The findings of this research indicate that the concept of decision support maturity is more associated with the Alter (2004) view of decision support, that an availability of DSS.

Figure 2.8 in Chapter Two correlates 1) reporting type decision support with level 1 of the Humphreys and Berkeley (1985) framework; 2) scrutinising type decision support with levels 2 and 3 of the Humphreys and Berkeley (1985) framework; and 3) discovery type decision support with level 4 of the Humphreys and Berkeley (1985) framework. The findings of this research indicate that support provided by the official IS and DSS will (and should) satisfy the requirement of reporting and scrutinising activity. This is true for BigBank and for most of the firms in the exploratory study. Moreover, scrutinising type reporting and inquiries are instrumental in providing much of the information requirements for decision makers at level 3 of the framework. However at level

3, the source of the data for the inquiring process is subject to extraction and manipulation, primarily because the legacy systems in BigBank reflect the business model of their build time, whereas the level 3 managers' information requirements necessitate the current business model to be reflected.

The information requirements at level 4 of the framework is recognised as requiring the domain experience of people, specifically experienced people. While, there is ample empirical evidence of this finding in BigBank, the exploratory study example of FIRM A discussed the evolution of modelling tools with discovery type inquiry capability. This offers the exemplar for the possibilities of a high level of decision support maturity that will facilitate and empower the important subject matter experts.

This research indicates that decision support based on DSS, does not fully leverage the concept of DSS in BigBank. However decision support based on information provided by subject matter experts is mature.

6.3. Synthesising the contribution to theory and to practice

Chapter Two concluded with the presentation of the Humphreys and Berkeley (1985) framework as a linear process of decision making, whereby, the level of abstraction of the decision problem is reduced over time. This reduction of abstract thinking evolves through the simultaneous refinement of the decision problem and the consideration of potential solutions. Decision support is considered from the prospective of the information availability from the ideal IS as per Earl and Hopwood (1980) and from the perspective of the corresponding inquiring classifications of Adam and Pomerol (2008). Table 2.8 presented a synthesis of the decision problem representation and information / inquiry classification. Decision support maturity was portrayed as a continuum whereby availability of reporting type inquiries and holistic search capability reflected a low level of decision support maturity; and a full portfolio of reporting, scrutinising and discovery inquiries and support applications reflected a high level of decision support maturity. Figure 5.3 presented a synthesis of the

research finding in relation to the BigBank case study. Figure 6.2 is derived from Table 2.8 and from Figure 5.3, and presents a model for exploring the relationship between managerial decision problems and decision support opportunities.

As discussed, this research study utilised the Humphreys and Berkeley (1985) framework as a mechanism to understand manager's thinking during the decision making process. Decision making is considered from a cognitive perspective, and the Humphreys and Berkeley (1985) framework represents the evolution of managers' thinking as they learn about the reality that surrounds them, from the point where expression of the problem is difficult because of the highly abstract nature of thinking, to the point when implementation of a best solution is possible. While the Humphreys and Berkeley's framework, first presented in 1982, within the psychology research domain of that time, has received citations to over three hundred various papers, it has not been empirically tested in the organisational decision support literature. Colquitt and Zapata-Phelan (2007) argue that even the most intuitive theories remain invalid until empirically tested. This research study provided an empirical testing of the Humphreys and Berkeley (1985) framework in the organisational decision making domain. The initial testing of the Humphreys and Berkeley (1985) framework concentrated on establishing the applicability of the frameworks' core proposition. The knowledge gained during the exploratory study, and during its further application in the main case, has facilitated the expansion of the framework to represent managerial decision making across five distinct levels of management activity and introduces the communication and handover activities that are a necessary part of managerial activity. Therefore, the application of the Humphreys and Berkeley (1985) framework proved to be very successful and realised both objectives: namely, the differentiation of the activities associated with decision making at the different organisational levels, and the specification of the informational and decisional guidance and support requirement at each of the levels. Based on the examination of the relationship of decision support supply and the decision maker's information and support requirements, a model

that links the decision problem identification and the decision support opportunities evolved (Figure 6.2).

The Humphreys and Berkeley (1985) framework proved to be extremely efficient in differentiating the activities at each of the five levels, as well as differentiating the decision maker's focus at each of the levels. At levels 4 and 5 of the framework, the focus is on strategy (formulation and realisation) and on external environmental complexity. However, the internal operational demands occupy the minds of managers at the lower three levels as identified in Figure 6.2. Interestingly, managers (the research participants) found the concept of a cognitive representation of managerial thinking very accessible. They readily identified with the categorisation and framing of decision problems, as it relates to the qualitatively different aspects of the decision problem when managers gain additional insights during the problem solving process as greater levels of understanding are achieved. The flexibility of the framework in its capacity to separate the progression of the reduction of abstraction coupled with a greater degree of solution specification is consider a positive feature. Providing a separation of the constituent elements of decision making that in turn facilitates a description of the decision support requirements is very powerful.

While the resolution of decision problems is a top-down approach, it is not a linear process. The selection of decision problems that are considered, as well as their choice alternative is typically determined at level 4 of the framework. However, in most scenarios, the implementation process is the remit of lower level managers, who operate at level 3 and below. Typically a handover of a ready-made and a restricted solution occurs, whereby level 4 executives dictate the solution. Revisiting the selected solution is rare unless its implementation proves problematic. However the same level of absolute handover or delegation is not apparent at the lower levels of the framework. Where delegation occurs at the lower three levels, there is an evident two-way communication flow, until implementation is complete.

Decision making					Decision Support		
Cognitive rep. Level	**Decision Problem Focus**	**Problem solution constraints**	**Communication and Handovers**		**Information requirements**	**DSS**	**People**
5	Future organisational strategy	External environment	Continuous scanning of organisational environment		Often beyond language: fused view of external industry information and internal status quo	Intuitive conceptual modelling possibilities	People experience and expertise providing reasoning & intuitive judgement
4	Policy type decisions	Ambiguity because of complex & uncertain external environment	Clarification of solution mitigating procedural uncertainty and complexity		BI & Big Data analytics for customer profiling & validation of external signals	Modelling tools that would generate solution scenarios	
3	Middle management organisational drivers	Level of autonomy. Performance metrics	Organisation. objectives and strategic implementation decisions		Performance metrics (multiple and flexible formats)	Aligned and integrated systems	Information source consistent for upward and downward analysis
2	Multiple sources of issues: diverse, divergent and intra-organisational	Resource (people and technology) availability	Sensitivity analysis ensuring best solution		Single view of customer & other organisational drivers	Fusion view of IT: seamless integration of decision making process and information	Heuristic elimination
1	Key organisational drivers: customer focus, managing resources and performance	Lack of standard processes. Reactive vs. proactive environment	Standard communication process for customer engagement		Control and monitoring information (multiple and flexible formats)	Full automation of transaction capture and real-time reporting	Operational decision making without escalation

Figure 6.2. A model linking management decision problem identification and decision support opportunities

The BigBank case reveals the shortcomings of decision support across the levels of the Humphreys and Berkeley (1985) framework. At the low levels, there are still issues with data granularity and latency, leading to time consuming reconciliation between 'system of record' derived information and real-time information. Large scale integration of data sources requires massive investment in resources over a period of time, as the legacy systems are slowly being retired. The full realisation of internet and eBusiness transacting has added a new layer of complexity at an operational level in organisations and has renewed the focus on business analytics at all levels in organisations. An organisation with a sufficient level of data analytics ten years earlier now find themselves in a position where a similar level of information and analytics is no longer sufficient and often, even this capability is no longer available because the recently introduced transactions cannot be seamlessly integrated. The BigBank case suggests that the best match to managerial decisional guidance requirements comes from the less formal decision support. Firstly there is a greater level of direct participation of business managers in the development of the most informal decision support. Secondly, in a regulated environment, the less formal systems are not as restricted and therefore, modifications that align with current business model requirements are easier to incorporate. However the isolated development of BI and BA type solutions make the emergence of standardised and integrative solutions very difficult. Ultimately, the emergence of the organisational *truth* on the one hand, and decision support on the other hand are highly collaborative processes, leading to negotiated outcomes: they embody the combined intentions of managers, technologists, support staff and any other stakeholders in the decision support arena.

Many of the recent initiatives in the BI, BA and Big Data domains are vendor-led and despite the claims of software vendors there is some evidence that the problems inherent in proposing effective decision support are of such a nature that technology solutions alone are unlikely to solve the real decision problems conclusively. It is the enlightened selection and the accurate capture of the critical indicators most useful to the business managers, within the

organisation's currently available data sources that is problematic. Pomerol (1997) differentiates between the 'diagnosis' and the 'look ahead' aspects of the decision process as depicted in Figure 2.3 (see section 2.3.2). Diagnosis relates to the current state based on what is known with some certainty, and is provided for with a combination of reporting type systems and scrutenising tools and inquiry systems, all of which support decision makers at levels 1, 2 and even 3 of the model presented in Figure 6.2. BI and BA systems have emerged as the means to provide 'Look ahead' knowledge. The 'solution' includes the 'big data' repositories and the specialised information systems that utilise then (Davenport *et al.*, 2010). However most of the organisations in this study have failed to exploit these possibilities when the requirements relate to level 4 and 5 decision problems and even at level 3 decision problems. At the intermediary levels, when users take matters in their own hands and develop specific solutions to their own local problems, the lack of integrated information mitigates against a cohesive and unified solution and thwarts the realisation of a 'requisite decision model' as defined by Phillips (1984). The model (Figure 6.2) facilitates a more refined perception of the decision making landscape of an organisation, and a corresponding definitive avenue for the development of decision support dedicated to the different levels that have been revealed by the application of a cognitive representation model. The decision support will include BI and BA tools and also the critical support staff and subject matter experts.

The model (Figure 6.2) highlights the significance of the knowledge attribute of the experienced subject matter experts who provide the reasoning and the intuitive judgement expertise that facilitates the integrated view of the external signals and internal key organisational status information. The capability of acquiring and sharing such knowledge is distinct to the decision making capability. The model (Figure 6.2) acknowledges that decision makers operate with different levels of constraint, which manifests itself as levels of discretion and levels of autonomy on the part of the decision maker. While constraints determine the nature of the activities that managers engage in, the nature of information availability is also impacted. However a realisation of the benefit to

an organisation of Alter's (2004) definition of decision support must be pursued. The ideal of a complete portfolio of integrated and consistent information that captures all operational activity and is made available to experienced organisational actors who have analytics capability, was suggested by Earl and Hopwood (1980) and has yet to be realised in many organisations.

Therefore, it is problematic to realise that the gap that must be bridged in organisations is not only (and not majorly) a knowledge gap. Many decades after the start of the IS field, the application backlog, reported as far back as 30 years ago (Rivard and Huff, 1984), is as large as ever, even though it has probably shifted from transaction processing systems towards the decision support systems. The incentive towards "end-user developed applications", borne out of managers' frustration with the unavailability of key applications, is definitely as strong as ever (Amoroso and Cheney, 1991). This empirical study identified the over-reliance on subject matter experts, who remain the key source of domain insights. Employing and retaining people with analytic and domain expertise is critical for an organisation as underlined by Davenport (2006) and the discussion regarding the organisational benefits gained through analytics.

Thus, although this research comes in the 21st century, it indicates that some basic elements of the overall decision support *project* are yet to be implemented in BigBank. Of course, this is only one case study and it provides no observations of the general development of decision support beyond this case, but it remains that BigBank is a leader in its industry and the distance between this research study's observations and those of others, such as Davenport *et al.* (2010), signifies the distance that many firms remain from the ideal. More research with more cases, across different industries and organisational types will yield a wealth of observations which can lead to new avenues for providing high levels of decisional guidance to managers.

6.4. Limitations of this research Study

Research projects must end, and therefore, they are constrained for many reasons, for example, time and financial resources. Despite the best efforts of researchers to make their research designs as robust as possible, it is impossible and unrealistic to believe that there is 'one best way' to conduct research (Jenkins 1985, McGrath 1984). This research study was no exception, and in hindsight, it can be criticised from a number of perspectives as described in the following section.

- The nature of empirical research:

  The case study approach used in this research study has generated a considerable volume of empirical material, sourced from interviewing and from organisation-specific documentation. While, this is a characteristic of case study research in general, it still remains, that differentiating the essential evidence from the array of empirical material collected is not easy. However, the outputs of this study are facilitated by a great depth of knowledge that was gained by using the case study method, which is a characteristic of the method's strong exploratory power.

- Sampling of the main case:

  The selection of BigBank for the main case provided access to a number of senior executives that operate at the higher levels of the Humphreys and Berkeley (1985) framework. However BigBank, as an organisation did not display the level of sophistication in the form of a comprehensive portfolio of BI and DSS as could be expected in a global organisation of its kind. An organisation in a different industry could have yielded a very different portfolio of decision support.

- A more extensive range of cases:

  This then highlights the need for further research in the area of decision support and decision support maturity. However, finding organisations where decision makers at the highest level are accessible to researchers, and who

are willing to discuss the competitive environment, their decision problems as well as their decision support requirements, is not easy. This researcher had very good access to senior executives in a world class organisation.

6.5. Recommendations for Further Research

This chapter has presented a summary of this research study, highlighting the contributions to DSS research and the implications for DSS research. This research has provided empirical validation to the use of the Humphreys and Berkeley (1985) framework as a mechanism to simply and accurately capture the decision problems experienced by managers and decision makers in a manner which would position the associated decision support requirements is a novel and accessible manner. Therefore, the framework deserves further empirical development in the decision making and decision support domain. It has remained unchanged since the original framework was presented in 1985 and it deserves theoretical development and enhancement.

Research on decision support maturity has not been explored sufficiently. The focus of BI maturity has been vendor led, whereby the solution is, very often, presented based on new tools used in conjunction with existing databases. This research indicates that the substance of what this approach has delivered falls into the 'reporting' and 'scrutinising' type application and inquiring systems. However, the challenge to understand the fundamental requirements for decision support at all levels of the framework, but especially at levels 3 and 4 of the framework, namely the models and the applications which will provide the subject matter experts with information that is reliable and consistently accurate, is reiterated in this research. Therefore research on decision making would be well served to go back to the core: understanding decision maker's requirements at all levels of an organisation.

The empirical research in BigBank suggests that a number of senior executives, whose normal domain is at level 3, spend an inordinate amount of their time at operational and solution implementation activities. Prima facia this

would indicate a poor use of these resources. As discussed, (Section 6.2.2) senior CAO staff perform data reconciliation tasks that could be automated if the appropriate technology and information systems were in place. However, with regard to this observation regarding senior staff engaged in levels 1, 2 and 3 activities, no ostensible reason emerged during the research data collection and analysis. However, it is significant and warrants further investigation and research.

Without doubt, financial institutions are faced with the immense challenge of ensuring that their current and new systems comply with the profusion of existing laws and new regulations while simultaneously realising the need for integrated information from flexible applications. Delivering on this dual challenge will require research in both the academic and the practitioner domains.

Finally, the role of decision support staff and expert human analysts has been discussed in literature (Murphy, 1994; Kohavi *et al.*, 2002; Keeney, 2004). However this research would indicate that this expertise is undervalued in practice and is under-researched in the IS domain.

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Appendix A. Interview guide

Depending on the role of the Interviewee there will be a focus in either Decision problems for "business" interviewee or decision support for "Technology" interviewee

[1] Understand the decision problems encountered, and how the "thinking" evolves, so that "handling" the problem can be stated, and both the problem and solution structured. I am interested in identifying the decision problems that are valuable to the role of the employee as well as the process of formulating a policy for action, or activities for handling a solution for the decision problem. Schema 1 and 2 will be used as data collection research instrument.

[2] Identify how "decision support" for executives is supported/considered within IT. Schema 3 as data collection research instrument.

Interviewee Details

Date of Interview	
Interviewee Name	
Interviewee Position in Organisation	

The Organisation / Business unit

What are the division's core activities?

Who are the key decision makers in the division?

What is the role of the division within the organisation

What is your role in the division? Describe it, as far as possible.

Individual Interviewee role

1. Sources of the decision problem. External focus: organisation goals and the external environment, something not working, external change..
2. Sources of the decision problem. Internal focus : Peers in same business unit, different business unit, superiors, subordinates. Schema Form 1 introduced.
3. Level of abstraction of the decision problem - Schema Form 2 (H&B) introduced
4. How well defined
5. Where on schema does the "thinking" process happen
6. Structuring of solution
7. Formulating a policy for action
8. When - at what stage of H&B Schema of problem definition does manager begin to communicate the decision problem, and with whom

Note: Listen for terminology used to describe the level of decision problems.

Is terminology specific to interviewee / division / organisation.

How generalisable /generic.

Sources of information of solution:

1. Current sources from IS systems
2. Value of such information
3. Non-IS based sources
4. Value of such information

Technology (additional topics)

1. What is the main driver for infrastructure investment - Organisational goals, CEO, Divisional heads – federal type org?
2. Decision support systems for executive decision making
3. Sources of data – system of record ….
4. Perceived strengths and weaknesses…..

Appendix B : Schemas utilised during the BigBank interviews

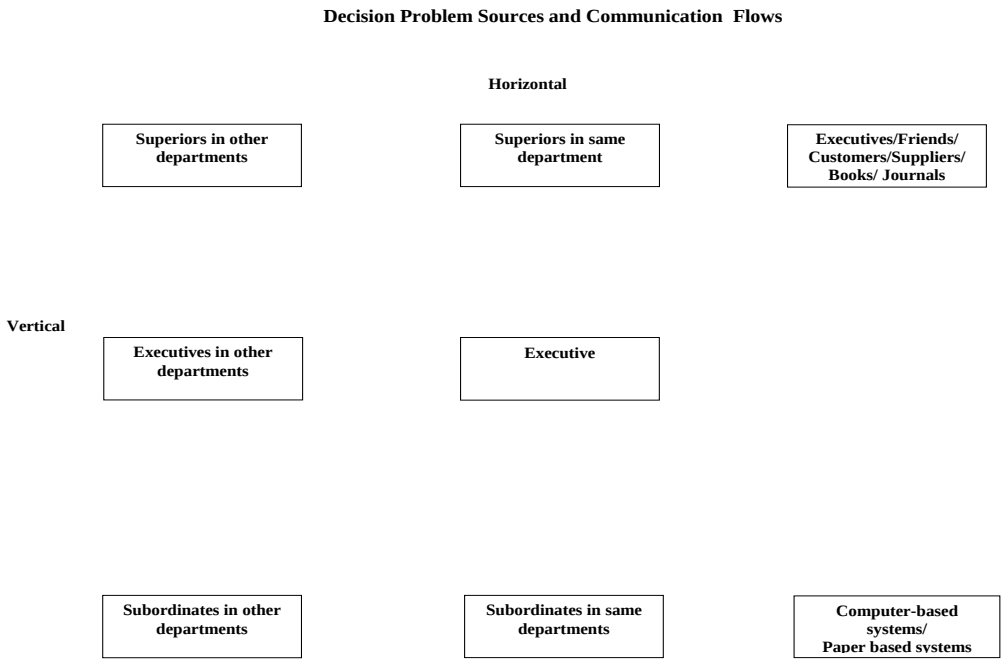

Figure B1: decision problem sources and communication flows (Jones et al. (1988)

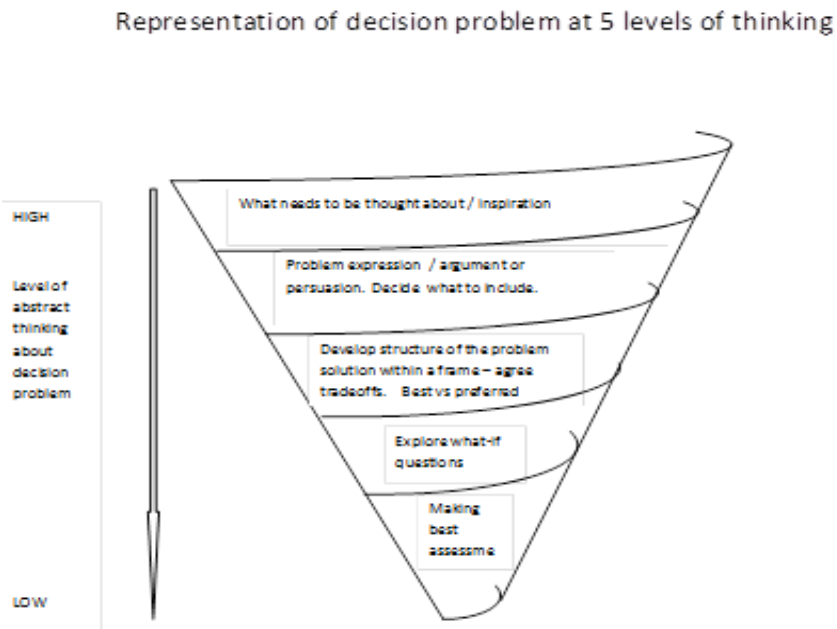

Figure B2: Humphreys and Berkeley (1985) framework

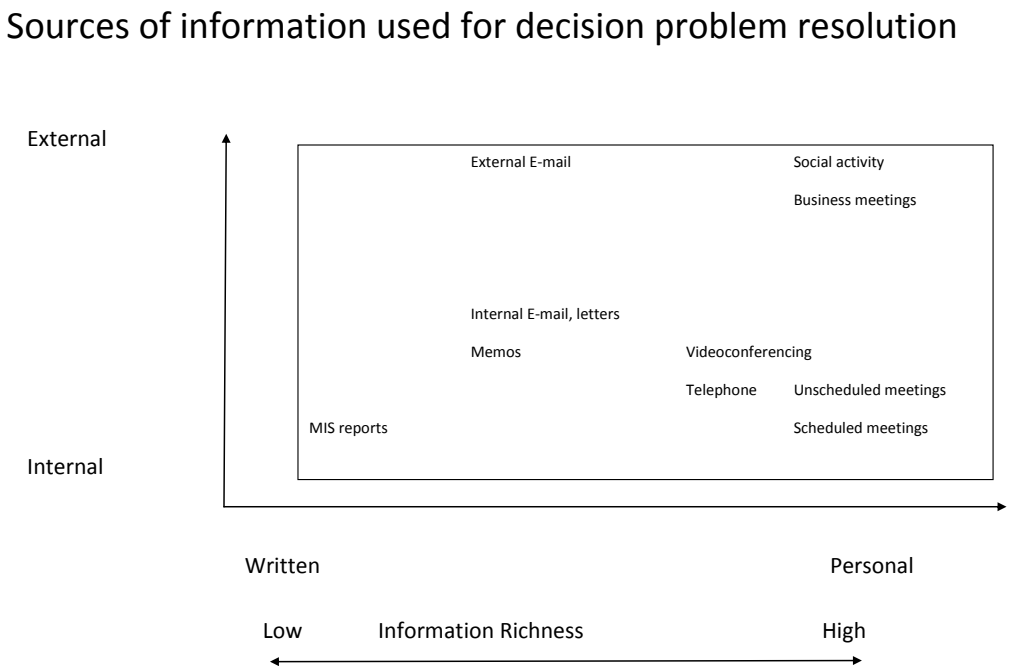

Figure B3: Sources of Information