APPLICATION OF GOAL PROGRAMMING ON A MARKETING DECISION FOR A PROMOTIONAL STRATEGY

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Abstract

Promotions have become an essential tool to financial performance of retail organisations. The actuation of this study was to map a way to survive in a stiff competition market environment by focusing efforts on products that are best financial performers in a grocery retail shop. In doing so, Pareto analysis was used to classify the products according to their sales frequency contribution. The products that exhibit the largest frequency were chosen as the vital few products and 14 out of 46 were identified. In addition to the sales frequency goal were 3 more priority goals that had to be considered because high sales do not necessarily mean high profits. That is where goal programming approach came in to strike a balance amongst the prioritised goals. Finally the number of products reduced to 10 for the optimal promotional product mix and they constituted approximately 20% of the total number of products under study. This complies with 80:20 PARETO principle. A survey in the consumer market confirmed the products and thus, validating the goal programming outcome. The study, therefore, concludes that a mathematical programming approach is effectively applicable to a marketing decision problem where a promotional marketing strategy is needed.

Key words: Marketing decision, Promotional strategy, Product mix, Pareto analysis, Goal programming.

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1.0 Introduction

According to a study by the Business, Market and Social Research (BMSR) Group in 2010, an average consumer usually would not switch to other brands which they do not regularly buy. So there is need to identify the well-known and bought brands, and those not known. The success of retail outlets is in the volumes that the company sells in a time period and is achievable by matching the demand trends over the whole trading year. The demand should be well matched with the time value of money. That is, knowing the time spent by a brand on the shelf before being bought. Heavy advertising and promotional marketing strategies are used to break through the clusters in order to gain more substantial share of the market. A promotional marketing strategy is one of the key factors in the marketing mix and has a key role in market success. Promotions act as competitive tools which provide consumers with an extra incentive to purchase one brand over the other or from one retailer over the other. Since the introduction of a multicurrency system in the Zimbabwean economy, there has been a significant increase in the number of retail outlets, [2]. The stiff competition that arose due the sprouting of so many retail outlets challenged some other businesses to liquidation. Thus, the need to develop sustainable marketing strategies. A good product mix and running promotions are some of the marketing strategies that may have been adopted in such a harsh market environment. Some companies were lacking the capacity to recognize and evaluate all the available information or, as some would say, the time or motivation. Instead, they used mental short-cuts or heuristics to deal with the business complexity which may be good enough, to some extent, for small emerging businesses but not adequate for large companies where large quantities of information has to be processed. Therefore, there arises the need to apply management science, in making these marketing decisions. Thus, this study intends to give an optimal solution on a marketing decision problem where a promotional marketing strategy is adopted. This includes product mix decisions. Because of the need to prioritise objectives, Goal Programming becomes the most appropriate decision making tool on finding the 'best' promotional marketing strategy.

2.0 Literature review

[3] did a study applying Pareto analysis as a quality control tool. The study aimed at identifying and compiling "Critical Success Factors (CSFs) for total quality management (TQM)" and applying the PARETO concept to sort the CSFs in descending order according to the frequencies of their occurrences. Pareto analysis was used as a quality tool to sort and arrange the CSF's according to the order of criticality, that is, the compilation and final reporting of the vital few CSFs. [4] applied the Pareto concept in an almost similar study only this was for Critical Factors for Effective Implementation (CFEI) of the Hazard Analysis of Critical Control Point(HACCP). Pareto analysis, again, as a quality tool was used to sort and arrange the motives and barriers to CFEIs of the HACCP system implementation on food safety. The two papers showed a compilation of all the CSFs for TQM and the CFEI of the HACCP. They showed that there are 20% critical factors that are vital and 80% that are trivial where management can choose from, whether to tackle all or some. In both papers, critical factors were compiled from the published articles which might be subject to author bias. In order to avoid this bias, we take the products (which are the factors) from the shop floor. Despite the author bias weakness, Pareto analysis has proven to be a powerful and useful tool in management decision making because it is easy to implement. It is because it categorises measurements using the same unit of measurement (frequency) for each cause, evaluates the area that causes the most problems and gives direction as to which area to prioritise, [5]. As a result, we also consider Pareto analysis as a suitable tool for selecting the best selling products in a brand promotional strategy.

In real world industrial situations, a manager has to choose between projects to do basing on constraints among candidate projects. Now, Goal Programming (GP) is an extension of Linear Programming. Where Linear Programming identifies from the set of feasible solutions, the point that optimizes a single objective, GP determines the point that best satisfies the set of goals in the decision problem and attempts to minimize the deviations from the goals. Each goal is given a target value and auxiliary variables are introduced to account for the deviation from the target (both positively and negatively, as needed). The objective function from linear programming is replaced by an achievement function, based on minimising the deviations from the goals, [6]. [7] applied this GP model in the management of the Miombo woodland in Mozambique. The study was triggered by the Mozambique government policy regarding the management of its natural resources in partnership with rural communities and the private sector. The GP framework proposed provided the decision makers with a powerful tool for making multiple decisions involving economic, environmental and governmental policies. The decision making panel involved people from the local communities, the forestry and tourism industry, represented stakeholders having different interests and priorities. [8] applied this model of GP in a multiple reservoir operation model in Tunisia. The study focused on the problem of water resources in north Tunisia aiming at finding the appropriate releases from the different reservoirs in order to satisfy three conflicting objectives: demands in water for irrigation and drinking, minimisation of salinity and minimisation of the pumping costs. The problem was formulated as a multiple-objective stochastic reservoir management program and stochastic GP was used to solve the problem. A goal programming model has also been applied by [9] to resolve a trucking terminal site location problem. This was accomplished by allowing consideration of quantifiable personal preferences of the individuals who provide and use the truck terminals services. [11] addressed the problem of scheduling the tour of a marketing executive (ME) of a large electronics manufacturing company in India using 0-1 goal programming. In this problem, the ME has to visit a number of customers in a given planning period.

Like other researches where GP was applied, in this study four competing objectives are considered where each goal is ordered into a priority level, with each level being substantially higher than the next. These goals have to be optimised simultaneously. [15] and [16] conlcuded that GP is the most powerful and easy tool to use when considering many objectives to be optimised. As a result, we apply GP on selecting the best product combination to include in the promotional strategy.

3.0 Assumptions

The following assumptions are considered in this study.

- Product price remain constant over the period of study.
- Future demand of the products is not deterministic.
- Demand is dependent on time of the year.
- Demands in different periods are independent and identically distributed.
- 80% of the products contribute to 20% of the sales or profitability, according to the PARETO 80 : 20 principle.

4.0 Methodology

4.1 Pareto analysis (ABC Classification)

An analysis using sales as the basis will be necessary to derive the greatest financial benefit from the effort exerted. A definite procedure is needed to transform the data to form a basis for action. The following generalized stepwise procedure is used to perform the analysis.

Step 1: List all of the elements

The first basic step will be to list all brands on sale. This list should be exhaustive to preclude the inadvertent drawing of inappropriate conclusions.

Step 2: Measure the elements

The same unit of measure is used with each brand. Brands will be measured according to a sales frequency and total contribution to profitability of the organisation.

Step 3: Rank the elements

This ordering takes place according to the measures and not the classification. The brands are ranked in order of and according to the frequency of occurrence. The demand distribution is structured by element and the total sales contribution.

Step 4: Create cumulative distribution

The measures are cumulated from the highest ranked to the lowest and each sales frequency shown as a percentage of the total. The elements are also shown as a percentage of the total.

Step 5: Drawing the Pareto curve

The cumulative percentage distributions are plotted on a linear graph. The cumulative percentage measure is plotted on the vertical axis against the cumulative percentage element along the horizontal axis.

Step 6: Interpreting the PARETO curve

A useful step is to draw a vertical line from the 20-30 percent area of the horizontal axis. Brands that appear on the left side of this vertical line will be the crucial brands to consider for the study. In this we classify the brands so as to reduce the risk of including class three (less important) brands. ABC classification is of paramount importance as it provides better basis for selecting the most important brands in stock from the whole list.

4.2 Goal programming

4.2.1 Formulating the model

Aiming at selecting the best financial performers in the pool of all the brands (i.e. the best brand mix) a pre-emptive goal programming can be applied. The formulation captures inter-relationships among different goals. We seek to achieve at least a total sales margin of S per quarter as the main goal to the problem. Total costs are pegged at, at most TC. Profit margin is placed at, at least P. The minimum and maximum shelf space allocated to each product in for each week is R, this quantity can exceed and fail to get to R by a quantity Δ, that is, $R-\Delta < R < R+\Delta$. That is, we are willing to reduce the quantity of product *i* on the shelves if optimality can still be satisfied to create space for other products. The objective on sales, profitability and minimising C are identified as the main priority goals and the rest are the minor priority goals. Therefore, there are two priority levels.

Notation

X - is the decision variable vector
m - number of goals
n - number of products
a_{ij} - unity contribution of product *i* to goal *j*
w_i - is the penalty associated with deviation of goal *j* by product *i*
S_i - is the total sales of product *i*
C_i - is the cost of selling product *i*
P_i - is the pro¯tability of product *i*
R_i - is the shelf quantity levels for product *i*

Each product's unit contribution is obtained as a ratio that each product is contributing to the each goal. Letting variables $x_1, x_2, \ldots, x_n$ be the decision variables for the number of products to choose from the 'class A' pool, the goals for the GP problem will be as follows:

$\sum a_{ij} x_i \geq S$; the sales goal
$\sum a_{ij} x_i \geq P$; the profit goal
$\sum a_{ij} x_i \geq R-\Delta$; the minimum quantity goal
$\sum a_{ij} x_i \geq C$; the total cost goal
$\sum a_{ij} x_i \geq R+\Delta$; the maximum quantity goal

If a `+' sign represent a positive deviation and likewise a `-' sign represent a negative deviation from achieving a goal then the above goals can be written in the following manner.

$$\sum a_{ij} x_i = (S_1^+ - S_1^-) + S$$

$$\sum a_{ij} x_i = (P_2^+ - P_2^-) + P$$

$$\sum a_{ij} x_i = [(R-\Delta)_3^+ - (R-\Delta)_3^-] + (R-\Delta)$$

$$\sum a_{ij}x_i = (C_4^+ - C_4^-) + C$$

$$\sum a_{ij}x_i = [(R+\Delta)_5^+ - (R+\Delta)_5^-] + (R+\Delta)$$

Given the penalty values for failure to meet each of the goals, w_i, and prioritizing the goal equations then on **Sales** the objective is to minimise the negative deviation of S, S_1^-; on **Profit** the objective is to minimise the negative deviation of P, P_2^-; and on **Quantity of product on shelves** the objective is to minimize the positive deviation of $(R-\Delta)_3^+$. As a result, we can have the following goal programming model.

$$\text{Minimise}: Z = w_1 S_1^- + w_2 P_2^- + w_3 (R-\Delta)_3^- + w_4 C_4^+ + w_5 (R+\Delta)_5^-$$

subject to

$$\sum a_{ij}x_i = (S_1^+ - S_1^-) + S$$

$$\sum a_{ij}x_i = (P_2^+ - P_2^-) + P$$

$$\sum a_{ij}x_i = [(R-\Delta)_3^+ - (R-\Delta)_3^-] + (R-\Delta)$$

$$\sum a_{ij}x_i = (C_4^+ - C_4^-) + C$$

$$\sum a_{ij}x_i = [(R+\Delta)_5^+ - (R+\Delta)_5^-] + (R+\Delta)$$

$$S_1^-,\quad P_2^-,\quad (R-\Delta)_3^+,\quad C_4^+,\quad (R+\Delta)_5^- \geq 0$$

Where

$$S_1^+ = \begin{cases} S_1, & \text{if} \quad S_1 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$S_1^- = \begin{cases} |S_1|, & \text{if} \quad S_1 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$P_2^+ = \begin{cases} P_2, & \text{if} \quad P_2 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$P_2^- = \begin{cases} |P_2|, & \text{if} \quad P_2 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$(R-\Delta)_3^+ = \begin{cases} (R-\Delta)_3, & \text{if} \quad (R-\Delta)_3 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$(R-\Delta)_3^- = \begin{cases} |(R-\Delta)_3|, & \text{if} \quad (R-\Delta)_3 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$C_4^+ = \begin{cases} C_4, & \text{if} \quad C_4 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$C_4^- = \begin{cases} |C_4|, & \text{if} \quad C_4 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$(R+\Delta)_5^+ = \begin{cases} (R+\Delta)_5, & \text{if} \quad (R+\Delta)_5 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

$$(R+\Delta)_5^- = \begin{cases} |(R+\Delta)_5|, & \text{if} \quad (R+\Delta)_5 \geq 0 \\ 0, & \text{otherwise} \end{cases}$$

4.2.2 The pre-emptive model

The goal programming model is now formulated as a pre-emptive GP model because two or more priority levels can be specified by the management. In this case only two priority levels are dealt with. As a result, we solve the model with the first priority deviational variables at first, in the objective function subject to their corresponding constraints.

$$\text{Minimise}: Z = w_1 S_1^- + w_2 P_2^- + w_3 (R - \Delta)_3^+$$

subject to

$$\sum a_{ij} x_i - (S_1^+ - S_1^-) = S$$
$$\sum a_{ij} x_i - (P_2^+ - P_2^-) = P$$
$$\sum a_{ij} x_i - [(R-\Delta)_3^+ - (R-\Delta)_3^-] = (R-\Delta)$$
$$S_1^-, \quad S_1^-, \quad P_2^+ \quad P_2^-, \quad (R-\Delta)_3^+, \quad (R-\Delta)_3^- \geq 0$$

If the solution from the above model is unique then the resulting optimal solution is immediately adopted without considering any additional goals on the second priority. However, if there are multiple optimal solutions with the same optimal value of the objective function, Z (denoted Z^*) then we prepare to break the tie among these solutions by moving to the second priority level by adding the second priority goals. Suppose there were *n* priority levels, then this is repeated until we get a unique solution.

Now, if $Z^*=0$ then all the auxiliary variables representing the deviations from first priority goals must equal zero, representing full achievement of these goals and ensuring that they stay achieved. Otherwise, if $Z^* > 0$ then we move to the second stage model, which simply adds the second priority goals to the first model. The constraint that the first stage objective function equals Z¤ is also added which enables us to delete the terms involving first priority goals. The solution stops when a unique optimal solution is found or when there are no more lower priority goals.

5.0 Results and Discussions

We now apply the procedure for Pareto analysis explained in section 4.1. Forty six products were considered for the analysis and their sales frequencies are as shown in appendix. The sales frequencies are the number of units of each product sold over a given week's time period. Ranking is done according to these frequencies i.e. the higher the frequency the better is the product to consider in the brand mix. Using the results in the appendix 1 we can construct the following graph.

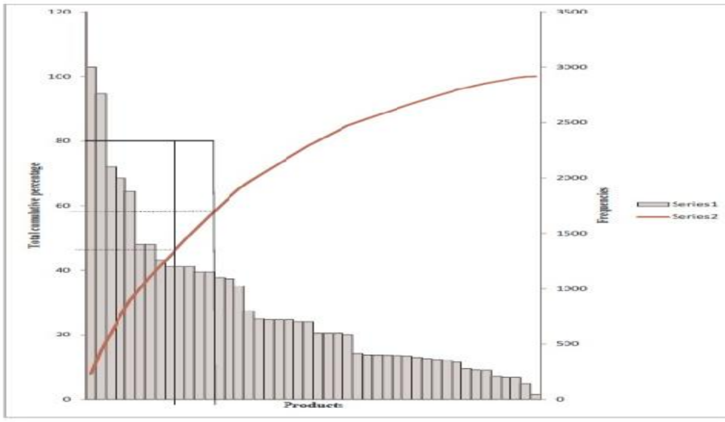

Figure 1. Pareto curve of the 46 products

Thus applying the ABC Classification, we should have nine products falling under the first 20% classification. They are: Sunsweet brown sugar, Lays chips, Irvines mixed portions, Lyons cascade, Mazoe orange crush, Dairyboard yoghurt, Dendairy maas, Irvines half-dozen eggs and Nugget shoe polish. However, their sales contribution is 44.50% and yet we would like an 60% sales contribution. As a result, we add the next ranked five products which are Romi low fat spread, Stock country spread, Castle can, Colgate dental cream and Delight cooking oil. The 14 products together now constitute 30% of the total number of products under consideration. Their contribution is approximately 60% and we can now classify them as class A products. A further analysis can be done centered on these 14 products. The number of units, x_i (i = 1, 2, …., 14), to order become the decision variables for the GP where for a particular studied retail shop in Zimbabwe (chosen arbitrarily) we can aim at

- achieving a weekly sales margin of at least $270 000,
- achieving a weekly profit margin of at least $106 000,
- holding the costs at less than $160 000 per week and
- maintaining the shelf stock level at 5 600 units for all 14 products.

Failure to achieve each goal attracts a penalty i.e. each goal needs weighting and the penalty weights can be calculated using the formula:

$$\sum_{i=1}^{14}\left(\frac{a_{ij}}{\sum_{j=1}^{4} a_{ij}}\right)-(n-1), \qquad j=1,2,3,4$$

Where n(= 4) is the number of goals to be achieved. Applying the formula to each goal gives the following table 1.

Table 1. Goal penalty weighting

	a_{1j}	a_{2j}					a_{ij}							a_{14j}	Goal	Penalty Weight (×10)
S	14	12	9	9	9	6	6	5	5	5	5	5	5	5	≤$270,000.00	7
P	9	3	13	6	9	4	4	14	3	2	5	8	7	13	≥$106,000.00	5
C	11	10	9	9	5	5	12	5	3	4	6	8	13	7	≤$160,000.00	4
R	9	4	10	3	8	4	22	12	3	1	3	3	15	3	=5 600 units	2(-),3(+)

We can split the fourth goal into two, simply because some products can achieve the same weekly goals set for them with less shelf space allocated to them. The first sub-goal caters for situations where products can be allocated less shelf space and still achieve the same profitability while the second sub-goal is for products that need more space to achieve the expected profitability. Then the problem formulation can be modified to a pre-emptive GP model. An importance analysis to the (now) five goals suggests that the first priority level is constituted by the sales margin, profit margin and the shelf stock level goals formulating the following pre-emptive GP model.

$$\text{Minimise}: Z = 7S_1^- + 5P_2^- + 2(R - \Delta)_3^+$$

subject to

$$14x_1 + 12x_2 + 9x_3 + 9x_4 + 9x_5 + 6x_6 + 6x_7 + 5x_8 + 5x_9 + 5x_{10} + 5x_{11} + 5x_{12} + 5x_{13} + 5x_{14} - (S_1^+ - S_1^-) = 270{,}000.00$$

$$9x_1 + 3x_2 + 13x_3 + 6x_4 + 9x_5 + 4x_6 + 4x_7 + 14x_8 + 3x_9 + 2x_{10} + 5x_{11} + 8x_{12} + 7x_{13} + 13x_{14} - (P_1^+ - P_1^-) = 106{,}000.00$$

$$9x_1 + 4x_2 + 10x_3 + 3x_4 + 8x_5 + 4x_6 + 22x_7 + 12x_8 + 3x_9 + x_{10} + 3x_{11} + 3x_{12} + 15x_{13} + 3x_{14} - (R_1^+ - R_1^-) = 5600$$

$$S_1^-, \quad S_1^-, \quad P_2^+ \quad P_2^-, \quad R_3^+, \quad R_3^- \geq 0 \quad x_i \geq 0, \quad i = 1, \ldots, 14$$

Solving the fitted model using LINGO (mathematical programming software) we can obtain the following optimal solution.

x_1 = 15.55; x_2 = 12.00; x_3 = 13.45; x_4 = 9.00; x_5 = 8.30; x_6 = 3.10; x_7 = 1.90; x_8 = 0.00; x_9 =0.00; x_{10}=0.00; x_{11}=7.40; x_{12}=0.60; x_{13}=0.00; x_{14}=11.80; S_1^-=242,000.00; P_2^- =148,800.00;

$R_3^+ = R_3^- = P_2^+ = S_1^+ = 0.00$; Z = 473,900.00

The LINGO output shown on Appendix 2 exhibits a 'snake eyes' in the solution i.e. a pair of zeroes in a row of the solution which is row 3 (Slack/Surplus=Dual Price=0). This row output represent the optimal value for the second constraint, which means that profitability of the 14 products (the Right Hand Side of the second constraint) could be changed without changing the objective function value. That is, there are several different combinations on the decision variables that would give an optimal objective function value of Z^* = 473,000.00. As a result, we proceed to the second priority level model. The second stage model adds up the second priority goals to the first fitted model because Z^* > 0 and gives the following GP model.

$$\text{Minimise}: Z = 4S_4^+ + 3(R + \Delta)_5^- + 7S_1^- + 5P_2^- + 2(R - \Delta)_3^+$$

subject to

$$14x_1 + 12x_2 + 9x_3 + 9x_4 + 9x_5 + 6x_6 + 6x_7 + 5x_8 + 5x_9 + 5x_{10} + 5x_{11} + 5x_{12} + 5x_{13} + 5x_{14} - (S_1^+ - S_1^-) = 270{,}000.00$$

$$9x_1 + 3x_2 + 13x_3 + 6x_4 + 9x_5 + 4x_6 + 4x_7 + 14x_8 + 3x_9 + 2x_{10} + 5x_{11} + 8x_{12} + 7x_{13} + 13x_{14} - (P_2^+ - P_2^-) = 106{,}000.00$$

$$9x_1 + 4x_2 + 10x_3 + 3x_4 + 8x_5 + 4x_6 + 22x_7 + 12x_8 + 3x_9 + x_{10} + 3x_{11} + 3x_{12} + 15x_{13} + 3x_{14} - (R_3^+ - R_3^-) = 5600$$

$$11x_1+10x_2+9x_3+9x_4+5x_5+5x_6+12x_7+5x_8+3x_9+4x_{10}+6x_{11}+8x_{12}+13x_{13}+7x_{14}-(C_4^+-C_4^-)=160{,}000.00$$

$$9x_1+4x_2+10x_3+3x_4+8x_5+4x_6+22x_7+12x_8+3x_9+x_{10}+3x_{11}+3x_{12}+15x_{13}+3x_{14}-(R_5^+-R_5^-)=5600$$

$$S_1^-+P_2^-+R_3^+=390{,}000.00$$

$$S_1^-,\quad S_1^-,\quad P_2^+\quad P_2^-,\quad R_3^+,\quad R_3^-,\quad C_4^+,\quad C_4^-,\quad R_5^+,\quad R_5^-\geq 0 \quad x_i\geq 0,\ i=1,\ldots,14$$

There is no 'snake eyes' in the solution as shown in the Appendix 3 and thus existence of a global optimum solution (i.e. there now exist a unique solution). The solution shows that the decision variables are valued at:

$x_1 = 14$; $x_2 = 12$; $x_3 = 9$; $x_4 = 10$; $x_5 = 8$; $x_6 = 4$; $x_7 = 0$; $x_8 = 11$; $x_9 = 0$; $x_{10}=0$; $x_{11}=0$; $x_{12}=7$; $x_{13}= 9$; $x_{14}=10$; $S_1^- = 393{,}920.00$; $P_2^- = 229{,}920.00$; $C_4^+ = 195{,}000$; $(R-\Delta)_3^+ = 5{,}800.00$; $(R+\Delta)_5^- = 4{,}900.00$; $P_2^+ = S_1^+ = (R-\Delta)_3^- = C_4^- = (R+\Delta)_5^+ = 0.00$; Z = 923,600.00

The above solution means that the 'best' promotional product mix for such a Zimbabwean retail grocery shop would be, for example, ordering 14 units of Sunsweet brown sugar, 12 units of Lay chips, 9 units of Irvines mixed portions etc. The ‘best’ promotional marketing strategy can be as shown in table 2 below. Therefore, the retail grocery shop can settle on the above ten products to include in its promotional marketing strategy. Ten out of forty-six gives 21.7%, which is insignificantly far from 20% of the 80:20 PARETO principle. As a result, these 10 products contribute approximately 80% profit margin to the total profitability of the retail grocery shop. We expect the products to be the best selling and it was confirmed by a small survey on 100 randomly chosen consumers from the same locality. They were asked to list 10 products they would prefer to buy (when given enough budget for the selected 10 products) out of the 46 under study and the results are as shown in table 3 below.

Table 2. The ‘best’ promotional marketing product mix

Product	Weekly number of units
Sunsweet brown sugar	14
Lays chips	12
Irvines mixed potions	9
Lyons cascade	10
Mazoe orange crush	8
Dairboard yoghurt	4
Irvines half-dozen eggs	11
Castle can	7
Colgate dental cream	9
Delight cooking oil	10

The results show that the same 10 products from our goal programming solution have the greatest percentages of being bought by any consumer when given the list of grocery products under our study. As a result, if we focus a promotional product mix on such products then chances of a successful and effective marketing strategy are increased. Such an approach can be implemented to a different set of products lined up for a promotional marketing strategic decision and similar results would be obtained.

Table 3. Customer product preference survey results

No.	Product	Weekly number of units
1	Irvines mixed portions	5.8
2	Colgate dental cream	5.4
3	Lays chips	5.4
4	Sunsweet brown sugar	5.2
5	Mazoe orange crush	5.0
6	Irvines half-dozen eggs	4.6
7	Castle can	4.2
8	Cremora	4.0
9	Geisha bath soap	3.3
10	Red seal roller meal	3.3
11	Bokomo cornflakes	3.3
12	Sunlight dish washer	3.1
13	Buttercup magarine	2.9
14	Dairyboard yoghurt	2.7

6.0 Conclusions

This study concludes by identifying 10 products from a total of 46 products acting as critical performers to the financial well being of the retail grocery shop. These products have exhibited a high financial performance more than the rest thereby making them the most important products in the shop's basket of 46 products. We can conclude that given a set of some priority goals, any retail grocery shop can use mathematical programming (i.e. goal programming in this case) to decide on a 'best' promotional product mix for its locality. This product mix for their promotional marketing strategy enhances profitability by identifying not only most selling but as well as most profitable products (it is known in the marketing field that high sales do not necessarily indicate high profits). Effective implementation of this study into any retail grocery shop needs keeping a fully documented database of daily transactions which include accurate sales frequencies of each product to be considered for the promotional marketing strategy.

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Appendix 1: Weekly Sales Frequencies

Product	f	F	%	Product	f	F	%
Sunsweet brown sugar	3000	3000	7.8524	Lays chips	2760	5760	15.0766
Irvines mixed portions	2100	7860	20.5732	Lyons cascade	2000	9860	25.8081
Mazoe orange crush	1880	11740	30.729	Dairyboard yoghurt	1400	13140	34.2934
Dendairy maas	1400	14540	38.0578	Irvines dozen eggs	1260	15800	41.3558
Nugget shoe polish	1200	1700	44.4968	Romi low fat	1200	18200	47.6377
Stock country spread	1200	19400	50.7787	Castle can	1152	20552	53.794
Colgate dental cream	1152	21704	56.8093	Delight cooking oil	1100	22804	59.6885
Royco usavi mix	1090	23894	62.5416	Schweppes mineral water	1025	24919	65.2244
Geisha bathing soap	800	25719	67.3184	Mazoe blackberry	727	26446	69.2212
Buttercup magarine	720	27166	71.1059	Dairyboard steri milk	720	27886	72.9904
Revive juice	720	28606	71.1059	French polony	700	29306	76.7072
KOO baked beans	700	30006	78.539	Green bar washing soap	600	30606	80.1099
Limpopo maas	600	31206	81.6804	Sunlight dish washer	600	31806	83.2509
Red Seal roller meal	587	32393	84.7873	Sunlight washing powder	416	32809	85.8762
Read Seal sugar beens	403	33212	86.931	Cape juice	401	33613	87.9806
Fisrt Choice UHT milk	400	34013	89.931	Mahatma rice	396	34409	90.0641
Bokomo cornflakes	392	34801	91.0902	Montic UHT milk	380	35181	92.0848
Product	f	F	%	Product	f	F	%
Pro Brand candles	367	35548	93.0454	Coca Cola can	360	35908	93.9877
Gloria self raising flour	353	36261	94.9117	Pro Brand Value rice	336	36597	95.7911
Rab Roy salad cream	278	36875	96.5188	Red Seal Pallenta	267	37142	97.2176
Explorer	264	37406	97.9087	Value Brand polony	210	38016	99.5053
Viceroy	144	38160	99.8822	Amarulla cream	45	38205	100.0000

Appendix 2: Lingo solution output to priority level 1 GP model

Optimal solution found.		
Objective value:		473.9000
Infeasibilities:		0.000000
Total solver iterations:		10
Model Class:		LGP
Total variables:	17	
Nonlinear variables:	0	
Integer variables:	0	
Total constraints:	4	
Nonlinear constraints:	0	
Total nonzero:	62	
Nonlinear nonzero:	0	

Variable	Value	Reduced Cost
X1	15.55000	0.000000
X2	12.00000	0.000000
X3	13.45000	0.000000
X4	9.000000	0.000000
X5	8.300000	0.000000
X6	3.100000	0.000000
X7	1.900000	0.000000
X8	0.000000	54.00000
X9	0.000000	33.00000
X10	0.000000	83.00000
X11	7.400000	0.000000
X12	0.600000	0.000000
X13	0.000000	79.00000
X14	11.80000	0.000000
S2	242.0000	0.000000
P2	148.4000	0.000000
Q1	0.000000	7.000000

Row	Slack or Surplus	Dual Price
1	473.9000	-1.00000
2	0.000000	0.2000000
3	0.000000	0.0000000
4	0.000000	6.0000000

Note: S_1^- is coded as S2, P_2^- as P2, $(R-\Delta)_3^+$ as Q1 and the output figures are in thousands of units.

Appendix 3: Lingo solution output to priority level 2 GP model

Optimal solution found.		
Objective value:		923.6000
Infeasibilities:		0.000000
Total solver iterations:		4
Model Class:		LGP
Total variables:	19	
Nonlinear variables:	0	
Integer variables:	0	
Total constraints:	4	
Nonlinear constraints:	0	
Total nonzero:	52	
Nonlinear nonzero:	0	

Variable	Value	Reduced Cost
X1	14.00000	0.000000
X2	12.00000	0.000000
X3	9.000000	0.000000
X4	10.00000	0.000000
X5	8.000000	0.000000
X6	4.000000	0.000000
X7	0.000000	395.0000
X8	11.00000	0.000000
X9	0.000000	138.0000
X10	0.000000	97.00000
X11	0.000000	38.00000
X12	7.000000	0.000000
X13	9.000000	0.000000
X14	10.00000	0.000000
C1	195.0670	0.000000
Q2	4.900000	0.000000
S2	393.9160	0.000000
P2	229.9170	0.000000
Q1	5.800000	0.000000

Row	Slack or Surplus	Dual Price
1	923.6000	-1.000000
2	0.000000	-4.000000
3	0.000000	19.000000
4	0.000000	-1.000000

Note: C_4^+ is coded as C1, $(R+\Delta)_5^-$ as Q2, S_1^- as S2, P_2^- as P2, $(R-\Delta)_3^+$ as Q1 and the output figures are in thousands of units.