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Optimizing of Advertising Print-Media by Fuzzy Goal Programming

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***Abstract*— This study aims to model Goal Programming and Fuzzy Goal Programming in advertising print-media selection problems of marketing. The system produced the optimal advertising print media and advertising times by the solutions obtained from Linear Programming Solver, and Python Programming according to target budget and audience constraints. The model of the BIG-M method is used to acquire the solution of the advertising print-media problem. The implemented system is meant to assist general businesses in determining the most effective advertising media, optimal advertising times, as well as prices for their market.**

Keywords—Goal Programming, Fuzzy Goal Programming, Advertising Print-Media.

I. INTRODUCTION

Advertising is a pervasive aspect of modern society, which dissipates information about products, services, and ideas through various channels such as print, digital, and social media platforms to reach a wider audience. It has a significant impact on how consumers behave, perceive things, and drive economic activity. Advertising in print media refers to the means of promoting products, services, or brands through traditional printed materials in newspapers, magazines, flyers, brochures, and other tangible forms of communication. This method of marketing has been a cornerstone of advertising for a significant period and continues to be a valuable tool for businesses to reach their target audiences. By strategically investing in advertising, businesses can increase brand awareness, drive sales, and gain a competitive edge in the market.

Incorporating principles of operational research into advertising practices can be a crucial strategy for organizations aiming to optimize their marketing efforts. It enables businesses to make data-driven decisions, identify key trends, and determine the most cost-effective ways to reach their target audience. Embracing a systematic approach rooted in quantitative analysis can lead to more efficient resource allocation, better campaign performance, and increased competitiveness in the ever-evolving landscape of the business world.

A. Operations Research.

Operations research arose during World War II by the efforts of military planners at that time. The main objective was to allocate limited resources effectively. After the war, commercial, government, and societal issues were addressed using the operations research tools they developed. Morse & Kimball defined operations research as “a scientific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control”. In operations research, issues are deconstructed into their most fundamental parts and then mathematically analyzed into a sequence of actions for solutions. When it comes to making decisions, operations research offers a more potent method than standard software and statistical solutions.

B. Multi-criteria Decision-making.

Operations research includes multi-criteria decision-making (MCDM) as an area of study. Multi-criteria decision-making is one of the main decision-making problems that aims to determine the best alternative by considering multiple conflicting criteria in the selection process. There are various MCDM problem and approach classes. Whether or not the answers to MCDM problems are defined readily or intuitively makes a big difference.

C. Goal Programming.

Goal programming is an aspect of multi-criteria decision-making, which is a subclass of multi-objective optimization. This program is for optimizing. It can be thought of as a specialization or further development of linear programming to handle several, usually contradictory objective measures. A target value or goal is assigned to each of these measurements in order to be met. An achievement function is then used to reduce undesired departures from this set of target values. Depending on the goal programming version used, this could be either a vector or a weighted sum. Underlying satisficing philosophy is assumed, as target satisfaction is considered to satisfy the decision maker. offering the most fulfilling solution given the different resources available and the goals' relative importance.

D. Fuzzy Goal Programming.

In an operational setting, fuzzy goal programming is an extension of traditional goal programming that is used to handle multiobjective issues with vaguely described model variables. Here are the steps to formulate FGP

- Identify objectives and decision variables relevant to the decision problem.
- Define fuzzy sets and membership functions for each objective and decision variable to represent their degrees of satisfaction or achievement.
- Specify fuzzy goals by assigning desired levels or targets using linguistic terms and membership functions.
- Develop deviation functions to quantify discrepancies between achieved and desired levels of objectives.
- Formulate constraints that must be satisfied in the decision-making process, such as resource availability or operational requirements.
- Construct the objective function, combining deviation functions and constraints to represent overall optimization criteria.
- Choose an appropriate solution method, such as linear programming or evolutionary algorithms, to find the optimal solution.
- Perform sensitivity analysis to assess the robustness of the optimal solution to changes in fuzzy goals or parameters.

II. LITERATURE REVIEW

Thaw Tar Aye and Myint Myint Yee [1] designed a system to help general businesses determine the most cost-effective advertising media and charges for their request. In response to the target budget and followership constraints, they used the BIG-M system with the Simplex algorithm to break the marketing advertising media selection problem. They discovered that a constraint structure, which is hypercritical, must be assessed to determine the stylish way to announce and the stylish or optimal advertising media within a given set of constraints.

Saravanan Venkatachalam et.al [2] enforced an optimization suite(zilch) to help with radio marketable scheduling. He created an announcement placement canon for each station, the OS employs optimization models and four heuristics processes. He concluded that the models in the OS allow for the most effective use of available force, as well as request and time inflexibility to meet demand, maximize profit, and ameliorate client satisfaction. likewise, the OS assists the deals department in making strategic opinions by aiding it in targeting unborn businesses.

Alf Kimms and Michael Muller Bungart [3] examined the channel's issue with choosing and arranging the time for the commercials to be shown. Using the created mathematical model and the five-heuristic method, the heuristics' performance of varying sizes has been assessed and a methodical process to create test cases for the current issue has been created.

Xinhui Zhang [4] identifies that allocating the slots to advertisers is one of the main issues the TV networks are facing. He proposes a two-step hierarchical approach to solve this problem. He concluded that the suggested models and methods of solving them can be used to address issues with commercial allocation in radio stations and cable networks. Effective distribution of advertising space to sponsors can offer these networks significant potential gains in income and profitability.

Prerna Manik et.al [5] describe a problem of scheduling advertisements on news websites, which have different capacities and rates, to maximize revenue within certain constraints. The paper proposes a mathematical model, specifically a mixed integer 0–1 linear programming approach, to optimize this scheduling task. The optimal schedule of ads in different time slots which maximizes the revenue is determined using techniques like branch and bound integer programming and goal programming.

Alberto García-Villoria et.al [6] investigate the problem of scheduling ad spots in the television industry, taking audience rating requests into account. They designed two mixed integers linear programming (MILP) models, as well as two constructive heuristics, local search procedures, and simulated annealing (SA) approaches. The MILP formulations that were discovered were found to be more efficient in solving optimal instances with up to 150 spots even the SA algorithm was also effective.

Fred S. Zufryden [7] developed a stochastic model to implement both the study of consumer behavior and the scheduling of advertising media. Further, he proposed efficient heuristic programming techniques for solving the media model. He concluded that stochastic advertising exposure to consumer purchase behavior is directly linked to each other and is an applicable decision-making tool.

M. H. J. Webb [8] critically studied the concept and application of advertising response functions in the first section and explained an approach to media planning that uses a "control parameter" instead of a "response function" in the second section. He argued that using the advertising response function to decide on an advertising schedule is illogical. He used a quasi-optimization process and demonstrated that an adaptive control parameter is consistent.

Ali Abdallah Alalwan [9] considers the primary objective of this study to be to determine and evaluate the key social media advertising-related variables that may influence purchase intention. He used the UTAUT2 model and SEM analyses, to predict the variances in the purchase intention of the customers. He found that five factors were significantly influencing the customers' purchase intention: performance expectancy, hedonic motivation, interactivity, informativeness, and perceived relevance.

Subodha Kumar et.al [10] consider the shape and exhibition frequency into consideration while creating a solution for the advertisement scheduling issue. In this case, he used hybrid GA to solve the problem, and then he compared the results by running CPLEX on the integer programming formulation of the problem. He concludes that if we apply the case study, where improvements were roughly between 4 and 24%, the real revenue increases could still be significant. If more people visited the website than 500 times per hour, the figures might go up even higher.

K. Shalini, and Sridevi Polasi [11] employed the lexicographic linear goal programming (LLGP) model to determine the ideal agricultural product compound in Sirsi, Uttara Kannada district, Karnataka's rice field. To maximize the benefit, goal programming was also applied for the outcome, and both results were compared. Determined that the LLGP model is the most effective option if they wish to boost revenue.

K. Shalini, Jahan Noor, and Sridevi Polasi [12] applied a variety of techniques to transportation problems, including the least cost method, Vogel's Approximation Method (VAM), the MODI method, and the northwest corner method. After modeling the Transportation Problem to LPP, several appropriate techniques, including the Simplex and Goal Programming model, were used to solve it. Ultimately decided that the goal programming approach is the most effective and should be chosen by the user to obtain reduced transportation costs.

Vraja Mohan Sammeta, Harish Babu G A, and Sridevi Polasi [13] focused on analyzing the several types of bananas, their manufacturing process in the tissue culture lab, their production costs, and their sales. In Banana Tissue Culture, they have employed the Goal Programming methodology to recommend a newcomer to attain the most potential in this domain. It was determined that although the cost of the plants is the same, selling the Yalakki fruit is more expensive, making Yalakki more profitable for the farmers.

III. PROBLEM FORMULATION

The business organizations want to advertise in a variety of advertising platforms to find out the greatest advertising media and to see beneficial market growth. The funds for the advertising budget were provided in kyat. The advertising print media namely Digital Life Journal, Living Color Magazine & The Time Newspaper defined the number of times to advertise the advertising in their respective media as 4,1,30 times/month. To comprehend the business organization about media's widespread appeal the average audience received by each advertising print media is mentioned and the amount required for advertising is specified by each advertising media

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TABLE I. DATA OF THE PROBLEM

Sl.No.	Media Name	Advertising Price	Average Audience	Printed times/month
1.	Digital Life Journal	50,000 Ks	90000	4
2.	Living Color Magazine	30,000 Ks	60000	1
3.	The Time Newspaper	50,000 Ks	60000	30

The marketing team of business organizations wishes to have top-notch advertising media having better exposure along with a reasonable budget. Accordingly, we have now classified the problem into two parts.

A. To Maximize the Audience

Objective Function: Maximize $Z = 90000x_1 + 60000x_2 + 60000x_3$
Subject to the constraints:
Budget limitation
$50000x_1 + 30000x_2 + 50000x_3 \leq 300000$
Number of times ad printed per month
$x_1 \leq 4$
$x_2 \leq 1$
$x_3 \leq 30$

On Simplification
Objective Function: Maximize $Z = 3x_1 + 2x_2 + 2x_3$
Subject to the constraints:
$5x_1 + 3x_2 + 5x_3 \leq 30$
$x_1 \leq 4$
$x_2 \leq 1$
$x_3 \leq 30$

B. To Minimize the Cost.

Objective Function: Minimize $Z = 50000x_1 + 30000x_2 + 50000x_3$
Subject to the constraints:
Audience
$90000x_1 + 60000x_2 + 60000x_3 \geq 504000$
Number of times ad printed per month
$x_1 \leq 4$
$x_2 \leq 1$
$x_3 \leq 30$

On Simplification
Objective Function: Minimize $Z = 5x_1 + 3x_2 + 5x_3$
Subject to the constraints:
$15x_1 + 10x_2 + 10x_3 \geq 84$
$x_1 \leq 4$
$x_2 \leq 1$
$x_3 \leq 30$
where x_1 is Digital Life Journal, x_2 is Living Color Magazine and x_3 is The Time Newspaper.

IV. METHODOLOGY

A. A General Goal Programming Model is given below:

Objective function: Minimize Z = $\sum_{i=0}^{n} P_i(d_i^+ + d_i^-)$
Subject to the constraints:

$$a_1x_1 + a_2x_2 + \cdots + a_ix_i + d_i^- - d_i^+ = A$$
$$c_1x_1 + c_2x_2 + \cdots + c_ix_i + d_i^- - d_i^+ = B$$
$$x_i + d_i^+ - d_i^+ = D$$

Where a is the number of audiences in each media, x is the advertising print-media(journal, magazine, newspaper), c is the cost for advertising, B is the budget limit, A is the maximum audience that can be reached, D is the maximum number of times advertised. P_i is the priorities of the assigned rank order of the goals that is $P_1 > P_2 > P_3 > \cdots > P_i$
d_i^+, d_i^- represents the over-achievement and under-achievement deviational variables respectively.

1) Goal programming to maximize the audience

Constraints:

$$5x_1 + 3x_2 + 5x_3 - d_1^+ = 30$$
$$x_1 + d_2^- - d_2^+ = 4$$
$$x_2 + d_3^- - d_3^+ = 1$$
$$x_3 + d_4^- - d_4^+ = 30$$

Objective function: Minimize Z= $P_1d_1^+ + P_2d_2^- + P_3d_2^+ + P_4d_3^- + P_5d_3^+ + P_6d_4^- + P_7d_4^+$

2) Python code to maximize the audience using goal programming.

```
from pyomo.environ import *
from pyomo.opt import SolverFactory
opt = SolverFactory('cplex_direct')
model = ConcreteModel()
model.x1 = Var(within = NonNegativeIntegers)
model.x2 = Var(within = NonNegativeIntegers)
model.x3 = Var(within = NonNegativeIntegers)
model.n1 = Var(within = NonNegativeIntegers)
model.p1 = Var(within = NonNegativeIntegers)
model.n2 = Var(within = NonNegativeIntegers)
model.p2 = Var(within = NonNegativeIntegers)
model.n3 = Var(within = NonNegativeIntegers)
model.p3 = Var(within = NonNegativeIntegers)
model.n4 = Var(within = NonNegativeIntegers)
model.p4 = Var(within = NonNegativeIntegers)
model.obj = Objective(expr =1000*model.p1 + 980*model.n2 + 950*model.p2 + 930*model.n3 + 900* model.p3 + 850*model.n4 +800* model.p4)
model.con1 = Constraint(expr = 5*model.x1 + 3*model.x2 + 5*model.x3 - model.p1 == 30);
model.con2 = Constraint(expr = model.x1 + model.n2 - model.p2  == 4);
model.con3 = Constraint(expr = model.x2 + model.n3 - model.p3 == 1);
model.con4 = Constraint(expr = model.x3 + model.n4 - model.p4 == 30);
opt.solve(model)
print("x1 = ", model.x1.value)
print("x2 = ", model.x2.value)
print("x3 = ", model.x3.value)
print("n1 = ", model.n1.value)
print("n2 = ", model.n2.value)
print("n3 = ", model.n3.value)
print("n4 = ", model.n4.value)
print("p1 = ", model.p1.value)
print("p2 = ", model.p2.value)
print("p3 = ", model.p3.value)
print("p4 = ", model.p4.value)
print("z = ", model.obj())
```

3) Goal programming to minimize the budget

Constraints:

$$15x_1 + 10x_2 + 10x_3 + d_1^- = 84$$
$$x_1 + d_2^- - d_2^+ = 4$$
$$x_2 + d_3^- - d_3^+ = 1$$
$$x_3 + d_4^- - d_4^+ = 30$$

Objective function:Minimize Z = $P_1d_1^- + P_2d_2^- + P_3d_2^+ + P_4d_3^- + P_5d_3^+ + P_6d_4^- + P_7d_4^+$

4) Python code to minimize the budget using goal programming.

```
from pyomo.environ import *
from pyomo.opt import SolverFactory
opt = SolverFactory('cplex_direct')
model = ConcreteModel()
model.x1 = Var(within = NonNegativeIntegers)
model.x2 = Var(within = NonNegativeIntegers)
model.x3 = Var(within = NonNegativeIntegers)
model.n1 = Var(within = NonNegativeIntegers)
model.p1 = Var(within = NonNegativeIntegers)
model.n2 = Var(within = NonNegativeIntegers)
model.p2 = Var(within = NonNegativeIntegers)
model.n3 = Var(within = NonNegativeIntegers)
model.p3 = Var(within = NonNegativeIntegers)
model.n4 = Var(within = NonNegativeIntegers)
model.p4 = Var(within = NonNegativeIntegers)
model.obj = Objective(expr =1000*model.n1 + 980*model.n2 + 950*model.p2 + 930*model.n3 + 900* model.p3 + 850*model.n4 +800* model.p4)
model.con1 = Constraint(expr = 15*model.x1 + 10*model.x2 + 10*model.x3 + model.n1 == 84);
model.con2 = Constraint(expr = model.x1 + model.n2 - model.p2  == 4);
model.con3 = Constraint(expr = model.x2 + model.n3 - model.p3 == 1);
model.con4 = Constraint(expr = model.x3 + model.n4 - model.p4 == 30);
opt.solve(model)
print("x1 = ", model.x1.value)
print("x2 = ", model.x2.value)
print("x3 = ", model.x3.value)
print("n1 = ", model.n1.value)
print("n2 = ", model.n2.value)
print("n3 = ", model.n3.value)
print("n4 = ", model.n4.value)
print("p1 = ", model.p1.value)
print("p2 = ", model.p2.value)
print("p3 = ", model.p3.value)
```

```
print("n3 = ", model.n3.value)
print("n4 = ", model.n4.value)
print("p1 = ", model.p1.value)
print("p2 = ", model.p2.value)
print("p3 = ", model.p3.value)
print("p4 = ", model.p4.value)
print("z = ", model.obj())
```

B. Formulation of Fuzzy Goal Programming

1) Fuzzy goal programming to maximize the audience

Constraints:

$\mu_1: 16 - 0.5(5x_1 + 3x_2 + 5x_3) + \varepsilon_1^+ - \varepsilon_1^- = 1$

$\mu_2: 3 - 0.5(x_1) + \varepsilon_2^+ - \varepsilon_2^- = 1$

$\mu_3: 1.5 - 0.5(x_2) + \varepsilon_3^+ - \varepsilon_3^- = 1$

$\mu_4: 11 - 0.33(x_3) + \varepsilon_4^+ - \varepsilon_4^- = 1$

Objective function: Minimize Z = $P_1\varepsilon_1^+ + P_2\varepsilon_2^- + P_3\varepsilon_2^+ + P_4\varepsilon_3^- + P_5\varepsilon_3^+ + P_6\varepsilon_4^- + P_7\varepsilon_4^+$

2) Python code to maximize the audience using fuzzy goal programming.

```
import pulp
prob = pulp.LpProblem("FuzzyGoalProgramming", pulp.LpMinimize)
x1 = pulp.LpVariable('x1', lowBound=0)
x2 = pulp.LpVariable('x2', lowBound=0)
x3 = pulp.LpVariable('x3', lowBound=0)
epsilon1_plus = pulp.LpVariable('epsilon1_plus', lowBound=0)
epsilon1_minus = pulp.LpVariable('epsilon1_minus', lowBound=0)
epsilon2_plus = pulp.LpVariable('epsilon2_plus', lowBound=0)
epsilon2_minus = pulp.LpVariable('epsilon2_minus', lowBound=0)
epsilon3_plus = pulp.LpVariable('epsilon3_plus', lowBound=0)
epsilon3_minus = pulp.LpVariable('epsilon3_minus', lowBound=0)
epsilon4_plus = pulp.LpVariable('epsilon4_plus', lowBound=0)
epsilon4_minus = pulp.LpVariable('epsilon4_minus', lowBound=0)
P1 = 1
P2 = 1
P3 = 1
P4 = 1
P5 = 1
P6 = 1
P7 = 1
prob += P1 * epsilon1_plus + P2 * epsilon2_minus + P3 * epsilon2_plus + P4 * epsilon3_minus + P5 * epsilon3_plus + P6 * epsilon4
prob += 16 - 0.5 * (5 * x1 + 3 * x2 + 5 * x3) + epsilon1_plus - epsilon1_minus == 1, "Constraint_μ1"
prob += 3 - 0.5 * x1 + epsilon2_plus - epsilon2_minus == 1, "Constraint_μ2"
prob += 1.5 - 0.5 * x2 + epsilon3_plus - epsilon3_minus == 1, "Constraint_μ3"
prob += 11 - 0.33 * x3 + epsilon4_plus - epsilon4_minus == 1, "Constraint_μ4"
prob.solve()
print("Status:", pulp.LpStatus[prob.status])
print("Objective Function Value:", pulp.value(prob.objective))
for variable in prob.variables():
    print(variable.name, "=", variable.varValue)
```

3) Fuzzy goal programming to minimize the budget

Constraints:

$\mu_1: 43 - 0.5(15x_1 + 10x_2 + 10x_3) + \varepsilon_1^+ - \varepsilon_1^- = 1$

$\mu_2: 3 - 0.5(x_1) + \varepsilon_2^+ - \varepsilon_2^- = 1$

$\mu_3: 1.5 - 0.5(x_2) + \varepsilon_3^+ - \varepsilon_3^- = 1$

$\mu_4: 11 - 0.33(x_3) + \varepsilon_4^+ - \varepsilon_4^- = 1$

Objective function: Minimize Z = $P_1\varepsilon_1^- + P_2\varepsilon_2^- + P_3\varepsilon_2^+ + P_4\varepsilon_3^- + P_5\varepsilon_3^+ + P_6\varepsilon_4^- + P_7\varepsilon_4^+$

4) Python code to minimize the budget using fuzzy goal programming

```
import pulp
prob = pulp.LpProblem("FuzzyGoalProgramming", pulp.LpMinimize)
x1 = pulp.LpVariable('x1', lowBound=0)
x2 = pulp.LpVariable('x2', lowBound=0)
x3 = pulp.LpVariable('x3', lowBound=0)
epsilon1_plus = pulp.LpVariable('epsilon1_plus', lowBound=0)
epsilon1_minus = pulp.LpVariable('epsilon1_minus', lowBound=0)
epsilon2_plus = pulp.LpVariable('epsilon2_plus', lowBound=0)
epsilon2_minus = pulp.LpVariable('epsilon2_minus', lowBound=0)
epsilon3_plus = pulp.LpVariable('epsilon3_plus', lowBound=0)
epsilon3_minus = pulp.LpVariable('epsilon3_minus', lowBound=0)
epsilon4_plus = pulp.LpVariable('epsilon4_plus', lowBound=0)
epsilon4_minus = pulp.LpVariable('epsilon4_minus', lowBound=0)
P1 = 1
P2 = 1
P3 = 1
P4 = 1
P5 = 1
P6 = 1
P7 = 1
prob += P1 * epsilon1_minus + P2 * epsilon2_minus + P3 * epsilon2_plus + P4 * epsilon3_minus + P5 * epsilon3_plus + P6 * epsilon4
prob += 43 - 0.5 * (15 * x1 + 10 * x2 + 10 * x3) + epsilon1_plus - epsilon1_minus == 1, "Constraint_μ1"
prob += 3 - 0.5 * x1 + epsilon2_plus - epsilon2_minus == 1, "Constraint_μ2"
prob += 1.5 - 0.5 * x2 + epsilon3_plus - epsilon3_minus == 1, "Constraint_μ3"
prob += 11 - 0.33 * x3 + epsilon4_plus - epsilon4_minus == 1, "Constraint_μ4"
prob.solve()
print("Status:", pulp.LpStatus[prob.status])
print("Objective Function Value:", pulp.value(prob.objective))
for variable in prob.variables():
    print(variable.name, "=", variable.varValue)
```

V. RESULT AND DISCUSSION

A. Solution Obtained using Linear Programming Solver to Maximize the Audience

Variable	Value	Obj. Cost	Reduced Cost
X1	4	3	0
X2	1	2	0
X3	1.4	2	0
d1+	0	1000	-900.4
d1-	0	0	0
d2+	0	800	-1301
d2-	0	900	-399
d3+	0	600	-900.8
d3-	0	700	-399.2
d4+	0	400	-900
d4-	28.6	500	0

Constraint	RHS	Slack	Dual Price
Constraint1	30	-	-99.6
Constraint2	4	-	501
Constraint3	1	-	300.8
Constraint4	30	-	500

Fig. 1. Solution obtained to maximize the audience using linear programming solver

Fig. 2. Graph obtained to maximize the audience using linear programming solver

```
x1 =  4.0
x2 =  0.0
x3 =  2.0
n1 =  None
n2 =  0.0
n3 =  1.0
n4 =  28.0
p1 =  0.0
p2 =  0.0
p3 =  0.0
p4 =  0.0
z =  24730.0
```

Fig. 3. Output from Python to maximize the audience using goal programming.

```
Status: Optimal
Objective Function Value: 9.538
epsilon1_minus = 0.0
epsilon1_plus = 0.0
epsilon2_minus = 0.0
epsilon2_plus = 0.0
epsilon3_minus = 0.0
epsilon3_plus = 0.0
epsilon4_minus = 9.538
epsilon4_plus = 0.0
x1 = 4.0
x2 = 1.0
x3 = 1.4
```

Fig. 4. Output from Python to maximize the audience using fuzzy goal programming.

The Fuzzy goal programming and goal programming model have been formulated by referring to the given problem in the Simplex method. Both of the models are used to identify the optimal way to maximize the audience. Subsequently, Linear Programming Solver and Phyton are utilized to solve the formulated goal programming and fuzzy goal programming models.

In Fig. 3. And Fig. 4. x_1 is Digital Life Journal, x_2 is Living Color Magazine, x_3 is The Time Newspaper. By comparing the results obtained for goal programming and fuzzy goal programming we can say that to advertise four times in Digital Life Journal as it is given more importance in both goal and fuzzy goal programming. Thus, Digital Life Journal is the top-notch advertising print media which has great exposure.

B. Solution Obtained from Linear Programming Solver to Minimize the Budget

Variable	Value	Obj. Cost	Reduced Cost
X1	4	5	0
X2	1	3	0
X3	1.4	5	0
d1+	0	0	0
d1-	0	1000	-1049.5
d2+	0	800	-1547.5
d2-	0	900	-152.5
d3+	0	600	-1098
d3-	0	700	-202
d4+	0	400	-900
d4-	28.6	500	0

Constraint	RHS	Slack	Dual Price
Constraint1	84	-	-49.5
Constraint2	4	-	747.5
Constraint3	1	-	498
Constraint4	30	-	500

Fig. 5. Solution obtained to minimize the budget using linear programming solver.

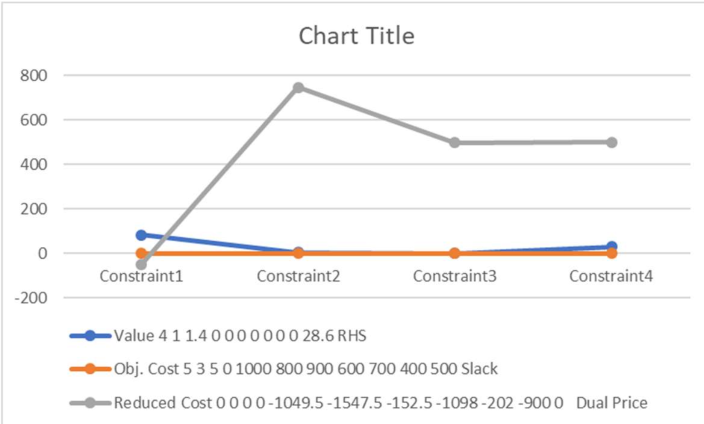

Fig. 6. Graph obtained to minimize the budget using linear programming solver.

```
x1 =  -0.0
x2 =  1.0
x3 =  7.0
n1 =  4.0
n2 =  4.0
n3 =  -0.0
n4 =  23.0
p1 =  None
p2 =  -0.0
p3 =  -0.0
p4 =  0.0
z =  27470.0
```

Fig. 7. Output from Python to minimize the budget using goal programming.

```
Status: Optimal
Objective Function Value: 0.0
epsilon1_minus = 0.0
epsilon1_plus = 144.51515
epsilon2_minus = 0.0
epsilon2_plus = 0.0
epsilon3_minus = 0.0
epsilon3_plus = 0.0
epsilon4_minus = 0.0
epsilon4_plus = 0.0
x1 = 4.0
x2 = 1.0
x3 = 30.30303
```

Fig. 8. Output from Python to minimize the budget using fuzzy goal programming.

The Fuzzy goal programming and goal programming model have been formulated by referring to the given problem in the BIG-M method. Both of the models are used to identify the optimal way to minimize the budget. Subsequently, Linear Programming Solver and Phyton are utilized to solve the formulated goal programming and fuzzy goal programming models.

In Fig. 7. And Fig. 8. x_1 is Digital Life Journal, x_2 is Living Color Magazine, x_3 is The Time Newspaper. By comparing the results obtained for goal programming and fuzzy goal programming we can say that it is given more importance to The Time Newspaper to advertise more number of times per in both goal and fuzzy goal programming. Thus, Time Newspaper is the cost-efffective advertising print-media.

VI. CONCLUSION

The problem of advertising media selection can be effectively addressed through the use of goal programming and fuzzy goal programming strategies. Within a given set of constraints, this approach can assist in determining an ideal advertising medium and an optimal advertising times. This research can also be extended to address ad allocation issues in digital and other social media platforms, where goal programming and fuzzy goal programming models can be employed to find solutions. Our study successfully tackled the problem of optimizing advertising times by combining goal programming and fuzzy goal programming methodologies. Utilizing Python and the Linear Programming Solver, we determined the ideal combination of advertising times that would minimize expenses and maximize audience exposure. Thus, this system will assist marketers in determining the best approach to advertise.

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