A Core AHP System for Contractor Selection Decision

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ABSTRACT:

Contractor selection process is generally believed to be impair the quality with lots of bias in most developing nations, which sometimes leads to incompetent contractor being selected because it is based mainly on human experience and feelings. One of the key activities of any client is contractor selection. Without a suitable and precise method for selecting the best contractor, the completion of a project will likely be affected. In this study, we examine the use of the analytical hierarchy process (AHP) as a decision-support model for contractor selection. In this study, an AHP-based model is tested using a hypothetical scenario in which candidate contractors are evaluated. Developing an appropriate model to address the problem of poor contractor evaluation would, no doubt, be a great relief in the selection of contractors. This model can assist project management teams in identifying contractors who are most likely to deliver satisfactory outcomes in a selection process that is not based simply on the lowest bid. Eight criteria for the primary objective are evaluated. The criteria used for contractor selection in the model are identified, and the significance of each criterion is determined using a questionnaire. Comparisons are made by ranking the aggregate score of each candidate based on each criterion, and the candidate with the highest score is deemed the best. This chapter presents a core system for contractor evaluation decision.

Keywords:
Core, Analytical Hierarchy Process, Multi-Criteria Decision-Making, Contractor Selection.

1. Introduction

Indian economy is classified in three sectors — Agriculture and allied, Industry and Services. Agriculture sector includes Agriculture (Agriculture proper & Livestock), Forestry & Logging, Fishing and related activities. Industry sector includes 'Mining & quarrying', Manufacturing (Registered & Unregistered), Electricity, Gas, Water supply, and Construction. Service sector includes 'Trade, hotels, transport, communication and services related to broadcasting', 'Financial, real estate & prof servs', 'Public Administration, defence and other services'. Services sector is the largest sector of India. Gross Value Added (GVA) at current prices for Services sector is estimated at 73.79 lakh crore INR in 2016-17. Services sector accounts for 53.66% of total India's GVA of 137.51 lakh crore Indian rupees. With GVA of Rs. 39.90 lakh crore, Industry sector contributes 29.02%. While, Agriculture and allied sector shares 17.32% and GVA is around of 23.82 lakh crore INR.

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the best contractor, the completion of a project will likely be affected. In this study, we examine the use of the analytical hierarchy process (AHP) as a decision-support model for contractor selection. This model can assist project management teams in identifying contractors who are most likely to deliver satisfactory outcomes in a selection process that is not based simply on the lowest bid.

2. Literature Review

A.Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is one of Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty. In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurement such as price, weight etc., or from subjective opinion such as satisfaction feelings and preference. AHP allow some small inconsistency in judgment because human is not always consistent. The ratio scales are derived from the principal Eigen vectors and the consistency index is derived from the principal Eigen value. This chapter addresses how an analytic hierarchy process (AHP) model developed for contractor selection can be implemented on the computer to get the right ratings using some existing computer software programs. Thus, the main objective of this chapter is to illustrate how an AHP model for contractor selection can be implemented on personal computer using existing software. The contractor selection process is a multi-criteria decision-making (MCDM) problem. Numerous MCDM models including utility theory [2] [3], fuzzy theory [4] [5], and performance-based modeling [6] have been developed for contractor qualification or final selection. The AHP [7] [8] is a decision-making method that was developed by Saaty. This technique calculates the qualified priorities of a given set of alternatives on a scale based on the judgment of the decision-maker. The process stresses the importance of the intuitive judgments of a decision-maker and consistency in the comparison of alternatives in the decision-making process. Skibniewski and Chao [9] suggested that the strength of this approach is that it organizes tangible and intangible factors in a systematic way and offers a structured, simple solution to decision-making problems.

3. Data Collection and Analysis

3.1)Problem Overview: The evaluation and selection of contractors prior to the award of a construction contract is a vital part of the construction process. Procedures related to the pre-qualification of potential bidders and the assessment of bids submitted by pre-qualified contractors are normally performed by a client's representative and ultimately lead to the selection of a contractor for the project.

The qualification and bid-assessment processes require the development of sufficient and suitable criteria. Project complexity and developer requirements have greatly expanded in the last two decades. This expansion has led to an increased use of alternative forms of project delivery systems. Conversely, the qualification and bid evaluation processes, which involve the quantification and the assessment of criteria, have remained unchanged. Applying a decision-making tool such as the AHP to contractor selection and qualification can be particularly useful to ensure that a project is successful because selecting a qualified and capable contractor to complete any project increases the likelihood of a timely delivery of results that are within the allocated budget and of acceptable quality. This study contributes to the construction sector in two ways: first, it extends the understanding of selection criteria to include degrees of importance, and second, it implements a multi-criteria AHP approach, which is a new method for analyzing and selecting the best contractor. The questionnaire was distributed to subject matter experts in the fields of contract procurement and project management from various departments at india including the contracting department, the project management team (PMT) and the project management office department (PMOD). It shows the types of questions used for data collection.

- Open tender: where all interested contractors submit tenders.
- Restricted/selected tender: where only invited or selected contractors are allowed to bid.

Reference [3] reveals that most organizations in the UK and many other countries adopt this method.

- Negotiated tender: where client consults the chosen contractors and negotiates the terms of contract with them.

3.2. Data Collection

Interviews and meetings were conducted with various groups of individuals involved in the contract procurement process and project management including senior project engineers, project managers, contract advisors, and project controllers. Based on previous information, we developed a questionnaire to collect the required data. The AHP model was formulated after the data were gathered from all of the questionnaire responses. All of the respondents to the questionnaire have been involved in the decision

making process of contractor selection. Sufficient practical experience was guaranteed from this survey. Respondents were asked to identify the criteria necessary for contractor selection. The superior significance of tender price was challenged (Figure 1). As expected, less than 100% (91%) of respondents accepted tender price as one of the criteria internal selection of contractor. Financial capability, past performance and past experience were ranked as the top selection criteria. 82% of the respondents agreed that their contractor selection processes were systematic, so clearly 18% disagreed. 36% of those who disagreed thought a more satisfactory decision would be achieved through a more systematic practice, 18% of the sample did not support the suggestion, while 46% gave no comment.

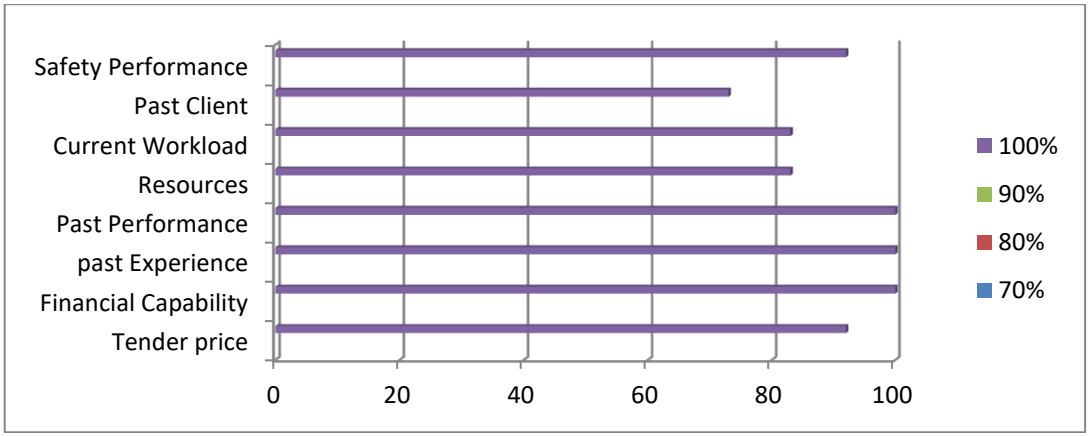

Figure1 Factors considered by clients in contractor selection

3.3) Building the Model: Given the dimensions and the merits of the problem, the model was developed to select the most appropriate contractor for the project.

Overall objective, criteria and sub criteria must be identified. In this section, the overall objective is 'selecting the most capable contractor', the main aim of our research. 68 criteria of contractor selection raised in 10 publications were collected and analysed. Among these criteria, which criterion will become

an element in the hierarchy is a problem. The definitions and rationales of the criteria are discussed. The reasons for choosing the criteria are explained in the table. The selection of the most capable contractor is broken up into a hierarchy. The criteria and the sub criteria are as follows.

In Figure 2 the overall objective 'selecting the most capable contractor' lies at the top of the hierarchy, and the 8 criteria include tender price, Financial capability, past performance, past experience, resources, current workload, past client–contractor relationship and safety performance. Some of the criteria are broken down into sub criteria, giving a total of 15 'criteria'.

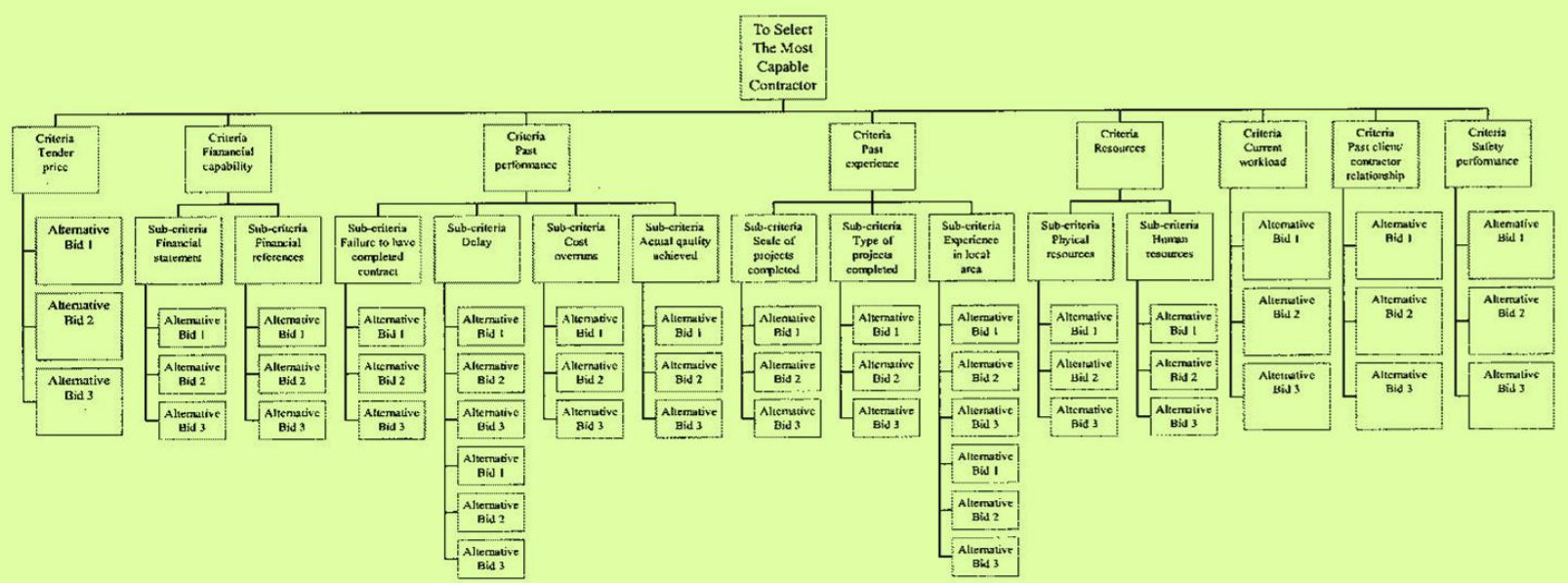

Figure 2 Hierarchy of selecting the most capable contractor

3.3.1) Decision Making:The AHP technique was used to select the most qualified and capable contractor to complete the project. The following six criteria for the contractors were chosen from the hierarchy structure:

- Tender price
- Financial Capability
- Past Experience
- Past Performance
- Resources
- Current Workload
- Past client
- Safety Performance

All of these criteria were evaluated with respect to the primary objective, which was to select the most qualified
and competent contractor for the contract. Ratings were assessed via surveys, which were distributed to subject matter experts in the areas of project management and contract procurement.

3.3.2)Core Development: In order to illustrate the implementation of a core system for contractor selection based on AHP methodology, a case study of the selection of a contractor for the infrastructure development of the National Centre for Technology Management (NACETEM), an agency of the Federal Ministry of Science and Technology in Nigeria, is used as illustration. NACETEM
is an agency vested with the mandate of training and developing middle- to high-level manpower and conducting policy research in the areas of science, technology, and innovation management for all tiers of government and the private sector.

To select the most suitable contractor for the infrastructural development of the agency base on AHP methodology, information was gathered from all the departments in the organization on the selection process and later carefully analyzed so that standard criteria and sub criteria could be established and later adjusted with respect to the general goal. Once the problem has been defined as selecting the best

contractor, the process starts with the design of the prototype system, which includes designing the system architecture and identifying the implementation and operational framework. The knowledge acquired through the knowledge acquisition process is represented in the prototype in four main steps:

1. Developing the hierarchy
2. Pair wise comparison of criteria and sub-criteria
3. Synthesis of the AHP model
4. Measuring inconsistency in decision-makers judgments

Judgment of the results by the expert (i.e., tenders board) and evaluation of the prototype are carried out, whereby the effectiveness of the software and hardware is checked. If the results or findings from the evaluation require some improvement, the prototype is modified and redesigned as appropriate.

3.3.3. Most Commonly Qualified Contractor (Alternatives—Level 2): Because of confidentiality reasons the identities of the contractors have not been disclosed. The purpose of this analysis was to develop an effective decision-making technique and apply it to contractor qualification and final selection using certain criteria.

3.4)Questionnaire: Questionnaires were used for data collection to prioritize the criteria and rate the relative importance of each criterion used in the AHP model. The survey was distributed to subject matter experts in the fields of project management, contract procurement and contractor evaluation. Contractors play critical roles in the success of any project, particularly in construction; therefore, selecting the most qualified primary contractor to complete the project is critical to the project's success. A pre-determined set of qualifying criteria are used to eliminate undesirable contractors from the bidding process, thus ensuring that the project is completed within the allocated budget, on schedule, safely, and to a desired level of quality. The following criteria were used for contractor qualification.

4. Tender Price/Financial Capability/Past Performance/Past Experience/Resources/Current Workload/Safety Performance

The questionnaire shown below in the appendix was developed to identify the most important criteria used for qualifying contractors during a technical bid evaluation process prior to awarding a contract. Respondents were asked to choose the number that indicated which item in each pair of criteria was a more important qualification criterion for contractor selection.

EXAMPLE:
Consider the different criterias

1.Criteria Matix

$$\begin{bmatrix} Criterion & A & B & C & D \\ A & 1 & 5 & 6 & 7 \\ B & 1/5 & 1 & 4 & 6 \\ C & 1/6 & 1/4 & 1 & 4 \\ D & 1/7 & 1/6 & 1/4 & 1 \end{bmatrix}$$

Relative Priorities of Criteria:

Tender Price-----0.342
Financial Criteria ------- 0.245
Past performance -------0.140
Past Experince --------- 0.090
Service Criteria -------- 0.079
Current Work Load ------ 0.049
Past Client/relationship ------ 0.032
Safety Performance ----- 0.023

$$\begin{bmatrix} Tender\,\mathrm{Pr}ice & Bid\ 1 & Bid\ 2 & Bid\ 3 & Normalized\ \mathrm{Pr}iorities \\ Bid\ 1 & 1 & 1/7 & 1/5 & 0.072 \\ Bid\ 2 & 7 & 1 & 3 & 0.650 \\ Bid\ 3 & 5 & 1/3 & 1 & 0.278 \end{bmatrix}$$

$\lambda_{\max} = 3.065,\ CI = 0.032, CR = 0.056$

Financial Criteria	*Bid* 1	*Bid* 2	*Bid* 3	*Normalized* Priorities
Bid 1	1	1/2	1/2	0.200
Bid 2	2	1	1	0.400
Bid 3	2	1	1	0.400

$\lambda_{\max} = 3.000,\ CI = 0.000, CR = 0.000$

Financial reference	*Bid* 1	*Bid* 2	*Bid* 3	*Normalized* Priorities
Bid 1	1	8	6	0.747
Bid 2	1/8	1	1/5	0.060
Bid 3	1/8	5	1	0.193

$\lambda_{\max} = 3.197,\ CI = 0.099, CR = 0.170$

Failure to have Contract Completed	*Bid* 1	*Bid* 2	*Bid* 3	*Normalized* Priorities
Bid 1	1	1/4	1	0.674
Bid 2	4	1	2	0.101
Bid 3	1	1/2	1	0.226

$\lambda_{\max} = 3.053,\ CI = 0.027, CR = 0.151$

Cost Over Runs	*Bid* 1	*Bid* 2	*Bid* 3	*Normalized* Priorities
Bid 1	1	8	8	0.796
Bid 2	1/8	1	2	0.125
Bid 3	1/8	1/2	1	0.079

$\lambda_{\max} = 3.053,\ CI = 0.027, CR = 0.05$

Delay	*Bid* 1	*Bid* 2	*Bid* 3	*Normalised* Priorities
Bid 1	1	4	6	0.691
Bid 2	1/4	1	3	0.218
Bid 3	1/6	1/3	1	0.091

$\lambda_{\max} = 3.053,\ CI = 0.027,\ CR = 0.051$

ActualQuality	*Bid* 1	*Bid* 2	*Bid* 3	*Normalised* Priorities
Bid 1	1	9	6	0.770
Bid 2	1/9	1	1/3	0.068
Bid 3	1/6	3	1	0.162

$\lambda_{\max} = 3.053,\ CI = 0.027,\ CR = 0.051$

Scale of Projects Comleted	Bid 1	Bid 2	Bid 3	Normalised Priorities
Bid 1	1	7	5	0.731
Bid 2	1/7	1	1/3	0.081
Bid 3	1/5	3	1	0.188

$\lambda_{\max} = 3.664,\ CI = 0.032,\ CR = 0.062$

Types of PC	Bid 1	Bid 2	Bid 3	Normalised Priorities
Bid 1	1	2	1	0.400
Bid 2	1/2	1	1/2	0.200
Bid 3	1	2	1	0.400

$\lambda_{\max} = 3.000,\ CI = 0.000,\ CR = 0.000$

Experience in LocalArea	Bid 1	Bid 2	Bid 3	Normalised Priorities
Bid 1	1	1/3	1/4	0.126
Bid 2	3	1	1	0.416
Bid 3	4	1	1	0.458

$\lambda_{\max} = 3.009,\ CI = 0.005,\ CR = 0.009$

Physical Resources	*Bid* 1	*Bid* 2	*Bid* 3	*Normalised* Priorities
Bid 1	1	6	8	0.754
Bid 2	1/6	1	4	0.181
Bid 3	1/8	1/4	1	0.665

$\lambda_{\max} = 3.136,\ CI = 0.068,\ CR = 0.117$

Human Resources	*Bid* 1	*Bid* 2	*Bid* 3	*Normalised* Priorities
Bid 1	1	6	4	0.691
Bid 2	1/6	1	1/3	0.091
Bid 3	1/4	3	1	0.218

$\lambda_{\max} = 3.053,\ CI = 0.027,\ CR = 0.051$

WorkLoad	*Bid* 1	*Bid* 2	*Bid* 3	*Normalised* Priorities
Bid 1	1	6	1	0.472
Bid 2	1/6	1	5	0.084
Bid 3	1	5	1	0.444

$\lambda_{\max} = 3.004,\ CI = 0.002,\ CR = 0.004$

Past Client Relationship	Bid 1	Bid 2	Bid 3	Normalised Priorities
Bid 1	1	9	8	0.804
Bid 2	1/9	1	1/2	0.074
Bid 3	1/8	2	1	0.122

$\lambda_{max} = 3.036,\ CI = 0.018,\ CR = 0.035$

Safety Performanœ	Bid 1	Bid 2	Bid 3	Normalised Priorities
Bid 1	1	1/4	1	0.184
Bid 2	4	1	2	0.584
Bid 3	1	1/2	1	0.232

$\lambda_{max} = 3.053,\ CI = 0.027,\ CR = 0.051$

Final Calculations of 3 Bids:

Composite Prioritisation:

Bid 1:

$$0.342(0.072)+0.221(0.200)+0.024(0.747)+$$
$$0.091(0.674)+0.023(0.796)+0.020(0.691)+$$
$$0.006(0.770)+0.043(0.731)+0.037(0.400)+$$
$$0.010(0.126)+0.0395(0.754)+0.0395(0.691)+$$
$$0.049(0.472)+0.032(0.804)+0.023(0.184)=0.342$$

Bid 2:

$$0.342(0.650)+0.221(0.400)+0.024(0.060)+$$
$$0.091(0.101)+0.023(0.125)+0.020(0.218)+$$
$$0.006(0.068)+0.043(0.081)+0.037(0.200)+$$
$$0.010(0.416)+0.0395(0.181)+0.0395(0.091)+$$
$$0.049(0.084)+0.032(0.074)+0.023(0.584)=0.375$$

Bid 3:

$$0.342(0.278)+0.221(0.400)+0.024(0.193)+0.091(0.226)+0.023(0.079)+0.020(0.091)+$$
$$0.006(0.162)+0.043(0.188)+0.037(0.400)+$$
$$0.010(0.458)+0.0395(0.065)+0.0395(0.218)+$$
$$0.049(0.444)+0.032(0.122)+0.023(0.232)=0.283$$

Normalized Matrix:

	Tender Price	Financial Criteria	Past performance	Past Experince	Service Criteria	Current Work Load	Past Client/relationshin	Safety Performa	Priority vector
Tender Price	210/449	1890/2483	75/209	140/419	63/293	49/204	28/153	7/39	0.342
Financial Criteria	35/449	315/2483	105/209	140/419	441/1465	21/68	28/153	5/39	0.245

Past performance	42/449	45/2483	15/209	100/419	63/293	35/204	8/51	6/39	0.140
Past Experince	30/449	45/2483	3/209	20/419	252/1465	35/204	4/51	6/39	0.090
Service Criteria	42/449	45/2483	3/209	5/419	63/1465	7/204	28/153	9/39	0.079
Current Work Load	30/449	35/2483	3/209	4/419	63/1465	7/204	28/153	1/39	0.049
Past Client/relationship	30/449	45/2483	5/418	20/1257	9/1465	1/204	4/153	4/39	0.032
Safety Performance	30/449	63/2483	5/418	10/1257	7/1465	7/204	1/153	1/39	0.023

5 Conclusion

This chapter simply demonstrates how an AHP model for contractor selection can be implemented on the computer to get the desired results. However, this does not foreclose the use of the procedure enumerated in the chapter for AHP model on other issues. Once the criteria, sub-criteria, and alternatives for any AHP model are clearly identified and stated, the step-by- step use in this chapter can be adopted to generate the needed result. It is believed that the procedure enumerated in the chapter will lessen the difficulty encountered by students and users of AHP models in getting results.

Multi-criteria selection methods should be implemented in project management to select the “best” contractors to achieve the project objectives. Contractor selection is a critical task for ensuring that a project is completed within budget and on schedule and that the results are of good quality. The goal of multi-criteria contractor selection is to identify the “best” contractor from a set of available options using an assessment based on multiples election objectives. The selection of a suitable contractor is highly beneficial and avoids many risks that might be encountered if a less capable contractor was awarded the project.

The decision model for contractor selection examined in this study involved multiple criteria that were evaluated

simultaneously by aggregating the knowledge of experts and managing uncertain information. A model based on the AHP technique was applied to determine the order of the criteria to identify the relative importance of each criterion. This model was then used to determine the best alternative (*i.e.*, bidder) to ensure a favorable outcome.

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