Optimization through Fuzzy linear programming problem with triangular fuzzy number

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Abstract

This paper proposes fuzzy optimization by triangular fuzzy linear programming problem. RCF Kapurthala's production cost data is considered in which the manufacturing cost is targeted for different coaches. For vacillating cases, the cumulative costs of the different constraints are known such that fuzzy LPP (right angle triangle) is used to reduce the production costs. The real cost of output is causing devastation due to probabilistic changes in the supply of various constraints. Here the situation-based Fuzzy model is presented in order to minimize the devastation in cost optimization and to analyze the optimized value reputation. RCF Kapurthalla data is the cost of manufacturing of various coaches from the year 2007-08. The total cost was aimed at minimizing labor cost restrictions, inventory costs, administrative overhead charges, plant overhead charges, township overhead charges, shop overhead charges and performa charges. The lower and upper bound are determined to obtain the optimal fuzzy LPP for the objective function. This optimized fuzzy LPP will offer membership grade for optimized cost of production. This tier of membership tackles fluctuating cost of production.

Keywords: Fuzzy linear programming, triangular fuzzy number, Optimization

Introduction

Operational analysis offers a comprehensive spectrum of problem-solving approaches and techniques to improve operational management decision-making and efficiency. Linear programming problem is a way to achieve best outcome by linear mathematical model relationships. This offers different methods through changing circumstances to address realistic problems in service science. Optimization is decision-making technique that offers a quantitative approach to modifying a procedure to optimize desirable variables and reduce undesirable variables within the defined collection of boundaries. As optimization emerged after the Second World War as transportation challenges were generated methodically. For some practical cases, the parameters or target objectives for LPP cannot be assumed to be useful or accurate. Through offering indication, several conventional optimization approaches provided successful results to solve problems. These optimization problems examine and expose crisp-defined goal feature and basic restriction structure. However, the actual life challenges are not known. Traditional optimization tackles severe limits. But due to the nature of such feasible changeability in industrial and economic environments, it is difficult to obtain necessary degree of satisfaction from the crisp optimal problem. It is apparent or necessary to use certain other LPP types, such as fuzzy-linear programming, when working with such situations. The effects of this type of fuzzy Lpp are real numbers replacing fuzzy estimates. There are several successful approaches to overcome an LPP. If the availability of constraints fluctuates from basic (bi) requirements to certain additive and minified availability, it can be done in a symmetric or non-symmetric form, then triangular fuzzy Lpp can estimate the optimization required under fuzzy conditions. Fuzzy means "uncertain." Fuzziness happens where a piece of knowledge has no definite boundary. The fuzzy set principle defined uncertain mathematical knowledge (Zadeh, 1965). Current model judgments may also be applied in different ways such as individual, multi-level, multi-level and multi-criteria structures. Within some crisp constraints, classical linear programming problems are limited to maximize the target. In this project, we use Fuzzy LPP to prevent cost minimization in real-time circumstances. Fuzzy Lpp to cope with probabilistic increase and decrease in classical optimization's simple availability (bi) and evaluate the outcome with targeted membership score. Triangular blurry Lpp interprets the possible complexity and offers precise knowledge in decision-making, risk assessment, and expert systems. Both are used in other fields such as crisis assessment, decision-making, and measurement. Human judgments are usually influenced by the presence of fuzziness, missing knowledge. Using fuzzy linear programming, several researchers have developed methods for solving this problem. J Reed, S. Leaven good (1998) explained the definition of simplex method and how to solve question of optimizing linear programming and use simplex method more. This paper further clarifies the definition of objective function, judgment variable and set constraints. PredragProdanovic (2001) suggested "fuzzy rating methods and various professional judgment modeling." This paper deals with the principle of fuzzy reasoning, reflecting inaccuracy through the assumption that certain artifacts have incorrectly or unknown borders. Giorgio B. Dantzig (2002) addressed the origin of linear programming and the historical significance of its mathematical programming extensions. He clarifies linear programming and transport problem. Yenilmez, K. Gasimov, R. (2002) focus on lpp with just fuzzy defined coefficients, where both the right and the wrong coefficients are fuzzy. They equate this approach with well-known "fuzzy conclusive set technique."Rogers et.all (2008) stressed difficulties with linear fuzzy programming. This paper discusses the issue of dynamic fuzzy programming that has fuzzy constraints of different objective function and constraints. Dr. Zaki's. S Tewfik and SabibhaFathil Jawed suggested (2010) a methodology to refine and solve Complicated LPP. DiptiDubey and AparnaMehra (2011) introduced "an approach to problem solving linear programming." This paper also clarifies the principle of rating a fuzzy number and the principle of fuzzy triangular number. A research paper by Dipankar Chakra borty, Deepak Kumar Jana and Tappan Kumar Roy (2014) provided "A fresh start to fuzzy optimization question utilizing inevitably and intrigue steps." (2014) illustrate and describe 'modern similarity of triangular fuzzy numbers and their use.' A novel method for estimating triangular fuzzy numbers is provided, taking into account the dissimilar region and midpoint of two triangular fuzzy numbers. UdaySharma[2015] explained a modern solution to Fully Fuzzy Linear Programming Problem (FFLP) with three-angle Fuzzy Numbers and all Fuzzy Equality or Uniformity drawbacks .. Monalisha Pattnaik(2015) suggested Big-M Approach in Fuzzy Based Linear Programming Problems for Post Optimal Study. A. Hosseinzadehet (2016) operates on a new methodology by using lexicography to solve Absolutely Fuzzy Static Programming. In this document, they develop a new FFLP resolution paradigm, considering the (L-R) fuzzy numbers and lexicography system along with crisp linear programming.

Classical optimization strategies are not sufficient enough to demonstrate the optimal desired result in fluctuating circumstance or feasible complexity. While fuzzy optimization strategies can manage these scenarios quickly, they often formulate the situation-based result. If there is an unknown increase or decrease in restriction supply, then Triangular Fuzzy linear programming problem (right angle) is recommended for proper optimization. And with participation, optimization reputation is often aimed.

Methodology

In the fuzzy linear programming, the function Max Z or Min Z is called an objective function with respect to the cost constraints. The c_j are called cost coefficients. The A=$[a_{ij}]$ matrix is called a restriction matrix and the b= $< b_1, b_2, \ldots, b_m >^T$ is called a vector on the right side. where x= $< x_1, x_2, \ldots, x_n >^T$ is the vector of variables.

The standard form fuzzy linear programming is represented by

$$\text{Max } Z = \sum_{j=1}^{n} c_j x_j$$

Subject to $\sum_{j=1}^{n} a_{ij} x_j \le \tilde{b}_i$

Where, $x_j \ge 0, i, j \in \mathbb{N}$ (1)

Where, the $\tilde{b}_i$ is the fuzzy number. With regard to the increase in the availability of restrictions, the fuzzy number can be presented in the above equation (2.5). The membership function would be described as follows.

$$\tilde{b}_i = \begin{cases} 1 & \text{when } x \le b_i \\ \dfrac{b_i + p_i - x}{p_i} & \text{when } b_i \le x \le b_i + p_i \\ 0 & \text{when } x \ge b_i + p_i \end{cases} \quad (2)$$

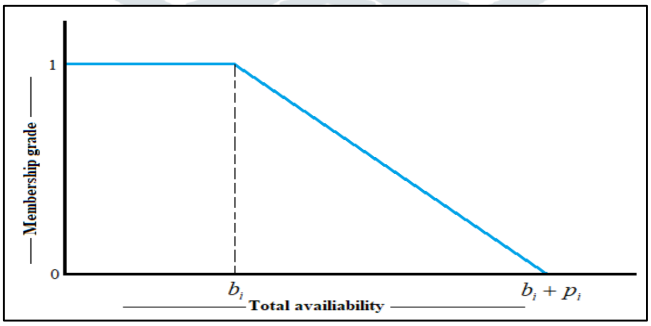

Figure 2.1: representation of membership function for $\tilde{b}_i$

The coefficient on the right is the membership function, i.e. the availability of restrictions. In order to optimize such a problem, we need to estimate the lower and upper boundaries of the optimum values. The lower bound (Z_l) value is

$$\text{Max } Z_l = \sum_{j=1}^{n} c_j x_j$$

$$\text{Subject to } \sum_{j=1}^{n} a_{ij} x_j \le b_i$$

$$\text{Where, } x_j \geq 0, i, j \in \mathbb{N}\ \ , x \epsilon R. \quad (3)$$

The optimal values upper bound (Z_u) is as follows

$$\text{Max } Z_u = \sum_{j=1}^{n} c_j x_j$$

$$\text{Subject to } \sum_{j=1}^{n} a_{ij} x_j \leq b_i + p_i$$

$$\text{Where, } x_j \geq 0, i, j \in \mathbb{N}\ \ , x \epsilon R \quad (4)$$

Where, p_i is an increase in probabilistic availability of restrictions. In this case, the total probabilistic increase of access to restrictions is determined by the right coefficient.

The Simplex method can now be used to find a solution for both the lower and upper bounds of the LPPs. Using these lower and upper bounds, the optimized fuzzy LPP will be obtained as follows.

$$\text{Max } Z=\lambda$$

$$\text{Subject to } \lambda(Z_u - Z_l) - \sum_{j=1}^{n} c_j x_j \leq -Z_l$$

$$\lambda\ (p_{i)} + \sum_{j=1}^{n} a_{ij} x_j \leq b_i + p_i \quad (5)$$

Where, $x_j \geq 0, i, j \in \mathbb{N}$ and $\lambda \in (0,1)$ is membership grade

It fuzzy streamlined LPP offers our initial LPP participation score. Here λ reflects membership tier, and the upper and lower limits are Zu and Zl. Cx is the LPP's objective function. The term with summation sign describes the constraints of given LPP, and p_i is the probabilistic increase in restriction supply.

Data

The following data comes from Railway Industries, 2007-2008 Kapurthala. This data demonstrates the production expense (in lac) of various forms of coach restrictions. Founded in 1986, Kapurthala Railway Industry. It is an Indian Railway coach production facility, producing over 30,000 passenger coaches of different styles.

COACH TYPE	LAB cost	MAT cost	FOH cost	AOH cost	TOH cost	SOH cost	TOTAL O/HEADS	PROF. CHAR.	TOTAL COST	TOTAL COST(w.p.c.)
SCN/AB	2.64	33.47	5.34	3.46	0.98	0.07	9.84	2.03	47.98	45.95
SCN/AB (CBC)	2.65	40.09	5.33	3.45	0.97	0.08	9.83	2.32	54.89	52.57
SLR/AB	2.45	29.81	5	3.23	0.91	0.06	9.21	1.84	43.31	41.47
SLR/AB (CBC)	2.45	37.69	4.83	3.13	0.88	0.08	8.91	2.17	51.22	49.05
GS/AB	2.36	31.55	4.82	3.12	0.88	0.06	8.88	1.89	44.68	42.79
GS/AB (CBC)	2.47	33.82	5.01	3.25	0.92	0.07	9.24	2.02	47.55	45.53
GSRD	2.44	33.26	4.98	3.22	0.91	0.07	9.17	1.98	46.85	44.87
MEMU/ MC	6.86	157.52	14.02	9.07	2.56	0.32	25.97	8.4	198.74	190.34
MEMU/TC	2.56	31.62	5.24	3.39	0.96	0.06	9.66	1.94	45.78	43.84
MBIU	5.33	544.44	10.91	7.06	2	1.09	21.05	25.25	596.07	570.82
ACCN/SG	4.94	82.28	10.06	6.51	1.84	0.16	18.58	4.68	110.49	105.81
Accn/sg (cbc)	5.14	87.59	10.38	6.72	1.9	0.18	19.17	4.95	116.84	111.89
WACCNH	4.32	49.03	8.8	5.7	1.61	0.1	16.21	3.08	72.63	69.55
WRRMDAC	4.29	165.48	8.77	5.68	1.6	0.33	16.38	8.24	194.39	186.15
WGCWNAC	4.29	91.04	8.72	5.64	1.6	0.18	16.14	4.93	116.4	111.47
Sg non ac/ra ab	3.69	38.46	7.55	4.89	1.38	0.08	13.89	2.48	58.52	56.02
SG AC/RA AB	4.43	77.6	9.01	5.83	1.65	0.16	16.65	4.36	103.03	98.67
VPH	1.89	23.59	3.85	2.49	0.7	0.05	7.1	1.44	34.02	32.58
VPU	1.73	21.48	3.53	2.28	0.65	0.04	6.5	1.31	31.02	29.71
EOG/LHB/ ACCB	7.08	182.6	14.15	9.16	2.59	0.37	26.26	9.56	225.49	215.93
EOG/LHB/ WLRRM	7.65	240.07	15.31	9.91	2.8	0.48	28.5	12.21	288.42	276.21
EOG/LHB/ ACCW	6.19	170.59	12.53	8.11	2.29	0.34	23.28	8.85	208.91	200.06
EOG/LHB/ ACCN	7.43	172.62	15.12	9.79	2.77	0.35	28.02	9.2	217.27	208.07
EOG/LHB/ ACCN (low cost)	5.46	97.14	11.12	7.2	2.03	0.19	20.54	5.44	128.58	123.14
TOTAL	101.76	2472.84	204.38	132.29	37.38	4.97	378.98	130.57	3155.71	2853.6

Table1: Production cost of different coaches

(Where LAB= labour, MAT= material, AOH= administrative overhead, FOH= overhead charges, TOH= overhead charges, SOH= overhead charges, PROF. CHAR= Proforma charges). Everything charges are lake (Indian rupee).

In 2007-2008, the overall cost of output of various coaches is taken as an analytical feature to be reduced in terms of restrictions. For any probabilistic improvement, the overall cost of increasing restriction can be increased and reached to b i+p I where b I is the specific cost and p I is the probabilistic change in the basic cost. In this case, we suggest a triangular fuzzy (right angle) LPP to reduce overall development costs. The complete number of restrictions is seen as follows:-

Cost parameters	b_i (Basic cost)	p_i(Probabilistic increment)	$B_i(b_i + p_i)$
Labour cost	100.74	4.1975	104.9375
Material cost	2472.84	103.035	2575.875
Factory overhead charges	204.38	8.515833	212.895833

Administrative overhead charge	132.29	5.12083	137.802083
Township overhead charges	37.38	1.5575	38.9372
Shop overhead charges	4.97	0.207083	5.177083
Total overhead charges	378.98	15.79083	394.77083
Performa charges	130.57	5.44017	136.01017

Table 2: Total basic availability of cost parameter with the probabilistic increments

Modelling of cost production of different coaches

As discussed above the main objective of this project work is to optimize the cost production.

Objective function

Let $x_1, x_2, x_3 \ldots \ldots \ldots . x_{24}$ be variables for different

$$\textbf{Minimise Z } 45.95\,x_1 + 52.57\,x_2 + 41.47\,x_3 + 49.05\,x_4 + 42.79\,x_5 + 45.53\,x_6 + 44.87\,x_7 + 190.34\,x_8 + 43.84\,x_9 + 570.82\,x_{10} + 105.81\,x_{11} + 111.89\,x_{12} + 69.55\,x_{13} + 186.15\,x_{14} + 111.47\,x_{15} + 56.04\,x_{16} + 98.67\,x_{17} + 32.58\,x_{18} + 29.71\,x_{19} + 215.93\,x_{20} + 276.21\,x_{21} + 200.06\,x_{22} + 208.07\,x_{23} + 123.14\,x_{24}$$

This objective function is subjected to some constraints:-

$$2.64\,x_1 + 2.65\,x_2 + 2.45\,x_3 + 2.45\,x_4 + 2.36\,x_5 + 2.47\,x_6 + 2.44\,x_7 + 6.86\,x_8 + 2.56\,x_9 + 5.33\,x_{10} + 4.94\,x_{11} + 5.14\,x_{12} + 4.32\,x_{13} + 4.29\,x_{14} + 4.29\,x_{15} + 3.69\,x_{16} + 4.43\,x_{17} + 1.89\,x_{18} + 1.73\,x_{19} + 7.08\,x_{20} + 7.65\,x_{21} + 6.19\,x_{22} + 7.43\,x_{23} + 5.46\,x_{24} \leq 100.74 \sim 104.9375\ (100.74 + 4.1975) \qquad (6)$$

$$33.47\,x_1 + 40.09\,x_2 + 29.81\,x_3 + 37.69\,x_4 + 31.55\,x_5 + 33.82\,x_6 + 33.26\,x_7 + 157.52\,x_8 + 31.62\,x_9 + 544.44\,x_{10} + 82.28\,x_{11} + 87.59\,x_{12} + 49.03\,x_{13} + 165.48\,x_{14} + 91.04\,x_{15} + 38.46\,x_{16} + 77.60\,x_{17} + 23.59\,x_{18} + 21.48\,x_{19} + 182.60\,x_{20} + 240.07\,x_{21} + 170.59\,x_{22} + 172.62\,x_{23} + 97.14\,x_{24} \leq 2472.84 \sim 2575.875\ (2472.84 + 103.035) \qquad (7)$$

$$5.34\,x_1 + 5.33\,x_2 + 5.00\,x_3 + 4.83\,x_4 + 4.82\,x_5 + 5.01\,x_6 + 4.98\,x_7 + 14.02\,x_8 + 5.24\,x_9 + 10.91\,x_{10} + 10.06\,x_{11} + 10.36\,x_{12} + 8.80\,x_{13} + 8.77\,x_{14} + 8.72\,x_{15} + 7.55\,x_{16} + 9.01\,x_{17} + 3.85\,x_{18} + 3.53\,x_{19} + 14.51\,x_{20} + 15.31\,x_{21} + 12.53\,x_{22} + 15.21\,x_{23} + 11.21\,x_{24} \leq 204.38 \sim 212.895833\ (204.38 + 8.515833) \qquad (8)$$

$$3.46\,x_1 + 3.45\,x_2 + 3.23\,x_3 + 3.13\,x_4 + 3.12\,x_5 + 3.25\,x_6 + 3.22\,x_7 + 9.07\,x_8 + 3.39\,x_9 + 7.06\,x_{10} + 6.51\,x_{11} + 6.72\,x_{12} + 5.70\,x_{13} + 5.68\,x_{14} + 5.64\,x_{15} + 4.89\,x_{16} + 5.83\,x_{17} + 2.49\,x_{18} + 2.28\,x_{19} +$$

$9.16\ x_{20} + 9.91\ x_{21} + 8.11\ x_{22} + 9.79\ x_{23} + 7.20\ x_{24} \quad \leq 132.29 \sim 137.802083\ (132.29 + 5.512083)$ (9)

$0.98\ x_1 + 0.97\ x_2 + 0.91\ x_3 + 0.88\ x_4 + 0.88\ x_5 + 0.92\ x_6 + 0.91\ x_7 + 2.56\ x_8 + 0.96\ x_9 + 2.00\ x_{10} + 1.84\ x_{11} + 1.90\ x_{12} + 1.61\ x_{13} + 1.60\ x_{14} + 1.60\ x_{15} + 1.38\ x_{16} + 1.65\ x_{17} + 0.70\ x_{18} + 0.65\ x_{19} + 2.59\ x_{20} + 2.80x_{21} + 2.29\ x_{22} + 2.77\ x_{23} + 2.03\ x_{24} \quad \leq 37.38 \sim 38.9372\ (37.38 + 1.5575)$ (10)

$0.07\ x_1 + 0.08\ x_2 + 0.06\ x_3 + 0.08\ x_4 + 0.06\ x_5 + 0.07\ x_6 + 0.07\ x_7 + 0.32\ x_8 + 0.06\ x_9 + 1.09\ x_{10} + 0.16\ x_{11} + 0.18\ x_{12} + 0.10\ x_{13} + 0.33\ x_{14} + 0.18\ x_{15} + 0.08\ x_{16} + 0.16\ x_{17} + 0.05\ x_{18} + 0.04\ x_{19} + 0.37\ x_{20} + 0.48\ x_{21} + 0.34\ x_{22} + 0.35\ x_{23} + 0.19\ x_{24} \quad \leq 4.97 \sim 5.177083\ (4.97 + 0.207083)$ (11)

$9.84x_1 + 9.83\ x_2 + 9.21\ x_3 + 8.91\ x_4 + 8.88\ x_5 + 9.24\ x_6 + 9.17\ x_7 + 25.97\ x_8 + 9.66\ x_9 + 21.05\ x_{10} + 18.58\ x_{11} + 19.17\ x_{12} + 16.21\ x_{13} + 16.38\ x_{14} + 16.41\ x_{15} + 13.89\ x_{16} + 16.65\ x_{17} + 7.10\ x_{18} + 6.50\ x_{19} + 26.26\ x_{20} + 28.50\ x_{21} + 23.28\ x_{22} + 28.02\ x_{23} + 20.54\ x_{24} \leq 378.98 \sim 394.77083\ (378.98 + 15.79083)$ (12)

$2.03\ x_1 + 2.32\ x_2 + 1.84\ x_3 + 2.17\ x_4 + 1.89\ x_5 + 2.02\ x_6 + 1.98\ x_7 + 8.40\ x_8 + 1.94\ x_9 + 25.25\ x_{10} + 4.68\ x_{11} + 4.95\ x_{12} + 3.08\ x_{13} + 8.24\ x_{14} + 4.93\ x_{15} + 2.48\ x_{16} + 4.36\ x_{17} + 1.44\ x_{18} + 1.31\ x_{19} + 9.56\ x_{20} + 12.21\ x_{21} + 8.85\ x_{22} + 9.20\ x_{23} + 5.44\ x_{24} \leq 130.57 \sim 136.01017\ (130.57 + 5.44017)$ (13)

$x_1, x_2, x_3 \ldots\ldots\ldots. x_{24} \geq 0$

Inequality -6 represents the constraints of labour cost for different coaches.

Inequality -7 represents the constraints of manufacturing cost for different coaches.

Inequality -8 represents the constraints of Factory overhead charges for different coaches.

Inequality -9 represents the constraints of Administrative overhead charges for different coaches.

Inequality -10 represents the constraints of Township overhead charges for different coaches.

Inequality -11 represents the constraints of Shop overhead charges for different coaches. Inequality -12 represents the constraints of total o/heads cost for different coaches.

Inequality -13 represents the constraints of Performa charges for different coaches.

b_i Represents the initial availability of the constraint and p_i is the probabilistic increase in the availability.

Result

- **Illustration of membership grades for these constraints are as follows-**

Let B_{lab} be the membership grade for Labour cost and it varies as:-

$$B_{lab} = \begin{cases} 1 & x \le 100.74 \\ \frac{104.9375 - x}{4.1975} & 100.74 < x < 104.9375 \\ 0 & x \ge 104.9375 \end{cases} \quad (14)$$

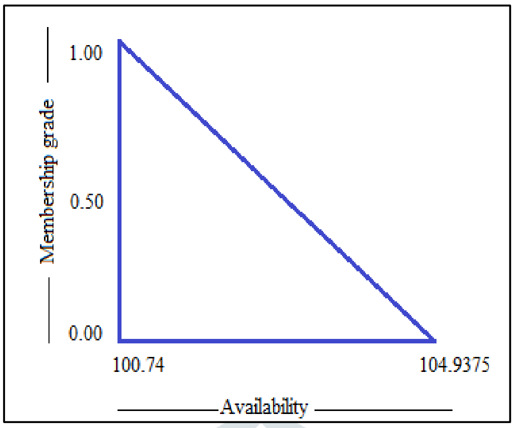

Figure 2: Membership grade for labor cost

B_{mat} be the membership grade for manufacturing cost and it varies as:-

$$B_{mat} = \begin{cases} 1 & x \le 2472.84 \\ \frac{2575.875 - x}{103.035} & 2472.84 < x < 2575.875 \\ 0 & x \ge 2575.875 \end{cases} \quad (15)$$

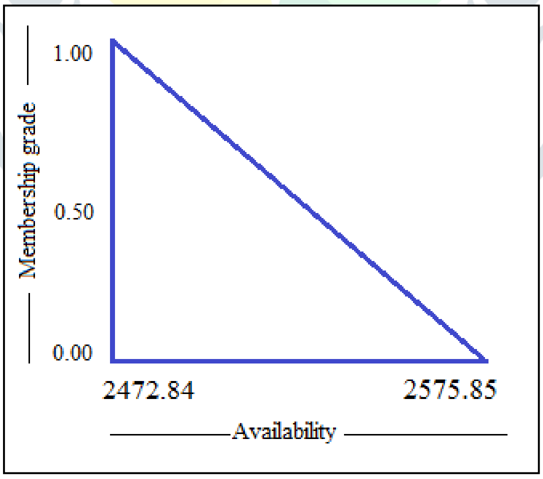

Figure 3: Membership grade for manufacturing cost

B_{foh} be the membership grade for Factory overhead charges and it varies as:-

$$B_{foh} = \begin{cases} 1 & x \le 204.38 \\ \frac{212.895833 - x}{8.515833} & 204.38 < x < 212.895833 \\ 0 & x \ge 212.895833 \end{cases} \quad (16)$$

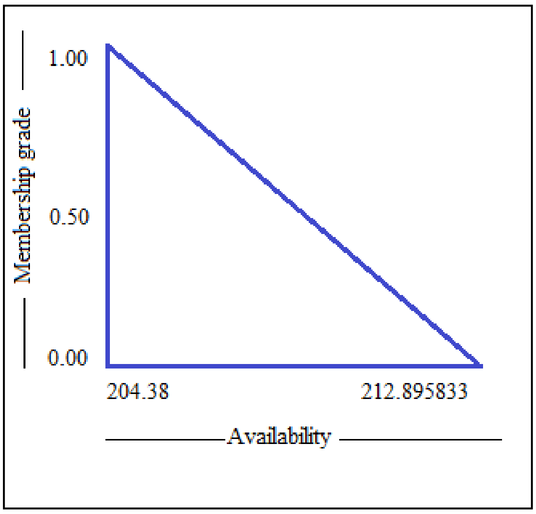

Figure 4: Membership grade for Factory overhead charges

B_{aoh} be the membership grade for Administrative overhead charges and it varies as:-

$$B_{aoh} = \begin{cases} 1 & x \le 132.29 \\ \frac{137.802083-x}{5.512083} & 132.29 < x < 137.802083 \\ 0 & x \ge 137.802083 \end{cases} \qquad (17)$$

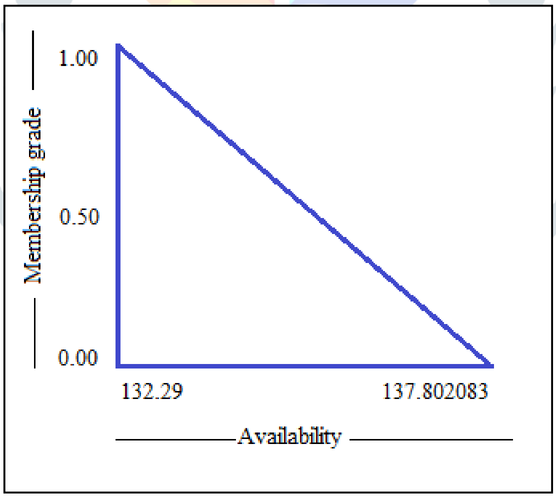

Figure 5: Membership grade for Administrative overhead charges

B_{toh} be the membership grade for township overhead charges and it varies as:-

$$B_{toh} = \begin{cases} 1 & x \le 37.38 \\ \frac{38.9372-x}{1.5575} & 37.38 < x < 38.9372 \\ 0 & x \ge 38.9372 \end{cases} \qquad (18)$$

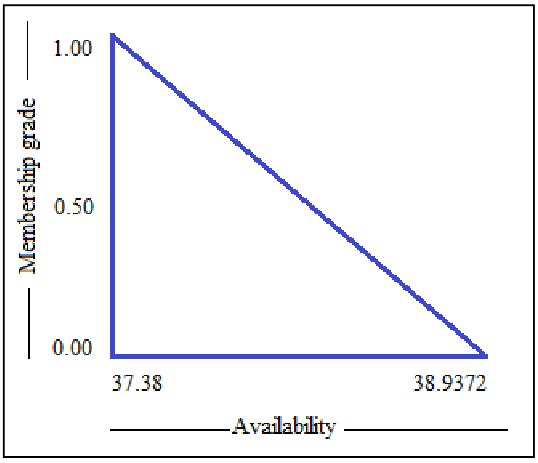

Figure 6: Membership grade for township overhead charges

B_{soh} be the membership grade for Shop overhead charges and it varies as:-

$$B_{soh} = \begin{cases} 1 & x \leq 4.97 \\ \frac{5.177083-x}{0.207083} & 4.97 < x < 5.177083 \\ 0 & x \geq 5.177083 \end{cases} \quad (19)$$

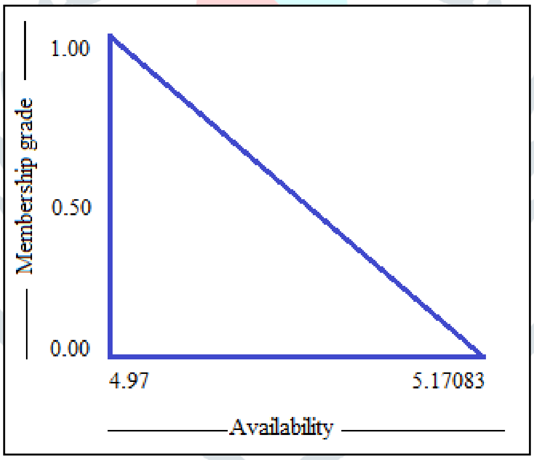

Figure 7: Membership grade for Shop overhead charges

$B_{o/h}$ be the membership grade for Total o/head charges and it varies as:-

$$B_{o/h} = \begin{cases} 1 & x \leq 378.98 \\ \frac{394.77083-x}{15.79083} & 378.98 < x < 394.77083 \\ 0 & x \geq 394.77083 \end{cases} \quad (20)$$

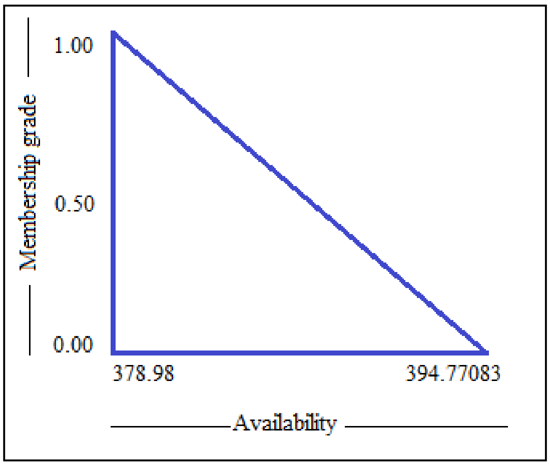

Figure 8: Membership grade for Total o/head charges

B_{prof} be the membership grade for Proforma charges and it varies as:-

$$B_{prof} = \begin{cases} 1 & x \leq 130.57 \\ \frac{136.01017 - x}{5.44017} & 130.57 < x < 136.01017 \\ 0 & x \geq 136.01017 \end{cases} \quad (21)$$

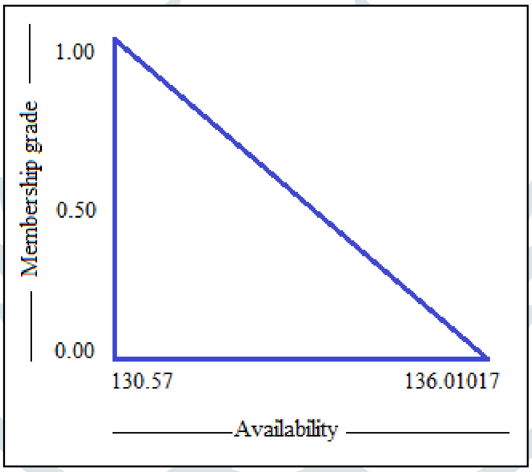

Figure 9: Membership grade for Performa charges

Using described methodology the modeling of production cost is being done and the Fuzzy numbers for all cost parameter have derived. The lower bound and upper bound are calculated the value of lower and upper bound are rupees **2952.381**(laks) and rupees **3075.203611** (laks) respectively.
The optimized fuzzy linear programming problem (OFLPP) has been constructed using the lower and upper bound.

Optimized Fuzzy Linear Programming Problem

The structure of OFLPP is given bellow.

Maxλ

Subjected to constraints

$122.82261\lambda - (45.95\, x_1 + 52.57\, x_2 + 41.47\, x_3 + 49.05\, x_4 + 42.79\, x_5 + 45.53\, x_6 + 44.87\, x_7 + 190.34\, x_8 + 43.84\, x_9 + 570.82\, x_{10} + 105.81\, x_{11} + 111.89\, x_{12} + 69.55\, x_{13} + 186.15\, x_{14} + 111.47\, x_{15} + 56.04\, x_{16} + 98.67\, x_{17} + 32.58\, x_{18} + 29.71\, x_{19} + 215.93\, x_{20} + 276.21\, x_{21} + 200.06\, x_{22} + 208.07\, x_{23} + 123.14\, x_{24}) \leq -2952.381$ (22)

$4.1975\, \lambda + 2.64\, x_1 + 2.65\, x_2 + 2.45\, x_3 + 2.45\, x_4 + 2.36\, x_5 + 2.47\, x_6 + 2.44\, x_7 + 6.86\, x_8 + 2.56\, x_9 + 5.33\, x_{10} + 4.94\, x_{11} + 5.14\, x_{12} + 4.32\, x_{13} + 4.29\, x_{14} + 4.29\, x_{15} + 3.69\, x_{16} + 4.43\, x_{17} + 1.89\, x_{18} + 1.73\, x_{19} + 7.08\, x_{20} + 7.65\, x_{21} + 6.19\, x_{22} + 7.43\, x_{23} + 5.46\, x_{24} \leq 104.9375$

(23)

$103.035\, \lambda + 33.47\, x_1 + 40.09\, x_2 + 29.81\, x_3 + 37.69\, x_4 + 31.55\, x_5 + 33.82\, x_6 + 33.26\, x_7 + 157.52\, x_8 + 31.62\, x_9 + 544.44\, x_{10} + 82.28\, x_{11} + 87.59\, x_{12} + 49.03\, x_{13} + 165.48\, x_{14} + 91.04\, x_{15} + 38.46\, x_{16} + 77.60\, x_{17} + 23.59\, x_{18} + 21.48\, x_{19} + 182.60\, x_{20} + 240.07\, x_{21} + 170.59\, x_{22} + 172.62\, x_{23} + 97.14\, x_{24} \leq 2575.875$ (24)

$8.515833\, \lambda + 5.34\, x_1 + 5.33\, x_2 + 5.00\, x_3 + 4.83\, x_4 + 4.82\, x_5 + 5.01\, x_6 + 4.98\, x_7 + 14.02\, x_8 + 5.24\, x_9 + 10.91\, x_{10} + 10.06\, x_{11} + 10.36\, x_{12} + 8.80\, x_{13} + 8.77\, x_{14} + 8.72\, x_{15} + 7.55\, x_{16} + 9.01\, x_{17} + 3.85\, x_{18} + 3.53\, x_{19} + 14.51\, x_{20} + 15.31\, x_{21} + 12.53\, x_{22} + 15.21\, x_{23} + 11.21\, x_{24} \leq 212.895833$

(25)

$5.512083\, \lambda + 3.46\, x_1 + 3.45\, x_2 + 3.23\, x_3 + 3.13\, x_4 + 3.12\, x_5 + 3.25\, x_6 + 3.22\, x_7 + 9.07\, x_8 + 3.39\, x_9 + 7.06\, x_{10} + 6.51\, x_{11} + 6.72\, x_{12} + 5.70\, x_{13} + 5.68\, x_{14} + 5.64\, x_{15} + 4.89\, x_{16} + 5.83\, x_{17} + 2.49\, x_{18} + 2.28\, x_{19} + 9.16\, x_{20} + 9.91\, x_{21} + 8.11\, x_{22} + 9.79\, x_{23} + 7.20\, x_{24} \leq 137.802083$

(26)

$1.5575\, \lambda + 0.98\, x_1 + 0.97\, x_2 + 0.91\, x_3 + 0.88\, x_4 + 0.88\, x_5 + 0.92\, x_6 + 0.91\, x_7 + 2.56\, x_8 + 0.96\, x_9 + 2.00\, x_{10} + 1.84\, x_{11} + 1.90\, x_{12} + 1.61\, x_{13} + 1.60\, x_{14} + 1.60\, x_{15} + 1.38\, x_{16} + 1.65\, x_{17} + 0.70\, x_{18} + 0.65\, x_{19} + 2.59\, x_{20} + 2.80 x_{21} + 2.29\, x_{22} + 2.77\, x_{23} + 2.03\, x_{24} \leq 38.9372$

(27)

$0.207083\, \lambda + 0.07\, x_1 + 0.08\, x_2 + 0.06\, x_3 + 0.08\, x_4 + 0.06\, x_5 + 0.07\, x_6 + 0.07\, x_7 + 0.32\, x_8 + 0.06\, x_9 + 1.09\, x_{10} + 0.16\, x_{11} + 0.18\, x_{12} + 0.10\, x_{13} + 0.33\, x_{14} + 0.18\, x_{15} + 0.08\, x_{16} + 0.16\, x_{17} + 0.05\, x_{18} + 0.04\, x_{19} + 0.37\, x_{20} + 0.48\, x_{21} + 0.34\, x_{22} + 0.35\, x_{23} + 0.19\, x_{24} \leq 5.177083$

(28)

$15.79083\, \lambda + 9.84\, x_1 + 9.83\, x_2 + 9.21\, x_3 + 8.91\, x_4 + 8.88\, x_5 + 9.24\, x_6 + 9.17\, x_7 + 25.97\, x_8 + 9.66\, x_9 + 21.05\, x_{10} + 18.58\, x_{11} + 19.17\, x_{12} + 16.21\, x_{13} + 16.38\, x_{14} + 16.41\, x_{15} + 13.89\, x_{16} + 16.65\, x_{17} + 7.10\, x_{18} + 6.50\, x_{19} + 26.26\, x_{20} + 28.50\, x_{21} + 23.28\, x_{22} + 28.02\, x_{23} + 20.54\, x_{24} \leq 394.77083$ (29)

$5.44017\, \lambda + 2.03\, x_1 + 2.32\, x_2 + 1.84\, x_3 + 2.17\, x_4 + 1.89\, x_5 + 2.02\, x_6 + 1.98\, x_7 + 8.40\, x_8 + 1.94\, x_9 + 25.25\, x_{10} + 4.68\, x_{11} + 4.95\, x_{12} + 3.08\, x_{13} + 8.24\, x_{14} + 4.93\, x_{15} + 2.48\, x_{16} + 4.36\, x_{17} + 1.44\, x_{18} + 1.31\, x_{19} + 9.56\, x_{20} + 12.21\, x_{21} + 8.85\, x_{22} + 9.20\, x_{23} + 5.44\, x_{24} \leq 136.01017$

(30)

$x_1, x_2, x_3 \ldots\ldots\ldots. x_{24} \geq 0,\ 0 \leq \lambda \leq 1$

The following table shows the solutions for optimized value of lower and upper bound and for the optimized membership grade.

Parametric variable	**For lower bound (b_i)**	**For upper bound ($b_i + p_i$)**	**For OFLPP (λ)**
x_1	0	0	0
x_2	0	0	8.797066
x_3	0	0	0
x_4	0	0	6.625152
x_5	0	0	0
x_6	0	0	0
x_7	0	0	0
x_8	2.1131	0	0
x_9	0	0	11.666309
x_{10}	1.66825	2.3149	1.278377
x_{11}	0	0	0
x_{12}	11.07097	10.34373	0
x_{13}	3.60959	7.48523	0
x_{14}	0	0	0
x_{15}	0	0	0
x_{16}	0	0	0
x_{17}	1.09540	1.80988	0
x_{18}	0	0	0
x_{19}	0	0	0
x_{20}	0	0	0
x_{21}	0	0	3.5685308
x_{22}	0	0	0
x_{23}	0	0	0
x_{24}	0	0	0
Z	**2952.381**	**3075.203611**	**0.50383964275671**

Table 3: solutions for all liner and fuzzy linear lpps

Analysis

The production cost of RCF is to be minimized using the cost parameter. The total minimum cost of the production is rupees 2952.381(in lakhs) and it can be extended till rupees 3075.203611(in lakhs) and then the optimum production cost has been obtained in order to get maximum membership grade. It shows that total production cost will provide the highest credibility if the optimized cost is less than or equal to $rupees\ 2952.38100(\text{in lakhs})$ and the credibility of production cost is being decreased if it is tending towards $rupees\ 3075.203611(\text{in lakhs})$. the following equation shows the fuzzy number for optimized membership grade.

Membership grade function of OFLPP

$$\lambda = \begin{cases} 1 & x \leq 2952.38100 \\ \frac{3075.203611 - x}{122.8228} & 2952.38100 < x < 3075.203611 \\ 0 & x \geq 3075.203611 \end{cases} \quad (31)$$

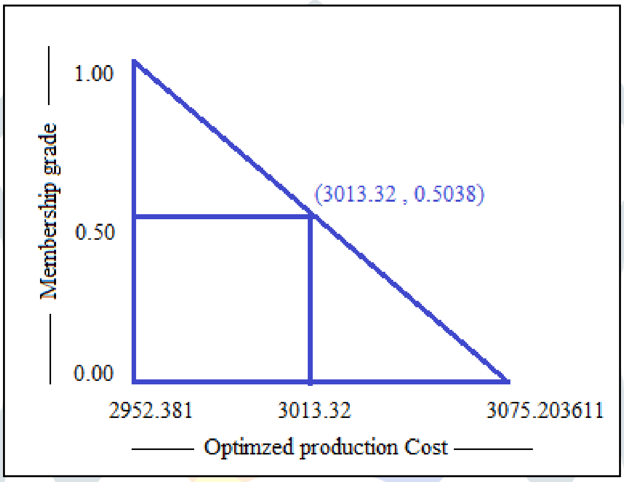

Figure 3: Membership grade for manufacturing cost

Furthermore the final optimal cost is rupees 3013.32(in lakhs) with optimized membership grade λ = 0.50383964275671

Conclusion

RCF kapurthala's output cost analysis and optimization was achieved by triangular (right angle) fuzzy linear programming. According to probabilistic changes in the existence of various restrictions, the real cost of output was reluctant or unclear, so we presented the situation-based Fuzzy model to minimize devastation in cost management and tested the legitimacy of optimized performance. Similar coaches' output costs from 2007-08 were considered data. Overall expenses were aimed to maximize. To get the optimal fuzzy LPP, the lower and upper limit are determined. The estimated minimum production cost is rupees 2952.381 (lakhs) which can be increased to rupees 3075.203611 and the optimal production cost was achieved to achieve the highest membership rate. Furthermore the final optimal cost is rupees 3013.32(in lakhs) with optimized membership grade λ = 0.50383964275671.This membership grade deal with the fluctuated production cost.

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