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CONSTRUCTION PROJECTS RISK ASSESSMENT BASED ON PERT, CPM AND PROJECT MANAGEMENT WITH FUZZY LOGIC TECHNIQUE

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Abstract

A project must complete in foreordained time and quality as per the limited budget. Therefore risk management of every project is necessary to get success. The most important step in project risk management is to identify the risk creating factors. In this study, risk factors are categorized in two main groups as external and internal factors. Each individual group consists of numerous factors. Here risk evaluation of construction project is invested by the proposed PERT (program evaluation and review techniques), CPM (Critical Path Method) and project management with fuzzy logic techniques. Fuzzy PERT (FPERT) and fuzzy CPM (FCPM), which has most utility in the fuzzy project production management and shall, supported to analyze the risk factor of a project. With definite activity intervals, classic PERT and CPM hike are examined. A survey of fuzzy set theorem in risk management has been discussed in this paper. Throughout this paper, we have observed here fuzzy set theory has many applications in most areas of Risk Management and research on fuzzy set theory in risk management has grown-up in recent years. FCPM and FPERT are extensively used in many fields now-a-days. Many problems are being solved by using FCPM and FPERT methods. These methods are useful to the decision makers. This research shows the project completion time 19.3 months and the project is started since January 2020. This Major Bridge project in Orissa, India, may be affected because of COVID-19 and might get extended further in view of unavoidable circumstances.

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Keywords: Project Management, CPM (Critical Path Method), PERT (Program Evaluation and Review Techniques), FCPM and FPERT.

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1. Introduction

Introduction of Fuzzy set theory by Lotfi A. Zadeh (1965) and Dieter Klaua as an elongate version of the classical concept of set theory, is as well as about well-ordered and exact data, but is indecisive and fuzzy data. Here the theory removes the limitations generated by classical mathematics and ambivalence taken in conclusion making process Stokar and Steyn (2014). In nearly all areas of science and technology, an extensive utilization of fuzzy set theory is appreciated.

Project risk management is a comparatively undeveloped regulation, awesome from risk management taken by using Operational, Financial and Underwriters' risk management. This is because of a number of causes: Risk Aversion, specifically public appreciation and risk in public activities.

Standards at risk, risk management, individual risks are almost replaceable, being both staff and economic influences respectively. Project risk management effects have greater diverse, potential, quality and schedule.

Project risk management is the method of figuring out and examining and then reacting to any hassle that appears over the existent cycle of a project to allow the undertaking to remain on track and meet its aim. Risk management isn't receptive fair, it should to be a phase of planning and procedure to understand the risk that may additionally shown up in the project and how to manipulate that risk if it actually happens. The risk of any project is some unidentified effect or situation that, in the case of incident, has an (positive or negative) effect on the project (or on one of the project objectives), hence on its cost, extent or standard.

Here the author intends to analyze the Major Bridge project in Orissa, India. Using Fuzzy CPM and Fuzzy PERT the project duration is optimized.

2. Literature Review and Hypothesis

Fuzzy Set Theory: "Fuzzy set theory is a research approach that can deal with problems relating to ambiguous, subjective and imprecise judgments, and it can quantify the linguistic facet of available data and preferences for individual or group decision-making" (Shan et al., 2015a).

Fuzzy Set: A fuzzy set (FS) A in a universal set X is given by $A = \{(x, \mu_A(x)/x \in X)\}$, where $\mu_A : X \to [0, 1]$ is the membership function.

Fuzzy Number: A fuzzy number A is a fuzzy set on the real line R with the membership function satisfying normality, convexity and piece-wise continuity. A fuzzy number with three tuple is called triangular fuzzy number, with four tuple trapezoidal fuzzy number and etc.

Triangular Fuzzy Numbers: "Triangular fuzzy numbers are shown as (a_1, a_2, a_3) Pillay and Wang (2003). Here a_2 is a number indicating the size is certainly. a_1 and a_3 indicating size and shows the acceptable values of upper and lower limit".

Elements of μ, with "*x*" is defined as shown in universal set, which is conventional for a subset of the membership function,

$$\mu_A(X) = \begin{cases} 1, \text{ If } x \in A \\ 0, \text{ otherwise} \end{cases}$$

LR Type Fuzzy Numbers: A function, usually denoted by L or R, is a reference function of a fuzzy number if and only if $L(x) = L(-x)$, $L(0) = 1$ and L is non-increasing on $[0, +\infty)$. A fuzzy number M is of left, right-type (LR-type), if there exist reference functions L (for left), R (for right), and scalars $\alpha > 0, \beta > 0$ with,

$$\mu_M(X) = \begin{Bmatrix} L\left(\dfrac{m - x}{\alpha}\right), & x \le m \\ R\left(\dfrac{x - m}{\beta}\right), & x \ge m \end{Bmatrix}$$

The variable (m) is called value of M, which is a real number and α and β are called the left and right spreads, respectively and M is denoted (M, α, β) LR.

Two LR-type fuzzy numbers $M = (m, \alpha, \beta)$ LR and $N = (n, \gamma, \delta)$ LR are said to be equal if and only if $m = n$ and $\alpha z = \gamma, \beta = \delta$.

3. Fuzzy Critical Path Method (FCPM)

CPM (Critical Path Method) is a approach used in the investigation. "This approach of the work done towards the realization of a project, when to start, and what bits work as well as when and what to do with the grid presents visible facts to the manager" (Lee and Mccahon, 1989). In this method, the formula of triangular fuzzy numbers, $\left(\frac{a+2b+c}{4}\right)$ "every with a precise representative values and values that are larger amongst themselves pessimistic, optimistic median optimal value was considered as the lowest value were calculated CPM" (Baykasoglu, Gokcen, 2012).

4. Fuzzy PERT Method (FPERT)

In this study, recognised as the technique of FPERT, "benchmarking technique is used in this technique assumes that every job is regarded of fuzzy time" (Zielinski, Chanas, 2001). Benchmarking technique has the earliest start, earliest finish, latest start, latest finish and is calculated in the below mentioned way.

$$ESi = \max_{Vj \in Pi}[ESj \oplus Aj],\ EFi = ESi \oplus Aj$$

$$LFi = \min_{Vj \in Si}[LFj \ominus Aj],\ LSi = LFi \ominus Aj$$

5. Data Collection from Bridge

Here we will be using FCPM and FPERT to reach the result. T, U, and V are the project team. This data is collected from SPS Constructions.

Table 1. Project Schedule.

Activity Code	Previous Activity	Definition of Activity	Startig Date	Ending Date	Normal Time (Mont)
A	-	Mobilization	1/20	2/20	1.6
B	A	Casing Pipe and	2/20	5/20	4

		Reinforcement Steel			
C	A	Pilling for Abutement and Piers	2/20	6/20	4.8
D	A	Casting of pile	3/20	4/21	14
E	A	Pile Cap Casting	3/20	2/21	12
F	B	Pier up to Bed Block	4/20	4/21	11.6
G	C	Casting of Bed Block	7/20	4/21	8.8
H	A	Abutement Casting (A1 and A2)	2/20	7/20	12.5
I	B	Fabrication and Inspection of Girder, Metalizing work	5/20	10/20	6
J	C	Transportation of Girder	10/20	12/20	3
K	J,I	Assembly and Erection of Girder	1/21	5/21	4
L	J,I	Deck Slab Casting	4/21	6/21	2.2
M	J,I	Protection work with retaining wall both end	1/21	5/21	4
N	J,I	Providing and filling of filter media behind abutment and return wall for A1 and A2 side	1/21	5/21	4
O	E, F, K, M, N	Blanketing	4/21	5/21	1.2
P	D, G, H, L, O	Miscellaneous work i.e. parapet, railing,	6/21	6/21	1

		ladder and final painting of Girder (etc.) and hand over			

In Table 1, column 1 (activity name) activity held, while column 2 (previous activity) activities would happen after the activity in the column 1, the column 3 demonstrates the activities, the fourth and fifth column tells about the starting and ending dates of the activities, the sixth column shows the time duration of each activity.

04-03-2020 00:02:58	Activity Name	On Critical Path	Activity Time	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Slack (LS-ES)
1	A	Yes	1.6	0	1.6	0	1.6	0
2	B	Yes	4	1.6	5.6	1.6	5.6	0
3	C	no	4.8	1.6	6.4	4.8	9.6	3.2
4	D	no	14	1.6	15.6	4.4	18.4	2.8
5	E	no	12	1.6	13.6	5.2	17.2	3.6
6	F	Yes	11.6	5.6	17.2	5.6	17.2	0
7	G	no	8.8	6.4	15.2	9.6	18.4	3.2
8	H	no	12.5	1.6	14.1	5.9	18.4	4.3
9	I	no	6	5.6	11.6	7.2	13.2	1.6
10	J	no	3	6.4	9.4	10.2	13.2	3.8
11	K	no	4	11.6	15.6	13.2	17.2	1.6
12	L	no	2.2	11.6	13.8	16.2	18.4	4.6
13	M	no	4	11.6	15.6	13.2	17.2	1.6
14	N	no	4	11.6	15.6	13.2	17.2	1.6
15	O	Yes	1.2	17.2	18.4	17.2	18.4	0
16	P	Yes	1	18.4	19.4	18.4	19.4	0
	Project	Completion	Time	=	19.40	months		
	Number of	Critical	Path(s)	=	1			

Figure 1.

Figure 1 displays the calculation of the problem through WinQSB program, the table showed in the figure yields the earliest start, earliest finish, latest start, latest finish and slack and hence the project completion time.

04-03-2020	Critical Path 1
1	A
2	B
3	F
4	O
5	P
Completion Time	19.40

Figure 2.

Figure 2, displays the critical path and the project completion time calculated through WinQSB. Also shows the project completion time i.e. 19.4 months.

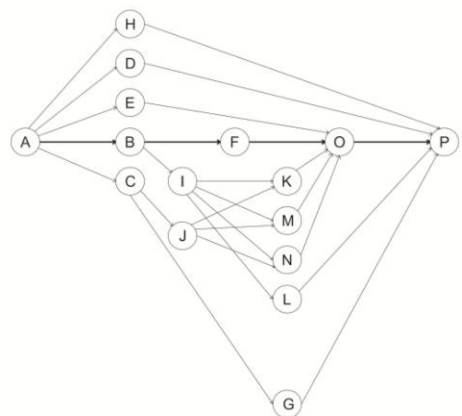

Figure 3.

WinQSB's graphical solution is displayed in figure 3, the darker lines shows the critical path of the project network.

04-03-2020 00:03:57	Activity Name	On Critical Path	Activity Time	Latest Start	Latest Finish	Planned % Completion
1	A	Yes	1.6	0	1.6	100
2	B	Yes	4	1.6	5.6	35
3	C	no	4.8	4.8	9.6	0
4	D	no	14	4.4	18.4	0
5	E	no	12	5.2	17.2	0
6	F	Yes	11.6	5.6	17.2	0
7	G	no	8.8	9.6	18.4	0
8	H	no	12.5	5.9	18.4	0
9	I	no	6	7.2	13.2	0
10	J	no	3	10.2	13.2	0
11	K	no	4	13.2	17.2	0
12	L	no	2.2	16.2	18.4	0
13	M	no	4	13.2	17.2	0
14	N	no	4	13.2	17.2	0
15	O	Yes	1.2	17.2	18.4	0
16	P	Yes	1	18.4	19.4	0
	Overall	Project:		0	19.4	15.4639

Figure 4.

Figure 4 tells us about the progress of the project for the overall time duration, consumed time and the time remaining till the completion of the project.

6. Fuzzy PERT Calculation of the Project Duration

"In the Table 1, T, U, and V are taken from normal time has been considered as triangular fuzzy number. This activity period on the basis of the average values were calculated for fuzzy PERT. In calculating the average value of the weight of each company by 1/3 and by summing the values are assumed to be average values were obtained" (Rahman, Barman, Saha 2017).

Average value $= (a(t, u, v), m(t, u, v), b(t, u, v))$

$a(t, u, v) = T, U,$ and V companies optimistic activity time's average values $a(t, u, v) = at + au + av$ is calculated by formula.

Where, $at = \frac{T1}{3}$, $au = \frac{U1}{3}$ and $av = \frac{V1}{3}$, $T1 = T$, $U1 = U$ and $V1 = V$.

Table 2. *T*, *U*, and *V* Company received from Operations Fuzzy and Average Value of Time.

Activity Code	Pervious Activity	Fuzzy Average Value ($a(t, u, v)$, $m(t, u, v)$, $b(t, u, v)$)	LR-type Fuzzy Number ($m(t, u, v)$, $a(t, u, v)$, $b(t, u, v)$)	Ranking Function D(M')
A	-	(1, 1.6, 2)	(1.6, 1, 2)	1.5
B	A	(3, 4, 5)	(4, 3, 5)	4
C	A	(3, 4.8, 6)	(4.8, 3, 6)	4.6
D	A	(12, 14, 16)	(14, 12, 16)	14
E	A	(10, 12, 14)	(12, 10, 14)	12
F	B	(10, 11.6, 13)	(11.6, 10, 13)	11.5
G	C	(7, 8.8, 10)	(8.8, 7, 10)	8.6
H	A	(12, 12.5, 13)	(12.5, 12, 13)	12.5
I	B	(5, 6, 7)	(6, 5, 7)	6
J	C	(2, 3, 4)	(3,2,4)	3
K	J, I	(3, 4, 5)	(4,3,5)	4
L	J, I	(2, 2.2, 3)	(2.2, 2, 3)	2.3
M	J, I	(3, 4, 5)	(4, 3, 5)	4
N	J, I	(3,4, 5)	(4, 3, 5)	4
O	E, F, K, M, N	(1, 1.2, 2)	(1.2, 1, 2)	1.3
P	D, G, H, L, O	(0.5, 1, 1.5)	(1, 0.5, 1.5)	1

Here we have 12 alternative paths, there paths are, (A-H-P), (A-D-P), (A-E-O-P), (A-B-F-O-P), (A-B-I-K-O-P), (A-B-I-M-O-P), (A-B-I-N-O-P), (A-B-I-L-P), (A-C-J-K-O-P), (A-C-J-M-O-P), (A-C-J-N-O-P), (A-C-G-P).

Calculation of fuzzy path lengths through the various paths:

Route 1 (A-H-P) = 15, Route 2 (A-D-P) = 16.5, Route 3 (A-E-O-P) = 15.8,

Route 4 (A-B-F-O-P) = 19.3, Route 5 (A-B-I-K-O-P) =17.8,

Route 6 (A-B-I-M-O-P) =17.8, Route 7 (A-B-I-N-O-P) =17.8, Route 8 (A-B-I-L-P) = 14.8, Route 9 (A-C-J-K-O-P) = 15.4,

Route 10 (A-C-J-M-O-P) = 15.4, Route 11 (A-C-J-N-O-P) = 15.4,

Route 12 (A-C-G-P) = 15.7.

After calculating the path lengths of the alternative paths route 4 tends to be the critical path of this project and the project completion time is 19.3 months and the related fuzzy number is (19, 19.3, 20).

6. Result and Conclusion

A survey of fuzzy set theorem in risk management have been discussed in this paper. Throughout this paper, we have observed here fuzzy set theory has many applications in most areas of Risk Management and research on fuzzy set theory in risk management has grown-up in recent years. FCPM and FPERT are extensively used in many fields now-a-days. Many problems are being solved by using FCPM and FPERT methods. These methods are useful to the decision makers. This research shows the project completion time 19.3 months and the project is started since January 2020. This Major Bridge project in Orissa, India, may be affected because of COVID-19 and might get extended further in view of unavoidable circumstances.

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