A HYBRID OF EXECUTIVE MANAGEMENT DECISION SUPPORT TOOLS

Farzad Khosrowshahi

School of Construction, South Bank University, Wandsworth Road, London SW8 2JZ, UK

The performance of a contracting company is closely linked with the quality of the decisions at the strategic level. However, the increasing complexity of organizations' internal and external environments and the unstructured nature of decisions at the strategic level make the decision making a very complicated task. The number of influential variables is so large and their effects are so varied that any attempt to encapsulate them in a rational manner can indeed hinder the decision making process. To this end, this research explores the advantages of decision support tools and the benefit these tools can yield for the strategic management.

Some of these tools are deterministic and structured: they rely on straightforward calculation or optimisation techniques. The solution to the unstructured problems, however, has relied on heuristic approaches and judgement of the decision-maker. While deterministic problems have to a large extent been addressed and appropriate models and algorithm have been developed for them, the unstructured problems have remained relatively unattended and the research works in this area tend to focus on single issues.

This research highlights the potential use of artificial intelligent techniques in assisting the managers with unstructured decisions. Further, it is argued that a strategic decision support system should assume an integrated structure, as many decision nodes, within the overall decision making structure, share common attributes and the inter-connection amongst these decision nodes has a complex structure. Therefore, the object-oriented approach will provide an efficient structure for the development of the overall framework.

In this paper, the characteristics of decision types are identified and cross tabulated against the attributes of various decision tools. The latter consist of both traditional and AI techniques.

The work forms part of a broader research work the aim of which is to develop a framework of executive decision support system that is based on a hybrid of decision support tools.

Keywords: Artificial intelligence, artificial neural network, decision support tools, executive information system, management decision structure.

INTRODUCTION

Construction contracting is a high-risk business characterised by a large number of bankruptcies. This is partly due to the high level of uncertainties and features such as the fragmented nature of the industry which contribute to its economic sensitivity.

The provision for these circumstances requires a complex decision making at the strategic level. To this end, the exploitation of the latest scientific management techniques is an imperative, as high quality management can not sustain its performance unless it is supported by scientific management tools. In today's complex business environment, the full exploitation of all available tools is of paramount importance. The performance of a construction contracting organisation, derived from

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its ability to achieve strategic goals and set higher quality goals, can be improved by the implementation of an enhanced executive decision support system. This can be achieved by the application of a system of an integrated decision support tools.

Literature review has revealed the development of theoretical body of knowledge relating to both decision structure of corporate management and the use of decision support tools. There have been many works defining the structure of corporate management and the related decisions (Skitmore et al 1992 and Hick 1990). Also, there have been many attempts to apply AI techniques to various aspects of management decision making (Moselhi et al 1991). The proposed research will build on the outcome of all previous works. However, the novelty of the research rests on the identification of the decision structure of a contracting organisation moulded into an object-based structure, and determination of the attributes of the comprising decision nodes (objects).

The product of the research will be an integrated framework of decision support system, which for a given situation, assists the management at the executive level to make more effective strategic decisions. The outcome of the work can be utilised by corporate managers to enhance their abilities rather than replace their judgmental input. Since, corporate decisions rely on information and decision from other levels of the organisation, the final product will also be a decision support tool for management at other levels. It will be a tool for the decision makers to improve the quality of their decisions by complementing their intellect.

STRATEGIC MANAGEMENT DECISION MAKING

The confrontation of the two schools of taught on education of corporate strategy – the experimental learning (intensive case programme) versus theoretical underpinning – has taken a rough ride since 1960s, but has not reached a conclusive end. Indeed, most believers of one school of taught accept that input from the other can provide a healthy supplement (Johnson and Scholes 1988). This compromise, as opposed to full negation, stems from the fact that while strategic decisions can benefit from a large body of theoretical work, the judgement and intuition of the decision-maker, too, plays a significant role. In other words, decision-making at the corporate level is not an exact science but is supported by highly sophisticated scientific techniques.

Modern organisations operate in an increasingly complex environment and the magnitude of the consequences of decisions at the strategic level demands high quality responses from the management. The ever-changing and turbulent internal and external environments of the organisation demands extreme sensitivity from the management in their reactions towards change. This often requires rapid response and the consequence of one course of action could be dramatically different from an alternative course of action.

Strategic decisions are a reflection of the attitude, values and expectations of the decision-makers at the top level. They have a long term effect on the direction and future activity of the organisation, and have resource implications, affecting decisions at the lower levels and initiating a wave of other, often lesser decisions (Hickson et al. 1986).

The uncertainties and complexities of strategic decisions direct the decision makers to reduce the infinitely large problem into a manageable one. This conversion to a manageable model of reality inherently involves a great number of assumptions, many of which, rely on the judgement of the decision maker. But the scale of the complexity and variety of variables surrounding the decision is such that some of the assumptions are ill-defined and possibly wrong. To combat these problems the managers categorise the uncertain decisions into a number of criteria: Laplace, insufficient reason to believe otherwise; Minimax, making the best out of worst possible conditions; Maximax, the best out of the best alternatives; Savage, the best of the regrets for not taking the right actions; and Hurwicz, giving a range of attitudes from optimistic to most pessimistic (Turban 1993). The choice of the approach is linked to decision-maker's conservatism.

The management of a contracting company is confronted with complex decision making. The strategic decisions such as expansion, consolidation, diversification, revision, etc., require an extensive analysis of numerous issues independently and in combination. The industry has been somewhat conservative, resisting to explore and exploit a range of available techniques and apply them at higher decision making levels. This is partly due to management's reluctance to recognise the need for scientific management. Also, there is a lack of appreciation as to the extent to which the application of management science can be useful. This often leads to a poor allocation of resources to areas of management science, hence, the technical capabilities to implement the science does not develop adequately. Where applied, the management science techniques are poorly located within the organisation. Their use is often scattered and undefined rather than being integrated as part of organisation's structure and culture. Indeed, there have been formidable forces of opposition to the management science activity within many organisations.

Integrated Approach to Decision Support Models

Decision-making at the strategic level affects the whole organisation (as well as its external environment), hence, it encompasses, in one form or another, all functional and operational activity and decisions within the organisation. Instead of focusing on a specific area, perhaps in isolation from the rest of the organisation, as maybe the case for functional problems, the strategic decisions require an integrated approach to managing the organisation. Therefore, in order to enhance the efficiency of the organisation, the decision making is structured in such a way as to cross the operational and functional boundaries and serve the strategic goals of the organisation. Also, the decision-makers are made aware of the links between their decisions and company's strategic goals.

Decision making relies wholly on the availability of relevant information in the right format and at the right time. The decisions at the higher levels encompass all the information generated by the activity within the organisation and the external factors such as the economy, competitors and the politics. Despite today's complex nature of decision structure of companies, the importance of the need for an integrated decision support system has not received adequate attention. By its nature, the object oriented approach facilitates integration and yields a high level of flexibility which is required to accommodate these complexities.

Decision support Tools

Management decision making is considered as an art because it is dependent on the experience, intuition and creativity of the decision-maker. The successful solution of a single problem can be achieved by a variety of approaches. However, the complex nature of today's managerial decisions, at the executive level, demands high quality information and the use of scientific decision making tools. These tools exist in various forms each suitable for a particular type of problem.

The scientific revolution of early 1900, introduced by F. W. Taylor, took a major turning during the Second World War. Since then there have been further advancements in the modern tools of decision making. However, in general, the contracting organisations do not seem to take full advantage of the modern scientific techniques. Studies by Shannon *et al.* (1980), Forgionne (1983), Morgan (1989) and Anderson et al (1994) suggest that only a handful of techniques are being used. More importantly, the techniques are often used in isolation rather than in an integrated manner. Whereas, an integrated approach to the use of various decision tools will prove to be more flexible and powerful: the enhanced capabilities of individual models will complement each other, hence, the capability of the whole will be greater than the summation of its individual components.

Also, the development of management science was paralleled with the advancements in computer-based information management systems. These fields of management support merged during 70s to form the Decision Support Systems - better known as “Interactive Computer-based Systems”. In order to provide support for complex decisions and to enable managers to exercise control over their decisions, fields of Decision Support Systems (DSS), Group Decision Support Systems (GDSS) and Executive Information Systems (EIS) were develop. To this end, various techniques have been developed and exploited.

Artificial Intelligent Techniques

The streams of artificial intelligence include expert system, natural language processing & semantic modelling, robotics & planning, intelligent computer-aided instruction, and machine learning consisting of neural computing, genetic algorithm, case-based reasoning, inductive learning, and explanation-based learning. These techniques have complementary characteristics with their individual strengths and weaknesses.

Artificial Intelligence is about the study of the thought process of humans and representing them via machines. They attempt to introduce and combine intelligence with the usual advantages of machines. In some ways they advance over natural intelligence: their ability to sustain operation; ease of duplication and dissemination, and consistency. They have the ability to deal with problems where an algorithm or procedural problem solving approach can not be adopted. This is very similar to the characteristics of many management decision makings at the strategic level: the processing primarily involves reasoning and intelligence rather than computing and algorithm; the input components are often incomplete and made of knowledge rather than just data; the search methods are usually heuristic; the outcome is probabilistic and incomplete. AI has the ability to exploit the range of knowledge needed to emulate intelligent behaviour and exercise a problem solving process.

The choice of the AI methods is primarily determined by the characteristics of each decision node (object), however, it is envisaged that the research will particularly focus on artificial neural network technique. This is an intelligent system which is capable of modifying its internal structure to improve its performance. In a pragmatic manner, the system works towards a solution. The output is elaborated by the ability of the system to learn from the past and recurring experiences in much the same manner as the neural system within human body. As far as the construction industry is concerned, the advancement in this area has been rather slow but it is on the increase.

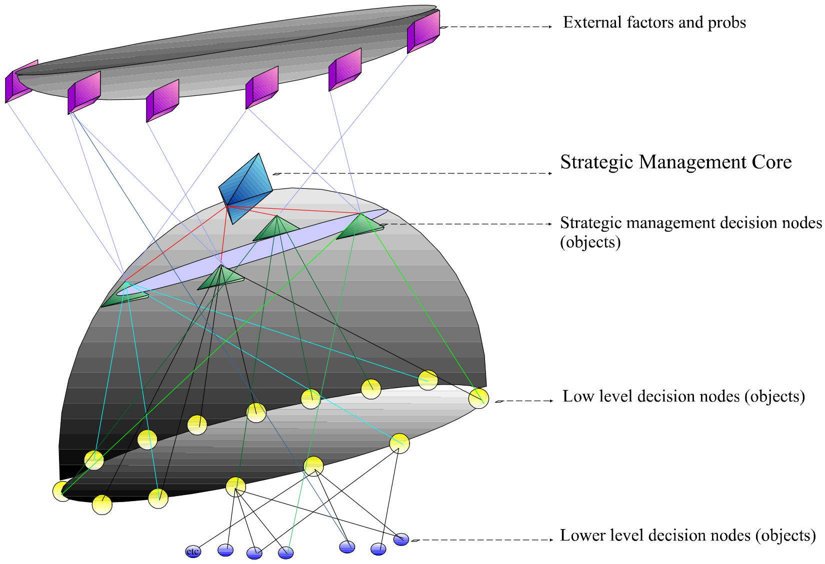

Figure 1. Strategic Management Decision Structure

PROJECT FRAMEWORK

The aim of the overall research is to develop an intelligent framework of Executive Decision System in support of strategic management decision making for construction contracting organisations, based on object oriented methodology and the use of a hybrid of decision support tools with a specific focus on the use of artificial intelligent techniques.

This process involves identification of the totality of the structure of management decision framework at the enterprise level. It also requires identification and definition of all decision nodes (objects) at strategic and mid-management levels. The construction of the overall model of executive information support system will require development of individual object models.

The research is carried out in two phases in a more or less sequential manner. Phase one consists of development of the structure of management decision making and the identification of appropriate decision making tools for each type of decision. In phase two, data will be collected and applied to the findings of phase one in order to develop a practical framework of decision support tools applied at the strategic level.

Phase one is the product of marriage of two separate investigations which are carried out in parallel order. Initially, as in the traditional hierarchical structure, the decisions at the executive level are identified. As shown in Figure 1, in order to be able to make such decisions, the management requires certain information or decisions some of which are external and others are organisation-related. These are referred to as decision nodes (objects). These decision nodes form the components of the objects of the overall structure. An example of object-based approach is given in Figure 2. The objects are interrelated and connected via filter functions. Also, the objects acquire information via the 'probes'. Different types of output are expected which differentiate yes/no, fuzzy (chance of occurrence) and risk analysis.

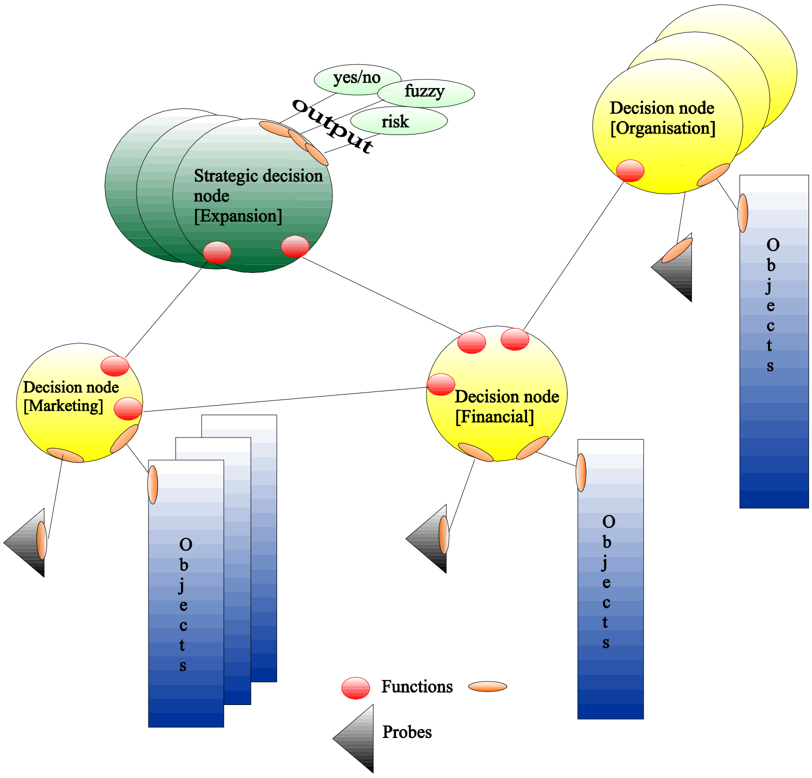

Figure 2. Example of structure of object-based decision model

Many decisions at the strategic level are envisaged to share one or more objects. Each decision node (object) is influenced by the information (obtained via probes) and decisions which are taken at a management level. Again, these decision nodes (objects) rely on the provision of a certain information and decisions at a management level.

Each decision is defined in terms of a number of characteristics such as degree of uncertainty (deterministic / stochastic), time dimension (static/dynamic), deductive consequences (normative/descriptive), nature of related data, and etc.

The outcome of this section is the development of the structure of management decisions. Parallel with this development, an investigation is carried out in order to identify the variety of available decision support tools. These tools (methods) are also categorised in terms of their attributes. The tools are expected to fall within the complete Enumeration, Optimisation (via algorithm or analytical formula), Simulation, Predictive, Heuristics, and other descriptive forms. The tools are also defined in terms of a number of characteristics and categorised accordingly. In Table 1 and Table 2, these models are categorised in accordance with attributes and characteristics respectively.

Table 1: Categorisation of the models based on their attributes

Model Attributes	Linear Programming	Transportation Linear Programming	Integer Programming	Network Methods	Calculus	Queuing Theory	Monte Carlo Simulation	Dynamic Programming	Markov Chains	Decision Tree	Stochastic Programming	Regression	Rule-based Systems	Case-based Systems	Model-based Systems	Artificial Neural Networks	GA-based Systems	Fuzzy ANNs
Deductive consequences																		
Normative	✓	✓	✓	✓	✓			✓		✓	✓	✓			✓	✓	✓	✓
Descrpitive				✓	✓	✓	✓		✓				✓	✓	✓	✓		✓
Time dimension																		
Static	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Dynamic	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Degree of uncertainty																		
Deterministic	✓	✓	✓	✓	✓			✓					✓	✓	✓			
Stochastic				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dynamism in run-time																		
Static	✓	✓	✓	✓	✓	✓				✓						✓		✓
Dynamic							✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Self dynamic																✓	✓	✓
Development practicality																		
Low	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			
High				✓	✓				✓							✓	✓	✓
Need to user intervention																		
Design time	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Runtime																✓	✓	✓
Data requirement for model justification																		
None	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			
Data required														✓		✓	✓	✓

Table 2: Model categorisation based on their characteristics

Model Characteristic	Linear Programming	Transportation Linear Programming	Integer Programming	Network Methods	Calculus	Queuing Theory	Monte Carlo Simulation	Dynamic Programming	Markov Chains	Decision Tree	Stochastic Programming	Regression	Rule-based Systems	Case-based Systems	Model-based Systems	Artificial Neural Networks	GA-based Systems	Fuzzy ANNs	Fuzzy GA
Procedures																			
Single pass					✓								✓	✓	✓				
Iterative	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓
Decision alternatives																			
Continuous	✓				✓						✓		✓						
Discrete		✓	✓	✓		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
Solution quality																			
Optimal	✓	✓	✓	✓	✓			✓		✓	✓	✓		✓		✓	✓		✓
Satisfactory				✓		✓	✓		✓				✓	✓	✓	✓		✓	✓
Required information for justification																			
Model parameters definition	✓	✓	✓		✓			✓	✓		✓		✓	✓					
Supportive data				✓		✓	✓				✓	✓		✓		✓	✓	✓	✓
Knowledge				✓	✓		✓		✓	✓		✓	✓	✓	✓				
Application																			
Analysis	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓					✓		✓
Optimisation	✓	✓	✓			✓	✓	✓	✓		✓		✓	✓			✓	✓	✓
Decision support	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
Instruction				✓	✓					✓			✓						
Diagnosis				✓					✓			✓	✓		✓				
Planning			✓				✓			✓			✓	✓		✓		✓	
Interpretation						✓				✓		✓	✓						
Monitoring					✓				✓						✓	✓		✓	
Control				✓	✓									✓		✓	✓	✓	✓
Forecasting											✓					✓		✓	
Prediction																✓		✓	

In these tables, AI method are separated from the traditional methods. In Table 3, a further comparison of AI methods is provided. This will help to identify their suitability for each decision type.

While it is intended to exploit deterministic decision tools to their full potential, it is envisaged that, due to the nature of management decisions, particularly at the executive level, the use of AI techniques will be significant. Also, it is envisaged that the artificial neural network will be most useful due to its self-learning ability and the use of the proposed 'learn-on-demand' methodology (Namatollahi and Khosrowshahi 1998) which enables it to cope with the complex and ever- changing nature of the problem.

Table 3: Comparison of Artificial Intelligence techniques

	Rule-based systems	**Case-based systems**	**Model-based Systems**	**ANNs**	**GA-based systems**
Difficulty at knowledge acquisition	high	Medium	medium	low	low
Required data	generalised knowledge	Cases	designated models	examples	examples
Explanation Capacity	excellent	good	good	poor	poor
Difficult at development	low	Medium	medium	high	medium
Appropriate application domains	Instruction, Diagnosis, Planning, Interpretation, Management.	Planning, Management.	Diagnosis, Monitoring, Control.	Cost-Estimation, Forecasting, Prediction.	Optimisation, Forecasting.

The product of phase one will be a framework model for management decision making at the strategic level based on the use of a hybrid of decision support tools. This comprises an integrated network of, sometimes interrelated, decisions at the strategic and tactical management levels.

Having identified the most appropriate decision tools for the decision nodes in phase I, working models will be developed for the decisions at the strategic level. This phase of the research relies significantly on the availability and access to relevant data. These include the independent data entities and the information contained in form of knowledge base of various applications.

The final model will consist of integration of individual decision models and these models will be placed in their context within the overall framework. This integration is inherent within the structure of the object-based model: following a strategic decision, a series of related decision nodes (objects) will be automatically fired to and each rattled object will in turn trigger a series of related object.

This process relies on the identification and acquisition of an appropriate Object Oriented database and the development of an appropriate object design platform. To this end, the AI core of functions will be acquired or developed and, on the basis of the selection of an appropriate language, an interface programme will be developed.

Finally, at this stage the adaptability of the framework, over time, will be investigated. The framework and its constituent models should have the flexibility to promptly adopt to the changing conditions. This consists of the ability to rearrange, add, delete, combine or change the constituent elements of the system. This is secured by the flexibility offered by using objects rather than relations and by adopting the aforementioned 'learn-on-demand' methodology Namatollahi and Khosrowshahi 1998). Furthermore, the object oriented approach to the analysis and development has the advantage of utilising (reusing) the existing models rather than having to generate new models. These include several models such as those for mark-up calculation (Moselhi et al 1993), bankruptcy evaluation (Khosrowshahi and Taha 1993), cash flow forecasting (Khosrowshahi 1991), planning (Al Shawi et al 1990) and other areas of application in construction (Moselhi et al 1992).

CONCLUSION

The performance of many construction organisations has been undermined by the quality of the decisions by the management. While recognising the importance of decision making at the strategic level and its significant impact on the performance of the organisation, the paper lays the foundation for development of a framework of executive decision support.

The paper discusses the structure of management decision system and suggests that the object oriented approach to the analysis and model-development will yield the necessary flexibility required for such a complex problem.

Although, many decisions are addressed through the use of deterministic and other established methods, inevitably, due to the nature of decisions at strategic level, the use of artificial intelligent techniques was seen as an imperative and the main focus is on the applicability of artificial neural network.

In order to identify the most appropriate decision model for each decision node, it was necessary to produce a common set of criteria against which both, models and decision nodes can be contrasted. While these criteria are descriptive of the nature of the decision model, they also reflect the nature of the decisions. To this end, the paper categorises these models in terms of the attributes and characteristics and a further comparative analysis is produced for artificial intelligent method.

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