Optimization of Media Mix Planning in Health Care System by an AHP Based Goal Programming Model

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ABSTRACT

In this paper, we present an analytic hierarchy process based goal programming model for media mix planning in health care system. Today health care providers, like most business, are using advertising in order to attract customers (patients) to its products or services. Media selection involves the allocation of advertising budget among a variety of media options in such way as to maximize the number of potential customers reached. In this study we considered exercise products, personal care products, home medical devices and general clinical services of large health care system in Hyderabad. The problem was solved and results are discussed.

Keywords: Media mix planning, Analytic hierarchy process (AHP), Goal programming (GP)

I. INTRODUCTION

The Indian healthcare area goes to register in a compound annual growth rate of 22.9 %in the period 2015-2020. Growing income degree, good health awareness, accelerated precedence of way of life illnesses and improved get right of entry to insurance coverage are the key points to the growth. Indian healthcare is a complex mixed public-private version, with constrained government funded public healthcare, alongside pricier and urban concentrated private providers. In 2015 India spent approximately 48.5% of GDP on healthcare; 32% funded publicly and 68% funded privately, totaling €70 expenditure on healthcare per capita. The healthcare system in India remains closely underneath assessment and being labored at, on the grounds that healthcare is neither common nor handy equally in all areas of India's great territory. It follows that much attention is required in health care to ensure the services or products reach the customers. Today, advertising in

media about heath care products is necessary for health care system, because of increased competition in the field, greater knowledge and demands by customers and very dynamic economic environment. In this study, we considered the exercise products, personal care products, home medical devices and general clinical services of the healthcare system.

II. LITERATURE REVIEW

In recent years health care systems have become active in marketing their services or products to the public and conducting such advertising via a number of media including television, radio, magazines, newspaper, highway billboards, websites and even email. Media planning has received much attention in the last three decades. The marketing team of a health care system is responsible to make decisions related to advertising media mix planning. The Researchers have presented various aspects of media planning such as models based on time, budget allocation models, media scheduling models, media effective models, market segment models. Several models and techniques were thus developed for the purpose of selecting and scheduling media purchases. Some of the studies in media research have attempted to develop models with the intention of providing management with a tool for the effective selection of media mix. We review few researches. Freedman [1] found that the return on amount invested by health care systems was four to six times the cost. Korhonen [2] proposed an evolutionary approach for media selection. Little and Lodish [3] presented a media planning model based on a heuristic search algorithm to select and schedule media, maximizing the total market response in different segments over the several time periods. Bhattacharya [4] proposed an integer programming model to determine the optimal number

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of insertions in different media for a single product with an objective of maximizing the reach to the target population. Moon and Marks [5] had stated that print media to be highly preferred to other media. Broadbent [6] presented mathematical model approach and algorithmic approach models for media planning. Bass et al [7] proposed a linear programming model for single product to maximize the media exposure.

Linear programming was one of the early methods applied for this purpose. Linear programming models, though helpful in the process of media selection, are limited in scope because of their short-comings. In the linear programming method, the objective function is one-dimensional, where the goal is to optimize the objective function. In reality however, the problems facing media planners or management in general are not one-dimensional, but rather they are problems involving multiple goals in multiple dimensions. It follows then, that appropriate decision techniques to be used are those which involve multi-dimensional objective functions. The media mix planning involves multiple criteria like selection of media, frequency of exposures, and frequency distribution of the number of occasion of exposures, budget, and resource allocation. The multiple criteria decision models can handle the media mix planning rather than the generalized linear programming model. Goal programming is widely used tool in multi criteria decision analysis [8].

Charnes et al [9, 10, 11, 12] introduced goal programming model for media planning and this addressed the problems associated with critical advertising measurement of frequency and reach. Dekluyner [13] had proposed the more realistic use of soft and hard constraints for linear programming models in media planning. MoihiotisTsakiris [14] proposed model to media planning, the best possible combination of commercial with the goal of highest rating subject constrained advertising budget. Rifai, A[15] et al proposed goal programming model for media mix. Kwak et al [16] proposed a AHP based media planning model for digital products, their model developed on three criterion advertising frequency, customer, and budget. Zufryden [17, 18] presented a media planning model with an objective of maximizing sales and determine the optimal media schedule over the time. Dwyer et al [19] had presented an optimization model for the direct mail

advertising. P.C.Jha et al [20] presented the practical aspect of segmentation and develop a model which deals with optimal allocation of advertising budget for multiple products which is advertised through different media in a segmented market. In this study, we follow the Kwak's model. There are two stages in this study, first we prioritize the goals by using (AHP) and in the second stage we solve the problem by using goal programming (GP)

III. METHODOLOGY

A. Generalized Goal Programming Model:
The generalized goal programming model is formulated as follows.

Minimize
$$z = \sum_{k=1}^{K}\sum_{i=1}^{m} w_{ki}P_k\left(d_i^- + d_i^+\right)$$

Subject to
$$\sum_{i=1}^{m} a_{ij}x_j + d_i^- - d_i^+ = b_i \qquad (j = 1.2,......n)$$

$$x_j, d_i^-, d_i^+ = nonnegative\ variables(i = 1, 2, ...m, j = 1, 2,...n)$$

Where
Z = the sum of the weighted deviational variables
w_{ki} = The relative weight assigned to k priority level for the ith goal constraint
P_k = The kth preemptive priority
d_i^- = anegative deviational variable describing under achievement of the ith goal
d_i^+ = a positive deviational variable describing over achievement of the ith goal
a_{ij} = technical coefficient for the decision variable x
x_j = j^{th} decision variable
b_i = the right –hand –side value for the ith goal constraint

In the goal programming, the objective function is the minimization of the deviational variables. For a goal both the under achievement (d_i^-) and over achievement (d_i^+) cannot achieved at a time, hence either one or both deviational variables is zero, that is $d_i^- \times d_i^+ = 0$.

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B. Analytic Hierarchy Process:

GP does not provide ranking for goals. Analytic hierarchy process (AHP) provides ranking for goals based on multiple-criteria. The AHP was introduced by Saaty [21] which is a practical method to solve multi-criteria decision problems. AHP considers the data about a decision in multi-level hierarchy manner. In the AHP method pair wise comparisons are used to get the weight of importance of decision criterion and relative importance measure of the alternatives corresponding to each individual criterion.

IV. DATA OF THE PROBLEM

The health care system used for this study is large health care system in Hyderabad, producing and selling health care products for domestic and international customers in both traditional and e-

business markets. The name of the company is being studied is not released for confidentiality table-1 shows the advertising expenditure, table -2 shows expected customer increase rate and table-3 shows the presence of advertising in various types of media, cost for each category.

Media category	Budget (Rs00000)	Unit cost (Rs000)
Magazines	1000	various
News paper	1800	various
Internet	1000	500
Television	2500	various
Total	6300	

Table 1

	Health magazines	General magazines	News paper	Internet	Television	Total	Target
Exercise equipments	8	5	6	6	7	32	40
Personal care products	5	3	4	7	8	27	35
General clinical services	7	4	3	6	9	29	40
Home medical devices	6	4	4	3	7	24	30

Table 2

		Variable	Frequency	unit cost (Rs 000)
Health magazines	I magazine B magazine L magazine D magazine H magazine F magazine	x_1, x_2, x_3, x_4, x_5 x_6	10,6,10,8,10,11	30,32,21,20,15,13
General magazine	K magazine H magazine N magazine M magazine	x_7, x_8, x_9, x_{10}	10,8,5,9	15,12,8,10
News paper	E news paper S news paper A news paper T news paper	$x_{11}, x_{12}, x_{13}, x_{14}$	20,30,40,25	10,12,8,9

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Television	E television T television A television T television	$x_{15}, x_{16}, x_{17}, x_{18}$	10,15,,8,12	40,30,25,45

Table 3

Note: The names are listed here using the first characters only to ensure their corporate security

V. MODEL DEVELOPMENT

A. Variables:

There are two types of variables:

$x_j^/$ = no of advertising in different media $j = 1, 2, 3, 4, 5$

$x_1^/$ = number of health magazine advertising

$x_2^/$ = number of general magazine advertising

$x_3^/$ = number of newspaper advertising

$x_4^/$ = number of internet advertising

$x_5^/$ = number of television advertising

x_j = number of advertising presence in various types of health magazines, general magazine, newspaper, television, internet $j = 1, 2, 3, \ldots \ldots 18, 19$.

B. Goal Prioritization:

In this study the goals, total customer increase goal(G_1),increase brand awareness by television(G_2),minimal presence in newspaper(G_3) , minimal presence in general magazines(G_4), minimal presence in health magazines(G_5), increase the brand awareness through internet(G_6), keep the television budget(G_7) ,newspaper budget(G_8), magazine budget(G_9), total budget(G_{10}) are prioritized under the ,advertising effects criterion, resource allocation criterion, customer relation criterion by using AHP. The overall importance of the 10 goals are 0.286, 0.242, 0.132, 0.085, 0.081, 0.060, 0.033, 0.031, 0.030, 0.020 (total 1.00) are respectively.

C. Goal Constraints

Priority-1: meet the expected total customer increase rate for each of the four products in table-2

$$8x_1^/ + 5x_2^/ + 6x_3^/ + 6x_4^/ + 7x_5^/ + d_1^- - d_1^+ = 40$$

$$5x_1^/ + 3x_2^/ + 4x_3^/ + 7x_4^/ + 8x_5^/ + d_2^- - d_2^+ = 35$$

$$7x_1^/ + 4x_2^/ + 3x_3^/ + 6x_4^/ + 9x_5^/ + d_3^- - d_3^+ = 40$$

$$6x_1^/ + 4x_2^/ + 4x_3^/ + 3x_4^/ + 7x_5^/ + d_4^- - d_4^+ = 30$$

Priority-2: Meet the expected presence in the various television channels given in table-3

$$x_{15} + d_5^- - d_5^+ = 10$$

$$x_{16} + d_6^- - d_6^+ = 15$$

$$x_{17} + d_7^- - d_7^+ = 8$$

$$x_{18} + d_8^- - d_8^+ = 12$$

Priority-3: Meet the expected frequency in newspapers given in table-3

$$x_{11} + d_9^- - d_9^+ = 20$$

$$x_{12} + d_{10}^- - d_{10}^+ = 30$$

$$x_{13} + d_{11}^- - d_{11}^+ = 40$$

$$x_{14} + d_{12}^- - d_{12}^+ = 25$$

Priority-4: Maintain the minimal presence in the general magazines given in table-3

$$x_7 + d_{13}^- - d_{13}^+ = 10$$

$$x_8 + d_{14}^- - d_{14}^+ = 8$$

$$x_9 + d_{15}^- - d_{15}^+ = 5$$

$$x_{10} + d_{16}^- - d_{16}^+ = 9$$

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Priority-5: meet the expected frequency of the health magazines given in table-3

$$x_1 + d_{17}^- - d_{17}^+ = 10$$

$$x_2 + d_{18}^- - d_{18}^+ = 6$$

$$x_3 + d_{19}^- - d_{19}^+ = 10$$

$$x_4 + d_{20}^- - d_{20}^+ = 8$$

$$x_5 + d_{21}^- - d_{21}^+ = 10$$

$$x_6 + d_{22}^- - d_{22}^+ = 11$$

Priority-6: the marketing team wants to increase brand awareness and company reorganization through internet bill board advertising (x_{19}). this will be well versed by arranging a contract with an agent for internet bill board coverage that can be purchased within the company budget 1000the budget has been divided into 200 equal units of Rs 0.5(000)

$$x_{19} + d_{23}^- - d_{23}^+ = 20$$

Priority-7: Meet the total adverting cost in television of2500

$$40x_{15} + 30x_{16} + 25x_{17} + 45x_{18} + d_{24}^- - d_{24}^+ = 2500$$

Priority-8: Meet the total advertising cot in the various newspapers of1800

$$10x_{11} + 12x_{12} + 8x_{13} + 9x_{14} + d_{25}^- - d_{25}^+ = 1800$$

Priority-9: Keep the magazine cost within the budget Rs1000

$$30x_1 + 32x_2 + 21x_3 + 20x_4 + 15x_5 + 13x_6 + 15x_7 + 12x_8 + 8x_9 + 10x_{10} + d_{26}^- - d_{26}^+ = 1000$$

Priotity-10: Meet the total advertising budget 6300

$$30x_1 + 32x_2 + 21x_3 + 20x_4 + 15x_5 + 13x_6 + 15x_7 + 12x_8 + 8x_9 + 10x_{10} + 10x_{11} + 12x_{12}$$
$$+ 8x_{13} + 9x_{14} + 40x_{15} + 30x_{16} + 25x_{17} + 45x_{18} + 0.5x_{19} + d_{27}^- - d_{27}^+ = 6300$$

D. Objective Function

$$Z = P_1 \sum_{i=1}^{4} \left(d_i^- + d_i^+ \right) + P_2 \sum_{i=5}^{8} \left(d_i^- + d_i^+ \right) + P_3 \sum_{i=9}^{12} \left(d_i^- + d_i^+ \right) + P_4 \sum_{i=13}^{16} \left(d_i^- + d_i^+ \right)$$

$$+ P_5 \sum_{i=17}^{22} \left(d_i^- + d_i^+ \right) + P_6 (d_{23}^- + d_{23}^+) + P_7 (d_{24}^- + d_{24}^+) + P_8 (d_{25}^- + d_{25}^+) + P_9 (d_{26}^- + d_{26}^+) + P_{10} (d_{27}^- + d_{27}^+)$$

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VI. SOLUTION

The model contains 19 variables and 27 constraints. The model was solved by QM for WINDOWS.Table-4 shows the goal achievement. Table -5 shows the values of deviational variables. All the goals except four goals namely $p_7, p_8, p_9, p_{10},$ are achieved. We can observe that the negative deviational variable $d_{24}^- = 910$, this means the total advertising cost in television can be decreased 910(Rs000). The goal p_8 is not achieved, because the negative deviational variable $d_{25}^- = 695$.This indicates that the total advertising cost in newspaper can be decreased 695(Rs000).The goal p_9 is not achieved, because the positive deviational variable $d_{26}^+ = 531$.This shows that the total advertising cost in magazine can be increased 531(Rs000).Finally, the total budget goal p_{10} also not achieved, because the negative deviational variable $d_{27}^- = 2064$.That is the total budget can be decreased 2064(Rs000).

Goal priority	Positive deviational variable (d_i^+)	Negative deviational variable (d_i^-)
P_1	0	0
P_2	0	0
P_3	0	0
P_4	0	0
P_5	0	0
P_6	0	0
P_7	0	910
P_8	0	695
P_9	531	0
P_{10}	0	2064

Table 5

VII. CONCLUSION

We solved the model by using QM for Windows and results are discussed. The purpose of this paper is to develop and analyze the goal programming model to allocate budget for various media categories. The model can be extended and applied in other fields where the same condition occurs.

Goal priority	Achievement
P_1	Fully achieved
P_2	Fully achieved
P_3	Fully achieved
P_4	Fully achieved
P_5	Fully achieved
P_6	Fully achieved
P_7	Not achieved
P_8	Not achieved
P_9	Not achieved
P_{10}	Not achieved

Table 4

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