Optimization of Advertising Media Scheduling Through Goal Programming
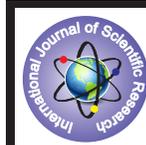
Mathematics

J. Ramesh Babu	Assoc. Prof. of Mathematics, Dept. of Humanities and Sciences, Malla Reddy College of Engineering and Technology, Hyderabad, A.P, India.
Dr. G. Ravindra Babu	Dept. of Computer Science and Engineering, Avanthis Scientific Technological and Research Academy, Guntapally (Village), Hayathnagar (M), R.R. Dist. Hyderabad, A.P, India
CH. Karuna Sree	Assistant Professor of Mathematics, Vignan University, Guntur – 522213.

ABSTRACT *This paper presents the possibility of goal programming application for the optimization of the advertising campaign. More specifically, this study attempts GMR Group, India in order to demonstrate the potential of goal programming for advertising media scheduling.*

1. INTRODUTION:

Advertising & Promotion play a pivotal role in any social & economic system. Any product that is targeted to a segmented market has to be advertised and the advertising division is inclined by the choice of media, effectiveness of the media and the budget incurred towards the selected media. One of the most difficult and most heavily subjective decisions that face an advertising manager is that of specific media selection. If the choices are limited to only two or three individual media, an experienced advertising man can probably does a fairly decent job of approaching the optimum mix for his campaign by using his own judgment. In the highly differentiated media of the advertising field, however, specific media choices reach into hundreds, and different combinations reach the millions, it becomes physically impossible for even a large team of experienced men to scan every possibility by hand and select an optimum combination alternative. It is quite challenging task to make a right decision where the goals, the constraints and consequences of the division made is unknown. On the other hand these decision making problems much seen in advertising as it demands huge investments. One needs to have critical thinking in this respect of choosing the right media and judiciously allocating the available budget.

In this era of globalization companies both private and public understand the importance of effective and efficient communication with the consumers for their instant success. For this companies go for a relevant marketing mix, which is blend of designing packing, pricing and placing the product. Advertising dominates the scenario of promotional mix by overtaking personal selling, publicity and sales promotion. Print media or electronic media are the various options available for a marketing manager who chooses the right media, and places the massage in the minds of the target audience at the right place and at right time by judiciously allocating the available budget.

It has become necessary to relay on the assistance of management science techniques in order to optimize advertising media scheduling. So far there have been various studies in which a number of different approaches have been attempts for advertising media planning. Research in the field of media selection and allocation began with work of Bass & Lonsdale (1966) who explored the use of Linear programming in the media selection. Charnes et al. (1968) introduced a Goal programming model for media selection to address problems associated with the critical advertising measurement of frequency and reach. The study on improvements in media selections based on generalized GP by Kendall (1975), De Kluyver (1978) proposed the more realistic use of hard and soft constraints for LP models to solve media selection. Keown and Duncan (1979) developed an integer goal programming to solve media selection problems. Lee and Kwak (1999) have developed an information resource planning using AHP based goal programming model. An approach to planning an advertising campain of goods and services was discussed by Belenky (2001, 2002). Mihiotis and Tsakiris (2004) reviewed

the recent study releated to advertising planning. Papers by Cheong and Leckenby (2006) and Zhu and Norwell (2003) both employed data envelopment analysis (DEA) to study the efficiency of various marketing strategies. Elliott (2005) also investigated the marketing mix problem. Philips (2006) who discusses the financial services media mix. A number of studies have addressed the use of quantitative techniques in determining the optimum marketing mix. However, these methods find very limited practical applications, because models often neglected multiple conflicting goals of advertizing campaign. In this paper we propose Goal Programming model for the advertising campaign of GMR group India, to demonstrate the potential of goal programming.

2. DATA OF THE PROBLEM

This study was carried out by GMR Media Group, which is one of the fastest growing private sector organizations in the country with infrastructure as its core business. Suppose we are planning an advertising campaign for the coming fiscal year. We have selected 45 media vehicles in seven categories as possible candidates for the campaign. Table 1 presents the list of vehicles, cost per inclusion, and the weighted exposure units per inclusion.

Table 1
Media Vehicles, Cost, and Audience Data Used for the Goal Programming Model

Media Category	Vehicle No	Cost	Exposure
A	General public Magazine (4 colour, page)		
	1	6,080.00	160000
	2	4,855.00	140000
	3	210.00	105000
	4	250.00	190000
	5	495.00	210000
	6	250.00	900000
B	General public Magazine (2colour, page)		
	7	375.00	100000
	8	820.00	125000
	9	980.00	350000
	10	500.00	375000
	11	800.00	400000
C	Ladies' Magazine (4colour, Page)		
	12	531.00	14820
	13	740.00	49500
	14	2410.00	15000
	15	800.00	30000
	16	2400.00	159300
D	Men's' Magazine (4colour, Page)		

	17	990.00	162000
	18	500.00	19500
	19	494.00	131200
	20	5250.00	74000
E	Spot Radio (Day,60 seconds)		
	21	2250.00	23100
	22	3150.00	160000
	23	943.75	160000
	24	899.00	82000
F	Spot Radio (Prime, 60 seconds)		
	25	4000.00	209900
	26	5020.00	104400
	27	3540.00	98000
	28	3700.00	296000
G	Day T.V. (30 seconds)		
	29	5500.00	100000
	30	7200.00	102000
	31	8300.00	115500
H	Day T.V. (60 seconds)		
	32	9000.00	120000
	33	12540.00	154000
	34	15656.00	170000
I	Spot T.V. (Day 30 seconds)		
	35	35000.00	690000
	36	40000.00	240000
	37	50000.00	241000
J	Spot T.V. (Prime, 60 seconds)		
	38	55000.00	250500
	39	68000.00	315000
	40	82165.00	485500
	41	57505.00	525000
K	Night T.V. (30 Seconds)		
	42	55000.00	310000
	43	15500.00	421600
	44	330000.00	510000
	45	110000.00	630000

3. GENERAL GOAL PROGRAMMING MODEL

A general GP model can be defined as follows

$$Min \sum_{i=1}^{k} p_i (w_i^- d_i^- + w_i^+ d_i^+)$$

$$s.t \quad c^1 X + d_1^- - d_1^+ = t_1$$

$$\cdots\cdots\cdots\cdots\cdots$$

$$c^k X + d_k^- - d_k^+ = t_k$$

$$X \in S$$

$$X, d_k^-, d_k^+ \geq 0$$

in which S is the feasible region; P_i is the priority of the i th goal, $c^i x$ is the ith goal criterion function, and the t_k are the target values of the k goal criteria. The d_i^- and d_i^+ are deviational variables, which measure achievements below and above goal. The w_i^- and w_i^+ are relative importance weights attached to the Underachievement and overachievement deviational variables.

The advertising director has multiple conflicting goals to achieve from the campaign. He lists the following goals in ordinal ranking of importance:

1. Allocate at least 60, 00,000 for the advertising campaign for the coming year.
2. Achieve at least 2, 00, 00,000 weighted exposure units from the entire campaign.
3. Limit the number of exposures per media category as follows:

Table 2

Media Category	Maximum Exposures
General Public magazine (A and B)	6
Ladies' Magazines (C)	10
Men's' Magazines (D)	5
Spot radio – day (E)	15
Spot radio – Prime (F)	7
Day T.V. (G and H)	18
Spot T.V. (I and J)	24
Night T.V. (K)	12

4. The total advertising expenditure should not exceed the budget by more than 5 percent.
5. Limit the advertising expenditures for various media categories as follows:

Table 3

Media Category	Maximum Expenditure
All Magazines (A, B, C, D)	1200000
Spot radio (E and F)	300000
Day T.V. (G and H)	1440000
Spot T.V. (I and J)	960000
Night T.V. (K)	1680000

6. Assure that there is at least the following number of exposures for certain specific vehicles in order to maintain the current market shares in various market segments:

Table 4

Vehicle No.	Exposures
2	2
10	3
14	2
21	4

7. Only four-color, full-page advertisements must be used in the general public magazines.

3.1 The Goal Constraints And The Objective Function Can Be Formulated As Follows:

1. The Budget

The total advertising budget, which is the sum of cost per exposure times the number of exposure for each vehicle, should come out to the allocated 6000000 for the coming year.

$$\sum_{i=1}^{45} c_i X_i + d_1^- - d_1^+ = 6000000$$

Where C_i = cost per exposure for the ith vehicle

X_i = number of exposures for the ith vehicle

d_i^- = under expenditure of the advertising budget

d_i^+ = over expenditure of the advertising budget.

2. Desired Level of Weighted Exposure Units

The total weighted exposure units, which is the sum of the weighted exposure units per exposure times the number of exposure for each vehicle, should reach the desired 20000000 units.

$$\sum_{i=1}^{45} b_i X_i + d_2^- - d_2^+ = 2000000$$

Where b_i = the weighted exposure units per exposure for the ith Vehicle.

d_2^- = underachievement of the desired level

d_2^+ = overachievement of the desired level.

3. Maximum Desired Exposures for Media Categories

The advertising director specified the maximum desired number of exposures for eight media categories as described in the third goal.

$$\sum_{i=1}^{11} X_i + d_3^- - d_3^+ = 6 \text{ (General public magazines)}$$

$$\sum_{i=12}^{16} X_i + d_4^- - d_4^+ = 10 \text{ (Ladies' magazines)}$$

$$\sum_{i=17}^{20} X_i + d_5^- - d_5^+ = 5 \text{ (Men's magazines)}$$

$$\sum_{i=21}^{24} X_i + d_6^- - d_6^+ = 15 \text{ (Spot radio-day)}$$

$$\sum_{i=25}^{28} X_i + d_7^- - d_7^+ = 7 \text{ (Spot radio-prime)}$$

$$\sum_{i=29}^{34} X_i + d_8^- - d_8^+ = 18 \text{ (Day T.V.)}$$

$$\sum_{i=35}^{41} X_i + d_9^- - d_9^+ = 24 \text{ (Spot T.V.)}$$

$$\sum_{i=42}^{45} X_i + d_{10}^- - d_{10}^+ = 12 \text{ (Night T.V.)}$$

4. Limit on over expenditure Of the Budget

The director desires to limit the over expenditure of the campaign to 5 percent of the budget. In other words, the over expenditure (d_1^+) should be limited to 300000

$d_1^+ + d_{11}^- - d_{11}^+ = 300000$

5. Maximum Expenditures for Media Categories

The director specified the maximum level of advertising expenditures for the five media categories as explained in the fifth goal.

$$\sum_{i=1}^{20} c_i X_i + d_{12}^- - d_{12}^+ = 1200000 \text{ (All magazines)}$$

$$\sum_{i=21}^{28} c_i X_i + d_{13}^- - d_{13}^+ = 300000 \text{ (Spot radio)}$$

$$\sum_{i=29}^{34} c_i X_i + d_{14}^- - d_{14}^+ = 1440000 \text{ (Day T.V.)}$$

$$\sum_{i=35}^{41} c_i X_i + d_{15}^- - d_{15}^+ = 960000 \text{ (Spot T.V.)}$$

$$\sum_{i=42}^{45} c_i X_i + d_{16}^- - d_{16}^+ = 1680000 \text{ (Night T.V.)}$$

6. Desired Number of Exposures for Selected Vehicles

The director has determined that there should be at least a specified number of exposures for selected vehicles in order to maintain,

$x_2 + d_{17}^- - d_{17}^+ = 2$

$x_{10} + d_{18}^- - d_{18}^+ = 3$

$x_{14} + d_{19}^- - d_{19}^+ = 2$

$x_{21} + d_{20}^- - d_{20}^+ = 4$

7. Use of Four-Color Full-Page Ads

The director has decided that in order to present quality advertisement in magazines it is essential that only four-color full-page ads be utilized. Therefore, this goal should eliminate all two-color ads as long as it does not hinder the achievement of the first six goals.

$$\sum_{i=7}^{11} X_i + d_{21}^- - d_{21}^+ = 0$$

3.2 The Objective Function

The objective of the model is to minimize deviations from a set of goals by assigning appropriate priority factors. After reviewing the priority structure of goals and the model constraints formulated above, we can derive the following objective function:

$$Min\ z = p_1 d_1^- + p_2 d_2^- + p_3 \sum_{i=3}^{10} d_i^+ + p_4 d_{11}^- + p_5 \sum_{i=12}^{16} d_i^+ + p_6 \sum_{i=17}^{20} d_i^- + p_7 (d_{21}^- + d_{21}^+)$$

In the above objective function, it is course possible to assign differential weights to deviational variables at P_3, P_5, and PC levels. The criterion for the determination of differential weights may be the weighted exposure units per dollar of cost for each of the media categories considered.

4. RESULT AND ANALYSIS

The GP model is solved by using QSB+ computer software will be interpreted as follows. The GP is developed with 45 decision variables, 42 deviational variables and 7 primitive priority goals. All decision variables for unit of advertising media and all directly related deviational variables have non-negative integer solutions. The deviational variables related to financial amounts have non-negative fractional solutions. The following **Table 5** shows the solution for the media selection.

Table 5
Solution Analysis

Priority	Goal Achievement	Deviational Variables
Priority 1 (P1)	Fully Achieved	$d_{18}^+ = 1476$
Priority 2 (P2)	Fully Achieved	$d_{20}^- = 248$
Priority 3 (P3)	Fully Achieved	$d_{21}^+ = 1122$
Priority 4 (P4)	Fully Achieved	
Priority 5 (P5)	Fully Achieved	
Priority 6 (P6)	Not Fully Achieved	
Priority 7 (P7)	Not Fully Achieved	

The satisfying values are equivalent to the goals for decision variables and all directly related deviational variables are zero except $d_{18}^+ = 1476$, $d_{20}^- = 248$, $d_{21}^+ = 1122$ .The goal priorities PI, P2, P3, P4, P5 are all fully achieved. P6, P7 are not achieved.

REFERENCE

1. Aouni B. et al. [2001]: A Goal programming model, A Glorious History and a Promising Future. European Journal of Operational Research, Vol.133, No. 2, (1-7). | 2. Ahmed Rifai et.al. [1975]: Planning the Media Mix through Goal Programming. The American Economist Vol. 19, No. 2, pp. 21-26. | 3. Arthur J.K. et al. [2009]: Integer goal programming in advertising media selection: Decision Science 10(4), 577-592. | 4. Bhattacharya [2009]: A chance constraints goal programming model for the advertising planning problem. European Journal of Operational Research Vol: 192, No2, P 382-395. | 5. Charnes A et al. [1977]: Goal programming and multiple objective optimization. European Journal of Operational Research, 1, 39 – 54. | 6. Charnes A et al. [1968]: Application of goal programming model for media planning. | 7. Gensch D.H. [1970]: Advertising planning: Mathematical Models in advertising media planning Amsterdam: Elsevier Scientific Publishing Company. | 8. Ignizio JP [1978]: A review of goal programming a tool for multi-objective analysis. Journal of Operational Research Society, 29, 1109 – 1119.Management Science, 14, 431 – 436. | 9. Stasch S.F. [1967]: Linear programming and media selection: JMR Journal of Marketing Research 4(2), 205-207. | 10. Shantanu Shankar Bagchi. [2009]: Goal Programming and its Applications in Management Science. The IUP Journal of systems Management, Vol, VII, No. 4, pp 15-33, Nov, 2009. | 11. Tamiz M. et al. [1998]: Goal programming for decision-making, and overview of the current state- of- the- art. European Journal of Operational Research 111, 569-581. |