

IMPROVED CAPITAL PROCUREMENT THROUGH INCREASED USE OF QUANTITATIVELY-BASED DECISIONS

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ABSTRACT: The procurement of major capital projects always involves significant risk and uncertainties and this is one of the primary causes for the variations from expected outcomes. This paper outlines the delimitation between strategies for making complex decisions using quantitative analyses as opposed to the techniques and applications currently being used by project and construction managers.

Various approaches have been developed and adopted by researchers and practitioners to improve the quality of critical project decisions to maximise benefits. Strategic frameworks and organisational hierarchies are frequently deemed as an optimal solution from the perspective of industrial participants, while numerous researchers indicate decisions with quantitative evidences, underpinned by proper choice of technique, will add additional benefits over current industrial practices.

It is asserted that improved decisions can be made through the additional use of quantitative approaches. This paper reports the finding of a study that has identified where the increased use of quantitative approaches may assist project and construction managers and proposes a mechanism to confirm the potential benefits.

KEYWORDS: Decision making, capital procurement, quantitative decisions, project management

1 INTRODUCTION

Sound decision making is an activity that lies at the heart of successful management, and this clearly applies during the capital project procurement process. Amongst all those decisions, the highest management level decisions are deemed as critical decisions. Such decisions have direct influence on strategic, tactical and operational activities. Therefore, the overall performance of projects is largely influenced by critical decisions.

Variation of project performance is frequently caused by insufficient capacity of making critical decisions to achieve the satisfactory quality expected. This contradiction is considered as the basic cause of majority of project failures [7]. Further, one primary reason of this contradiction in the capital project process is that the complexity of the critical decision comprises of many issues, such as the ability of realising the decision situation and accuracy of the decision evidences, especially when time matters in the decision making process.

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Quantitatively-based decisions have potential to be superior to non-quantitative or qualitative based decisions. This potential increases for critical decision making, particularly complex decision situations [1-4]. However, the potential benefits from quantitative decisions require efficient integration of quantitative approaches into critical decision making process, such that they reflect reality.

Upon the basis detailed, this paper explores the decision phenomenon from different perspectives and discusses a potential technique maximise the project benefits from quantitatively-based decisions. Such benefits may enhance the critical decision making processes for capital projects. Further, this paper reports the findings of a study that has identified where the increased use of quantitative approaches may assist project and decision makers and proposes a reasonable mechanism to assess these potential benefits.

2 REVIEW OF DECISION PHENOMENON

Critical decision making processes for capital project procurement processed are always complex [5-7]. Such complexity comprises of numerous variables, complicated interrelationships amongst the variables [8-10], inconsistent information (decision evidences) and criteria in analysing this information [11], different methods in structuring and organising the information into options[12], and individual difference in subjective aspects of decision making (psychological aspect) [2, 9].

Hierarchical structure has been widely accepted for decision making processes [13-16], and this approach is considered reasonable when used together with the notion of decision making lifecycle [17]. Considerable improvements in the decision quality are made by utilising a systematic thinking process called structured thought; however, more benefits are expected to be added where appropriate quantitative approaches are adopted.

In a decision making lifecycle, decisions are always made to achieve the objectives according to the options (alternatives) identified [9, 17]. Validity of the identified decision objectives, establishment of alternatives, and choice amongst options are the three major factors influencing the final decision quality. In a project context, existing managerial approaches facilitate sound decisions in respect to objectives. However, this approach does not enhance the development of options or selection of the most appropriate outcomes [7]. The individual perspective of decision makers can be influenced by the quality of alternatives and supporting decision evidences. Therefore, benefits from utilisation of quantitatively-based approach in decision making process are actually obtained through improved capacity of collection, integration and selection of relevant decision evidences.

A quantitatively-based decision is a decision made upon the most suitable alternative by using proper quantitative approach in both generating the alternatives and selecting from them. During this process, an appropriately tailored quantitatively-based approach is vital to the decision quality, and the development of such approach depends on good understanding of the requirements and their inferences of the critical decisions in the capital projects.

3 THE REQUIREMENTS OF QUANTITATIVE APPROACH IN CRITICAL DECISIONS

A study exploring the requirements of the proposed quantitative approach from critical decision making has been conducted for the above purposes. This study identifies the primary requirements from four perspectives: historic perspective of development of decision making in project management; theoretical perspective of decision making phenomenon; practical perspective of current decisions making in capital project; and applicable perspective of the available tools in assisting quantitative decision making. All of the analyses and discussions are conducted via managing the risks, which assume that risk is the cause of deviation from the expected decision quality, and the variables relating to the risks are the initiatives of changes in critical decisions. Key statements on the requirements and

empirical analyses on these key statements result in the exploration of in-depth solution about how to gain additional benefits from quantitatively-based critical decisions.

Historic perspective of critical decisions

Critical decisions evolved from simply formed religious decisions [18], with mathematical and probabilistic approaches included as an indispensable part after the appearance of such theories [19]. Decisions only became a complex phenomenon since the 19th century, when the prosperity of industries with specific development of management knowledge.

Modern management principles require optimisation of the outcomes from project, which results in a complicated environment for decision making. Continuous increases of the size and complexity of capital projects further emphasises the challenges in front of the decision makers. For the critical decisions with multiple-objective (or multi-criteria), review of the historic perspective suggests that quantitative analyses should be well involved in the decision making processes.

Theoretical perspective of critical decisions

Application of decision theories is dominated by the perspective used by the decision makers on a singular project. However there are unavoidable inter dependencies existing between similar projects [20]. Empirical knowledge is used as evidences underpinning the project decisions. In some circumstances, making a decision is to identify a pattern of experiences (alternative) where it is available in the subjective 'database'. If no identical decision pattern (alternative) being available, an optimisation process is to be carried out between several 'similar' ones to establish the preferred alternative. Sophisticated mathematical models and methods are used to complete this process [11, 14].

The subjective influence of decision makers is another aspect of the theoretical consideration. Jennings and Wattam [9] considered that sometimes unwise decisions can be achieved with rational evidences due to individual irrationality. The sensitivity of capital project performance to the critical decisions determines the limited tolerance of such irrationality, therefore a reasonable mechanism to avoiding the negative subjective influence from decision maker is a prerequisite.

Practical perspective of current decisions in capital projects

Critical decisions in the industrial practice are always made according to different 'world views' [9]. Different perspectives on the decision situation cause the problem in identifying and evaluating the risks to deal with. Figure 1 shows the typical process of critical decision making process via risk management perspective during project lifecycle.

Critical decisions are expected to be mutually beneficial to all the stakeholders. The biggest challenge to such objective is to define the agreed viewpoint on the decision situation [9], as well as the accuracy. This is a well recognised way to obtain potential benefits from the application of managerial approaches.

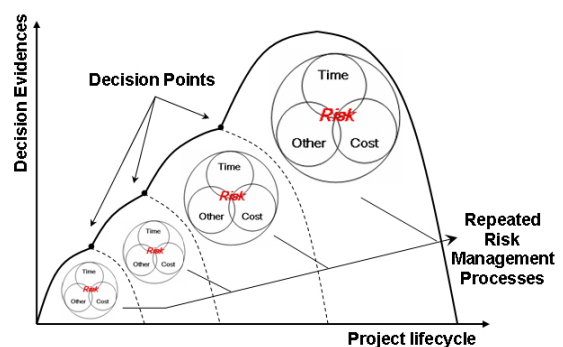


Figure 1. Decision making via perspective of risk

Figure 1 also shows that the interrelationships between the factors influencing the judgement of project performance are of great importance to the decision quality, which has also been discussed by Jennings and Wattam [9]. Quantitatively-based approaches increase the capacity to gain more benefits

by depicting such relationships in a precise manner, especially on considering the sensitivity of capital project's performance to the critical decisions[7].

Applicable perspective of available approaches

Various approaches that contribute to decision making via the perspective of risks are available. According to the Australian Risk Management Standard AS4360, risk identification and evaluation are the two stages from which decision evidences are obtained to support critical decision making [21, 22]. The requirements on the proposed quantitatively-based approach are then the requirements on the quantitatively-based risk identification and evaluation approaches.

Risk assessment approaches reviewed in the study

In terms of the definition of Decision Supporting System (DSS) [23], any approach contributing to the decision is categorised as DSS or Decision Making Supporting System (DMSS) [24]. From this context, thirty-six approaches are considered in this study, as reviewed by Lyons [25], which are listed in Table 1.

All these approaches aim to assess risks faced by the decision makers. They identify and evaluate the decision evidences via the perspective of risks on both qualitative and quantitative basis. Individual approach can also be combined in practices.

Further, an analysis of the popularities of the approaches has been based on Lyons [25]. In each category, individual popularity is calculated by dividing the appearance of an approach in the reference with total number of references reviewed. Finally, a ranking of approaches is concluded and shown in Figure 2.

Within each category, the most popular approaches in the top 25% of the list are identified as Table 2 shows. From this table, empirical information is dominant throughout the whole decision making process, where majority of the risks to be dealt with depend on the experiences. For application of quantitatively-based approaches, such as Monte Carlo Simulation, the accuracy of simulated outcomes relay largely on the quality of the inputs from the specialists.

These approaches reviewed are widely adopted in all kinds of decision making processes, however in terms of the challenges in the critical decisions in capital projects; current approaches are inadequate in providing sufficient confidences to the decision makers. This point is supported by anecdotal evidences where critical decisions with considerable complexity and influences are required.

Requirements identified for critical decisions in capital projects from this study

1	Brainstorming	19	Decision Trees
2	Case-based Approach	20	Expected Monetary Value
3	Checklists	21	Intuition/Judgement/Experience
4	Flow Charts	22	Monte Carlo Simulation
5	HAZOP	23	Stochastic Dominance
6	Influence Diagram	24	Probability Impact Grids
7	Questionnaires	25	Utility Theory
8	Scenario Building	26	Cause & Effect
9	Periodic Reporting	27	Simulation
10	Interviews	28	PERT
11	Synetics	29	Critical Path Analysis
12	Risk Documentation	30	Risk Adjusted Discount Rate
13	Norminal Group Technique	31	Risk Impact Assessment
14	Delphi Technique	32	Risk Premium
15	Cause & Effects	33	Sensitivity Analysis
16	Force Field Analysis	34	Fuzzy Logic
17	Algorithms	35	Bayesian Theory
18	Decision Analysis	36	Artificial Neural Network

Table 1. List of decision supporting approaches via risk assessment

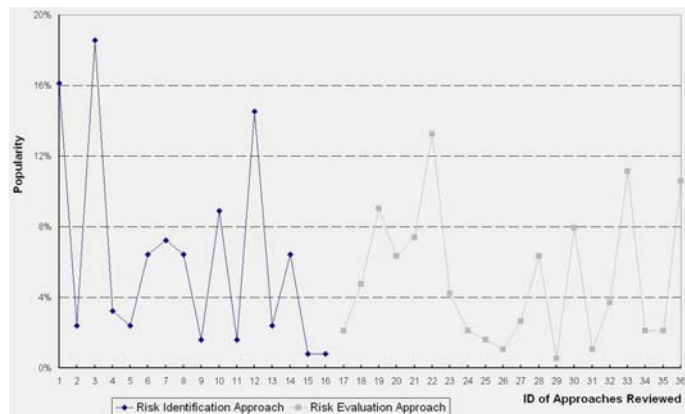


Figure 2. Popularity ranking of approaches reviewed

Risk Identification Approaches		
3	Checklists	1st-18.55%
1	Brainstorming	2nd-16.13%
12	Risk Documentation	3rd-14.52%
10	Interviews	4th-8.87%
Risk Evaluation Approaches		
22	Monte Carlo Simulation	1st-13.23%
33	Sensitivity Analysis	2nd-11.11%
36	Subjective Probability	3rd-10.58%
19	Decision Trees	4th-8.99%

Table 2. Top 25% ranking of popularity

Based on the reviews from four different perspectives and approaches in decision making, this study summarises the potential requirements on a proposed approach which is competent in supporting critical decision making along the capital project lifecycle.

The basic requirements of such an approach are easily identified as Figure 3 indicates, which are accuracy of the decision evidences provided to the decision makers, compatibility to the current managerial approach, practicability to the end users, flexibility in adjusting the outcomes according to the expectation of a specific decision situation, and ability to provide real-time decision evidences on the dynamic decision situation.

Accuracy of the outcomes from this proposed approach is of great importance. Due to the sensitivity of the capital project performance to the critical decision, such approach should utilise accurate techniques to quantify the input information, which is either from historic data or specialists' experiences.

Current managerial approaches in capital project management benefit the project performance significantly. It is unreasonable to thoroughly dispose the existing profitable methods. Instead, an integrated decision making process with both the current managerial approach and the quantitative approach will be a better solution to gain additional benefits [6, 7]. Therefore, the compatibility to the managerial approach is required.

Practicability is as a requirement on the interface to the end users. Consistency to the existing knowledge within the project team is important in applying this approach. The consistency is guaranteed by a friendly interface, which facilitates the integration of this new method into practice. Reduction of complexity in the decision situation with clear definition of the quantitative approach can also increase the practicability.

As the approach is based on similar experiences and historic data, accuracy is comprised by the differences between the new and previous information to some extent. Flexibility of this approach therefore entitles an efficient method to communicate information between previous data and the new decisions. Specific considerations on the new decision situation are also enabled by the approach's flexibility.

The final requirement on the quantitative approach is reflected by the dynamic feature of the decision situation. Generally, decision is considered as 'one-off' at a special point with few considerations on constant changes. Accumulation of changes in a decision situation can be a main reason impacting validity of a decision. A real-time based mechanism can minimise this impact and provide decision makers with the timely information of the decision situation, which considerably increase the opportunity to achieve a better decision.

After the primary requirements being identified, this study further explores the details within each requirement by analysing the key statements expressed by the references reviewed. All the five primary requirements are summarised into three aspects, which are accuracy, timeliness and interface. And these aspects are discussed through two stages if risk identification and evaluation within risk assessment

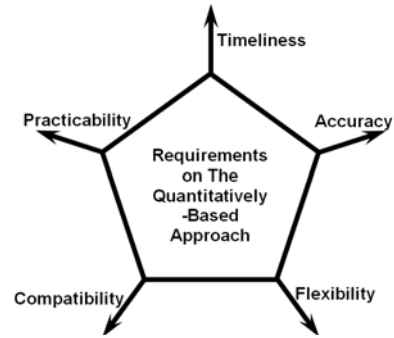


Figure 3. Functionality Requirements

Quantitatively-Based Approach			
	Risk Identification	Risk Evaluation	
Accuracy	Comprehensiveness	Relationship	
	Balance		Quantification
	Dynamic Update		Optimisation
Timeliness		Simplification	
	Computerisation		Dynamic Process
			Computerisation
Interface	User Interface	Visualisation	
	Change Monitoring		Interface to Managerial Approach

Table 3. Detailed sub-requirements of the quantitative approach

process before the critical decisions being made. By this way, detailed requirements (sub-requirements) of this approach are clarified.

From this study, totally forty-eight key statements are identified, which include statements of several combined sub-requirements. And a summarised list of all the sub-requirements is shown in Table 3.

Sub-requirements		
1	Comprehensiveness	12.31%
2	Balance	6.15%
3	Relationship	21.54%
4	Quantification	15.38%
5	Optimisation	10.77%
6	Simplification	7.69%
7	Computerisation	9.23%
8	Dynamic process	9.23%
9	Visualisation	4.62%
10	Interface to Managerial Approach	3.08%

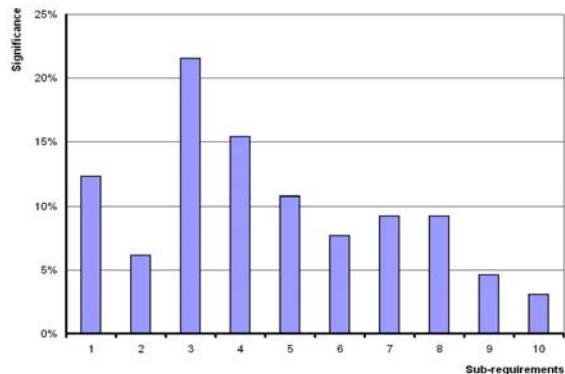


Figure 4. Ranking of sub-requirements' significance

In Table 3, each of the sub-requirement has different significance. By using the similar method as in Figure 2, the importance of these sub-requirements is worked out by accumulating their appearances in the key statements. And the ranking of sub-requirements' importance is shown in Figure 4.

4 CONCLUSION

The purpose of this study was to improve the capacity and quality of critical decision making for capital project procurement. A comprehensive review of the requirements and the inherent complexity and decision has been reported. Requirements of appropriate quantitatively-based approach have been explored.

Having considered the conclusions of accuracy, timeliness and interface, refer to Table 3, it is considered that the accuracy of the outcomes from the proposed quantitative approach is the most important aspect in quantitative decision making.

Two important factors to enhance accuracy are:

- Inter-relationships between individual risks (variables), and
- The technique adopted to quantify individual risks.

Also, the comprehensiveness (quality) of inputs to the approach and trade-offs between different perspectives influences the potential accuracy.

The decisions derived through the use of existing managerial approach would be enhanced if this approach is further developed to include the conceptual approach and referred to as the quantitative approach. Benefits can also be obtained from this quantitatively-based approach if a real-time and visualised interface is provided.

What the review has not identified, interface as a key consideration, its importance should not be overlooked [7,8].

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