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ASSORTMENT OF CONSTRUCTION PROJECT MANAGER USING MCDM METHODS

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Abstract

The construction sector assists as a fundamental pillar for the advancement of the nation. Over the past several years, the construction industry has experienced significant growth, contributing in excess of ten percent to the gross domestic product (GDP) of the Indian economy. All construction initiatives necessitate a substantial allocation of resources, including human labor, machinery, and financial capital, among others. Effectively managing these resources and ensuring the project's completion with considerable profit presents a formidable challenge for contractors. Within this complex process, the project manager assumes a crucial role, adeptly balancing the interests of the client, contractor, and resources. The present study seeks to identify the most suitable project manager by employing Multi Criteria Decision Making (MCDM) methodologies, such as PIPRECIA (Pivot Pairwise Relative Criteria Importance Assessment) and WSPLP (Weighted Sum Method based on the Decision Maker's Preferred Levels of Performance), from the pool of qualified candidates. In alignment with the specific needs and demands of the project, a set of eligibility criteria was established through consultations with clients, contractors, and experts in the field of construction projects.

Keywords: Construction, Project manager, PIPRECIA, WSPLP, Selection.

1. INTRODUCTION

Today construction sector is the major sector in India contributing significantly to the growth of the country and many people are directly or indirectly involved in contributing to the growth of the sector and building the Nation. The construction project requires huge resources in terms of manpower, materials, and money. Recently the construction projects, management became an art and profits are narrowing day by day, A lot of risk is involved in construction projects from the beginning to the end of the project [1]. These challenges are directing to choose the right project manager for executing the construction project. The construction project manager requires to portray variety of skills in terms of technical and managerial aspects [2]. The project manager is the driving force of the entire project and his actions will be helpful in improving the project operations leads to fulfilling the deliverables of the project[3,4]. As per the project priority listing out the priorities for the selection of persons is very important for organizations. The priorities are established for this research paper from the opinions of the client, contractor and construction Industry professionals, six essential priorities are listed for selection of project manager position mentioned in the table 1.

Multi criteria decision making (MCDM) techniques like AHP, Fuzzy AHP, SAW TOPSIS, weighted sum method(WSM)s are proven track record for ranking the candidates as per the listed priorities in terms of selection of suppliers, selection of HR managers, [5]. The proposed model was suitable to the Indian construction projects. To prioritize the rankings of the examined candidates, the paper is systematized as follows. The second part is related to literature review, the third part is related to the proposed model of PIPRECIA (Pivot Pair wise Relative Criteria Importance Assessment) and WSPLP (Weighted Sum method based on the decision maker's Preferred level of Performances), the fourth part is related to the analysis of these proposed models with an example, fifth part is the conclusion part of the study [6,7].

Table 1. Criteria for selection of Project Manager

Criteria/ Priority		Remarks
Priority-P1	Experience as Project Manager(PM)	Experience in handling the similar type of projects as a PM from Start to End
Priority-P2	Familiarity with Similar Projects	If the Similar projects are not handled directly then his awareness about statutory procedures

Priority-P3	Risk Assessment and Mitigation	Able to assess the risk in the project and then mitigating the same
Priority-P4	Working with teams	Working with different teams towards the fulfilling Project deliverables
Priority-P5	Working flexibility	Depends on the conditions flexibility to work at any given time
Priority-P6	Qualifications and professional certifications	Preference may be given to properly qualified and certified persons like PMP certified, any other professional certifications

2. LITERATURE REVIEW

Taking decision under the multi criteria aspects are very popular in determining the ranks for the selected criteria [8,9] using multi criteria decision methods. The importance and application of these techniques are gaining significant importance in the present-day research activity [10]. The decision-making process involves every single conflicting criterion which is making the final selection easier to the decision makers (DMs). Numerous methods are available in MCDM for making the decisions simpler and easier. The most popular MCDM techniques used are AHP by the author Saaty[11]. Fuzzy AHP which is the extension to AHP, COPRAS [12], ELECTRE, PROMETHE, SAW or WSPLP, TOPSIS, Fuzzy TOPSIS and VIKOR models are used for ranking purpose [13]. The above methods are convenient and easy to use and many authors applied to materialize their proposals [14]. All the above MCDM methods have good proven procedure to analyze the data in terms financial and non-financial aspects quickly [15].Now a days there is lot of uncertainty and imprecision in all most all business activities and requires new generation MCDM techniques to address these issues[16]. The popular MCDM techniques proposed after the year 2000 are ARAS, MULTIMOORA, SWARA, WASPAS, WS PLP by Stanujkic & Zavadskas, and PIPRECIA etc.. are able to address the complexities of business to the extent[17,18]. As many authors applied new generation MCDM techniques and they found that solutions obtained through these methods are very much useful under uncertainty [19]. Some authors applied these new generation MCDM techniques for market research, strategic planning, location selection problems [20]. Gabrijela POPOVIC applied these techniques for making investment in hotel construction projects. He also developed the frame work for ranking the selections property development projects. Gholamreza Dehdasht has applied DEMATEL- ANP technique for assessing the risk in oil and Gas construction projects Gholamreza Dehdasht[21].

3. THE PROPOSED FRAMEWORK

The current section proposes the detailed procedure and computation of PIPRECIA and WS PLP methods, which helps in selection of the right candidate who will be offered the position of the construction project manager [22]. The PIPRECIA method is useful in defining the significance of the evaluation criteria by weight, whereas the WS PLP method points the final rankings from the available alternatives and selecting the optimal candidate [23].

3.1 The PIPRECIA Method

Defining the weight criteria is the important step in MCDM methods as per Vatansever & Akgűl. For this purpose many authors applied AHP method, Fuzzy AHP method, Entropy method, TOPSIS method, SWARA method etc.. The limitations of all the above methods are restricted to limited selection criteria, Whereas if you want to have the large selection criteria we need to choose other MCDM methods like PIPRECIA is very much useful mentioned by Stanujkic et., al [24,25].

The steps involved in the proposed method are as follows:

Step1. Define the evaluation criteria based on the probable significance

Step 2. Second criteria from the beginning, start calculating the relative importance Sj of the criteria j, in relation to the previous criteria (j-1)

$$Sj = \begin{cases} > 1 \text{ when significance of } Cj > Cj-1 \\ 1 \text{ when significance of } Cj = Cj-1 \\ < 1 \text{ when significance of } Cj < Cj-1 \end{cases} \quad \text{Eq. (1)}$$

Step 3. Calculate coefficient kj using equation 2

$$kj = \begin{cases} j = 1 \\ 2 - Sj, j > 1 \end{cases} \quad \text{Eq. (2)}$$

Step 4. Obtain the recalculated weight using equation 3

$$\begin{cases} 1 & j = 1 \\ q_j & \frac{qj-1}{kj} \quad j>1 \end{cases} \quad \text{Eq. (3)}$$

Step 5. Calculate the relative weight (wj) using equation 4

$$Wj = \frac{qj-1}{\sum_{k=1}^{n} qk} \quad \text{Eq. (4)}$$

By using the equations (1)- (4), the proposed frame work for selection of project manager, three DMs are identified for six eligible potential candidates. Each and every candidate possess some good criteria's and some bad criteria's which are mentioned in table1. All these criteria's mentioned in the table 1 are opinions of the experts and the requirements of the projects from time to time. Another important criteria i.e salary is not taken in the present study as it is assumed as constant. The output calculations of three DMs are portrayed in table 2, table 3, and table 4 respectively.

Table 2. Criteria Weights- DM-1

Criteria		sj	kj	qj	wj
Priority -P_1	Experience as Project Manager (PM)		1	1	0.19
Priority -P_2	Familiarity with Similar Projects	1.0	1.0	1.0	0.19
Priority -P_3	Risk Assessment and Mitigation	0.8	1.2	0.83	0.16
Priority -P_4	Working with teams	0.8	1.2	0.69	0.13
Priority -P_5	Working flexibility	1.1	0.9	0.77	0.15
Priority -P_6	Qualifications and professional certifications	1.2	0.8	0.96	0.18
				5.25	1.00

Table 3. Criteria Weights- DM-2

Criteria		sj	kj	qj	wj
Priority -P1	Experience as Project Manager(PM)		1	1	0.15
Priority -P2	Familiarity with Similar Projects	1.2	0.8	1.25	0.19
Priority -P3	Risk Assessment and Mitigation	0.9	1.1	1.14	0.17
Priority -P4	Working with teams	0.7	1.3	0.88	0.13
Priority -P5	Working flexibility	1.3	0.7	1.25	0.19
Priority -P6	Qualifications and professional certifications	0.9	1.1	1.15	0.17
				6.67	1.00

From the table 3, familiarity with similar projects and working flexibility criteria were significant than others criteria

Table 4. Criteria Weights- DM-3

Criteria		sj	kj	qj	wj
Priority -P1	Experience as Project Manager(PM)		1	1	0.19
Priority -P2	Familiarity with Similar Projects	1.1	0.9	1.11	0.22
Priority -P3	Risk Assessment and Mitigation	0.9	1.1	1.0	0.19
Priority -P4	Working with teams	0.6	1.4	0.71	0.14
Priority -P5	Working flexibility	0.9	1.1	0.65	0.13
Priority -P6	Qualifications and professional certifications	1.0	1.0	0.65	0.15
				5.12	1.00

3.2 The WSPLP Method

This WSPLP method is extension of the weighted sum method (WSM) proposed by Dragisa STANUJKIC et.al and is widely applied in decision making process[26,27].

The WSPLP method procedure is as follows

Step 1. Define the evaluation criteria and expected weights are estimated based on the significance criteria

Step 2. Decision Matrix(DM) establishes the preferred performance rating (PPR) values according to the preferences mentioned and this is helpful to depicts the virtual alternative elements i.e $A_0=\{x_{01}, x_{02}, \ldots x_{0n}\}$. If the *DM* fails to define the PPR value of any mentioned criterion, can be obtained as follows:

$$x0j = \begin{cases} \text{Max } xij \mid j \in \Omega\max \\ \quad i \\ \text{Min } xij \mid j \in \Omega\max \\ \quad i \end{cases} \qquad \text{Eq. (5)}$$

Where x_{0j} is the optimal PPR of the criteria of j; $\Omega_{\max}$ symbolizes set of beneficial criteria and $\Omega_{\min}$ symbolizes set of cost criteria.

Step 3. Now the normalization is done by using the equations (6) and (7)

$$rij = (xij - xoj)/(x_j^+ - x_j^-) \quad j\text{cfi max} \qquad \text{Eq. (6)}$$

$$rij = (xij - xoj)/(x_j^+ - x_j^-) \quad j\text{cfi min} \qquad \text{Eq. (7)}$$

Calculate the normalized performance rating (r_{ij})of the alternative i with respect to criteria j. where xo_j represents PPR value of the criterion j, and x_j^+ and x_j^- are the highest and the lowest performance ratings of the criterion j, respectively.

Step 4. Now the overall performance rating (S_i) for each alternative is calculated by the below mentioned equation-(8)

$$Si = \sum_{j=1}^{n} Wj\, rij \qquad \text{Eq. (8)}$$

Where S_i represents the overall performance rating of the alternative i, and $S_i \in [0,1]$.The above calculation should be performed, in case two or more alternatives fulfils the condition $S_i>0$. Otherwise, the procedure ends with this step and biggest S_i value is the best choice to choose the alternative.

Step 5. In continuation to the previous step 4 If $S_i > 0$, the compensation coefficient C_i is calculated by using the below equation-(9)

$$C_i = \lambda\, d_i^{max} + (1-\lambda)\ \hat{S}_i^{+} \quad \text{Eq. (9)}$$

Where $d_i^{max} = max\ di = max\ r_{ij}\ w_j$ Eq. (10)

$$\hat{S}_i^{+} = \frac{s_i^{+}}{n_i^{+}} \quad \text{Eq. (11)}$$

Whereas d_i^{max} is the max weighted normalized distance of the alternative i relative to the PPR values of all the criteria, $rij > 0$

Step 6 The adjusted performance rating is calculated by eq(12) to obtain the alternatives

$$S_i' = \sum_{j=1}^{n} wj\ rij - \psi\, c_i \quad \text{Eq. (12)}$$

S_i' denotes the overall performance alternative i; C_i is the compensation coefficient; (C_i>0), and γ is the coefficient (λ= [0,1]).

Step 7. The highest value S_i' is the most acceptable alternative, it is ranked as the first and the remaining alternatives are listed in the ascending order according to their S_i' values.

Table 5, table 5 and table 7 contain the decision matrix (DM) related to available candidates' evaluation criteria as mention in the table 1. There are six candidates are assuming to be appearing and we need to select the right person for the project manager position. By using the PIPRECIA weights are calculated and using WSPLP finding best alternative among the available choice of candidates (i.e AL1, AL2, AL3, AL4, AL5, AL6).

Step 8. The final rankings are calculated by using the eq(13) As per WSPLP method

and results are portrayed in table 9.

$$S_i'' = \sum_{i=1}^{k} W_k S_i' \quad \text{Eq. (13)}$$

Where W_k significance weight given to the decision maker (DM) k

4 AN EXAMPLE FOR THE PROPOSED MODEL

To show the applications of the proposed models an example was presented for the recruitment of the Construction project manager in this section. A leading multinational construction Company is looking for dynamic project manager in India. They want to give the priority to the candidates who worked in similar projects earlier or previous experience as construction project manager (Darjan Karabašević et.al, 2018). About six candidates are short listed for the final round and selection criteria was mentioned in table1.The final decision of the available alternative candidates are based on the opinion of the three decision makers(DMs) who are experts in this area. It is also accentuate that all decision makers don't have equal significance in decision making process. The chairmen of the selection committee was attributed with a weight of 0.5 and rest of committee members were attributed with a weight of 0.25 each in decision making process , which represents DM2 and DM3 respectively. The short listed candidates are evaluated according to the criteria mentioned in the table 1 and criteria weights using PIPRECIA are portrayed in table 2, table 3 and table 4 respectively.

From the table 2 it is observed that previous experience as project manager and Familiarity with similar projects criteria was significant than others. From the table 4, familiarity with similar projects stands out with higher significance than others criteria, but previous experience as project manager and Risk assessment and Mitigation in projects criteria having second equal priority.

In tables 5, 6, 7 the decision matrices DM-1, DM-2, DM-3 were presented. Each matrix contains the estimation of the candidates related to evaluation criteria as mentioned in table 1 using WSPLP method. The assessment was done in a scale of 1 to 5, where 1 being the lowermost grade and 5 being the uppermost grade. Each decision matrix contains PPR value using the equations (6)-(13), ranks of the candidates are determined. Table 8 portrays the ranks of results calculated from all the three DMs i.e from Table 5, 6, 7 respectively.

The table 8 portrays the consolidated decision matrix from the three decision makers, each decision matrix portrays best rank for different alternatives i.e DM-1 is showcasing alternative 6(AL6),DM-2 is showcasing alternative 3(AL3), whereas DM-3 is showcasing alternative 2(AL2). Now we need to identify the overall performance of all the available alternatives. This can be calculated from the weights allocated to the individual decision makers. The ranks are portrayed in the table 9.

The table 9 represents the rankings obtained using WSPLP method and highlights that among the available candidates Alternative AL4 stands out as top rank for the given set of alternatives and

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The table 9 represents the rankings obtained using WSPLP

method and highlights that among the available candidates Alternative AL4 stands out as top rank for the given set of alternatives and requirements expressed through PPR values. Proper care was taken during the evaluation process and decision making was based on the single criteria and higher performance ratings are avoided to make results more realistic and dependable.

Table 5. The Decision Matrix DM-1 using WSPLP

	P_1	P_2	P_3	P_4	P_5	P_6
w_j	0.19	0.19	0.13	0.13	0.15	0.18
PPR	5	4	4	4	4	3
Alternative (AL)1	5	5	5	4	3	4
Alternative (AL) 2	4	5	4	5	4	4
Alternative (AL)3	4	4	5	4	4	4
Alternative (AL)4	5	4	4	4	5	3
Alternative (AL)5	4	5	4	5	4	4
Alternative (AL)6	5	4	5	5	4	4

Table 6. The Decision Matrix DM-2 using WSPLP

	P_1	P_2	P_3	P_4	P_5	P_6
w_j	0.15	0.19	0.17	0.13	0.19	0.17
PPR	4	3	4	3	4	4
AL_1	4	5	4	3	4	4
AL_2	4	4	3	3	4	3
AL_3	4	4	4	4	3	3
AL_4	3	4	4	3	4	5
AL_5	3	3	4	3	3	5
AL_6	4	3	3	3	4	4

(Source: author calculation)

Table 7. The Decision Matrix DM-3 using WSPLP

	P_1	P_2	P_3	P_4	P_5	P_6
w_j	0.19	0.22	0.19	0.14	0.13	0.13
PPR	4	4	4	3	3	3
AL_1	5	5	4	3	3	3
AL_2	5	5	4	4	3	3
AL_3	4	5	3	3	4	3
AL_4	5	4	4	3	4	3
AL_5	4	4	3	3	4	3
AL_6	5	5	3	3	4	4

(Source: author calculation)

Table 8. Ranking results of consolidated decision matrix

	DM-1		DM-2		DM-3	
	S_i'	Rank	S_i'	Rank	S_i'	Rank
AL_1	0.35	2	0.38	1	-0.19	6
AL_2	0.18	5	-0.15	3	0.64	1
AL_3	0.12	6	-0.17	4	0.16	4
AL_4	0.34	3	0.34	2	0.32	3
AL_5	0.31	4	-0.34	5	-0.06	5
AL_6	0.44	1	-0.17	4	0.50	2

(Source: author calculation)

Table 9. Final ranking results Obtained from all the three DMs

		Rank
Alternative (AL)1	0.22	3
Alternative (AL) 2	0.21	4
Alternative (AL)3	0.07	6
Alternative (AL)4	0.33	1
Alternative (AL)5	0.05	5
Alternative (AL)6	0.30	2

5. CONCLUSIONS

The current research of selection project manager is very important for any construction company because the success or failures of any project operations are on the hands of the project manager. The decisions are effected by day to day operations, permissions and availability of labor from time to time. The huge amount of capital is involved in any construction project; hence certainty in decisions and proper planning is very important to retain the pre estimated profit in the project. This is completely depends on the right decisions of the project manager. The deliverables and success of any construction project depends on the execution of the project. In the current manuscript the frame work is evaluated using recently proposed MCDM techniques like PIPRECIA and WSPLP. The reason being the decision makers (DMs) preferences are expressed concretely through PPR values. The application of the proposed frame work is demonstrated through a numerical example. We can prepare another set of criteria for extending the current problem since the input data for decision making process is connected to lot of uncertainty. The criteria selected in the research work can be made more elaborative along with the combination of some more MCDM techniques for future research work.

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