Original Research Article

APPLICATION OF GOAL PROGRAMING FOR FINANCIAL MANAGEMENT OF A LISTED INDUSTRIAL GOODS FIRM IN NIGERIA

ABSTRACT

In today's competitive business environment, companies are faced with a lot of problems such as setting goals, planning how these goals can be achieved, organization and control of how the available scarce resources can be used to satisfy the aim and objectives of the company. Every decision made determine if the company will maintain, increase or lose its market share in today's competitive market. Thus, there is need for mathematical modeling tools to help in making the right decision. Although we have different mathematical techniques that can be used, Goal Programing technique is chosen in this study since it enables the decision to strive toward multiple objectives, thereby enable optimum use of resources. This paper is aimed at demonstrating the use of goal programing for financial management of a listed Industrial Goods Firm in Nigeria. The result shows that two out of the five formulated goals were met. The least expected total of revenue, expenses, asset and employer benefit should be 10.61 billion naira annually if the company wants to meet the asset and expenses goal.

Keywords: Goal Programming, Linear Programming, Deviational Variables, TORA Package, Industrial Goods Firm.

INTRODUCTION

Real world problems are mostly multi-objectives in which the decision makers seek to satisfy multiple and normally conflicting objectives. In the business world today, it is necessary for management of a business to do their best in increasing both quality and quantity of their products at a cheaper price so as to maintain their value in today's competitive market. And one of the best ways to achieve this is the use of mathematical models so as to help them in making the right decision.

Application of multi-objective programing model like Goal Programing(GP)Technique is very important for analysis and decision making in various aspect of management system. Although the sole aim of setting up a business is to make maximum profit from goods or services provided by the company but due to pressure of today competitive market the business management sector are faced with set of multiple objectives such as increasing quality of product, reduction in cost of production, allocation of resources etc.In

order to make optimum uses of available scarce resources to satisfy this multiple (usually conflicting) objectives of the management, Goal Programing Technique is needed for decision making which is an extension of linear programing whose requirement are represented by linear relationship. Nyor, Omolehin and Rauf(2014) submitted that, Linear Programing is applicable when there is a single objective or aim such as minimization of cost of production or maximization of profit. In most real-life situations, linear programing does not give optimum solution due to multiple (mostly conflicting) goals of the decision maker. Goal programing enables us to strive towards these multiple objectives simultaneously (Nyor et al., 2014).

Goal programing was formulated in the year 1955 by Charnes, which was applied to constrained regression in which minimization of the deviational variable was applied as a means to least absolute value regression. The reason for this was that goal programing formulation gave ability to constraint result to meet the managerial salary requirement. And this minimizes the difference between the competitor and market offer. This has developed into least absolute estimate. Although Charnes and Coopper claim that the idea actually started in 1953, the initial development of the goal programing was due to Charnes and Coopper (1961). They proposed a technique and model for handling a particular linear programing problem in which managerial conflicting goals are included as constraint.

The major advantage of goal programing is it simplicity and ease of use and this account for the application of goal programing in many and diverse field such as: management of solid waste, accounting and financial aspect of stock management marketing, quality control, human resources, production, transportation, site selection, agriculture, telecom, engineering etc.

Some Basic terms which can be found in this work include Optimization Problem - a type of problem in which one seek to minimize or maximizes a specific quantity(objective) which depend on finite number of input variable which may be related through one or more constraint, or may be independent of each other; Mathematical program - an optimization problem in which the objective and constraints are expressed as a mathematical function and functional relationship; Objective Function - the quantity we seek to minimize or maximize; Constraint – limitation(s) that restrict the available alternative option of the decision maker; Optimal solution - a feasible solution for which the objective function is optimized.

LITERATURE REVIEW

Goal Programming is an extension of Linear Programming. It is a mathematical modeling tool used in handling multiple (possibly conflicting) objective measures (goals). It is a well-known approach applied to Multi-criteria Decision Making (M-DM).Each of these objective measures (goal) is given a target value to be achieved; unwanted deviation from these goals is then minimized in an achievement function. This can be a vector or weighted sum depending on the goal programing variant used.In this situation, it is difficult to have single solutions that satisfy the conflicting objective, in such cases goal programing is one technique that can be used in such situation.Goal programing provides a means of striving toward such conflicting objectives (goals) simultaneously. According to Ignizio (1978), goal programing is a tool that has been proposed as an approach and model for analysis of problem which involve multiple conflicting objectives.

Goal programming problems can be solved using computer linear programing packages either as a single linear program or as a lexicographic variant (series of connected linear programming).Hence goal programing can deal with relatively large number of objectives, variable and constraint.Ignizio (1976) gave an algorithm that show how a pre-emptive goal programing (otherwise known as lexicographic goal programing) can be solved as a series of linear programing model. Pre-emptive goal programing should be used when there exist a clear priority ordering among the goals to be achieved.

Rupesh*etal*, (2006) used mixed integer goal programingto formulate multi criteria decision making model for paper recycling distribution network in India.Increase in target reverse logistics cost (minimum 60%) is necessary for fulfilling the decision maker's desire to satisfy the stated three goals irrespective of the priority of non-relevant and wastepaper recovery goals which will indirectly benefit the environment as well as improve the quality of wastepaper reaching the recycling unit

Ekezieet al. (2013) used the weighted goal programing methodto find a compromise solution among the different conflicting goals of the Imo State University, Owerriand to minimize the total weights associated with meeting the annual budget requirements of the institution.The simplex method (Big–M Method) was used tosolve the weighted goal programming modelformulated, and the optimal solution was obtained.

Jyotiet al. (2015) studiedgoal programming for operating cost distribution of an organization/institution, Authors used combination of weight and pre-emptive goal programing to find optimum solution among variety of conflicting

goals of St. Brother's Public School, India and concluded that goal programing provide optimal solution based on the decision maker preference and the weight assign to each goals.

Fitra et al; (2018) employed preemptive goal programing methodto develop optimal food combination to meet the daily nutrition needs of adolescent with preemptive goal programing. Overall, the sum of unwanted deviation obtained using goal programming is smaller compared to sum of deviation using preemptive goal programming for all cases, but the preemptive goal programming is superior in meeting energy and fat requirements which are top priority in preemptivegoal programming models.

Helena (2020) observed that, so far, some evident analogies between M-DM under certainty and scenario-based one-criterion decision making under uncertainty (1-DMU) have not been revealed in the literature of which the similarities give the possibility to adjust the goal programming to an entirely new domain. Helena (2020) did a work to create a novel method for uncertain problems on the basis of the GP ideas by carefully examining the analogies occurring between the structures of both issues (M-DM and 1-DMU) as well as analyzing some differences resulting from a different interpretation of the data. The new decision rule may be helpful when solving uncertain problems since it is especially designed for neutral criteria, which are not taken into account in existing procedures developed for 1-DMU.

Vasantha K.L., Harish B. G. A. and Uday K.K. N. (2021) presented a financial planning to achieving incommensurable and incompatible goals using goal programming. Maximizing the both capital structure and growth in earnings were the main goals of the study. Vasantha*et al* (2021) discussed the application of Goal Programming in optimization of financial planning for an organization called SVR, Karnataka, India, as a case study. The results of the study were calculated and verified using the LINGO 18.0 Software and proposed that the model should be considered as a road map for making financial decisions and to developing strategies to deal with various economic outlines.

Cavita (2022) applied goal programming to the planning of medical care by particularly introducing a resource allocation model for hospital management based on goal programming where there was insufficient human resources to help in strategic planning and shipment. Staff were delegated to the correct shift hours so that management can achieve the goal of lowering overall payroll costs while keeping patients happy. The data generated by a Midwest-based health-care agency was used to demonstrate a Goal Programming model. In this way, Goal

Programming model implementation provided understanding of resources allocation planning functions in health-care organizations

METHOD OF SOLUTION

Let $G_i(x)$ be the mathematical representation of the objectives which may be linear or nonlinear (mostly linear)

Let h_i be the aspiration level, the three possible goals are.

i. $G_i(x) \leq h_i$

ii. $G_i(x) \geq h_i$

iii. $G_i(x) = h_i$

In linear programing these would have constraints, but in goal programing we measure the deviation from the goals.

The methods of solving goal programing are:

i. The Weights Method

In this method the single objective function is the weighted sum of the function representing the goals of the problem.The model is of the form:

$$\text{Minimize} \quad Z = \sum_1^n d_i(r_i^+ + r_i^-)$$

$$\text{Subject to:} \quad \sum_{\substack{1\leq i \leq m \\ 1\leq j \leq n}} \left(a_{ij}x_j + d_i^+ - d_i^-\right) = b_i$$

for

$$i = 1,2,3 \ldots\ldots, m \quad j = 1,2,3 \ldots\ldots, n \quad \text{and} d_i^+, d_i^- \geq 0$$

Where r_i^+ and r_i^- are non-negative constraint, representing the weight assign within the priority level to the deviation variable and this can be real number.W_i^+ is the positive weight of the decision maker's preference and $w_i^-$is the negative weight reflecting the decision maker's preference regarding the relative importance of each goal.

ii. The Pre-Emptive Method (lexicographic)

In this method the goals of the problem are rank by decision maker according to its importance, after which the model is optimized using one goal at a time such that the optimum value of higher priority goal is consider before lower priority goals. This variant is called lexicographic goals

Preemptive model is given as

$$\text{Minimize} \quad Z = \sum_1^n d_i(r_i^+ + r_i^-)$$

$$\text{Subject to:} \quad \sum_{\substack{1\leq i \leq n \\ 1\leq j \leq m}} \left(a_{ij}x_j + r_i^+ - r_i^-\right) = g_i$$

$$x_j, r_i^+, r_i^- \geq 0$$

Where di is the priority level assign to each relative goal in rank order (i.e. $d_1 > d_2 >, \ldots, d_n$)

iii. Combination of Weights and Pre-emptive Method

The lexicographic goal programing and weight goal programing can be combined in a model. E.g.

Weighted lexicographic goal programing the weight and rank model according to Kwak et al (1991) is giving by

$$\text{Minimize} \quad Z = \sum_{i=1}^{n} c_i \sum_{\substack{1 \le i \le n \\ 1 \le k \le n}} (r_{ik}^{+} + d_i^{+} + r_{ik}^{-} - d_i^{-})$$

$$\text{Subject to:} \quad \sum_{\substack{1 \le i \le n \\ 1 \le j \le m}} (a_{ij} x_j + d_i^{-} - d_i^{+}) = g_i$$

$$x_j, d_i^{+}, d_i^{-} \ge 0$$

Where: d_i^- and d_i^+ are deviation variable

x_j = decision variable

a_{ij} = decision variable coefficients

r_i^+ and r_i^- are non-negative constraint represent relative weight.

C_i = this is priority level assign to each relevant goal in rank order (i.e. $c_1 > c_2 > \ldots > c_n$)

Steps in Formulating Goal Programing Problem

The steps in formulating goal programing model is similar to that of linear programing model. The difference in the formulation is that linear programing focuses on single variable while goal programing allows one to have multiple objectives which might be conflicting. Goal programing arrange this unwanted deviation into a number of priority level so that the minimization of deviation in higher priority level is much more important than any deviation of lower priority level.

The steps to follow in formulating goal programing problems using pre-emptive are

i. Determine the decision variable.
ii. Specify the goals including their types e.g. one way, two ways and there target.
iii. Determine the priority for the pre-emptive.
iv. State the objective function of deviation to be minimized.
v. State other given requirements.
vi. Ensure that the model can specify the decision maker preferences.

The Problem Situation

It is assumed that the management of a listed Industrial Goods Firm in Nigeria is faced with the following problems

i. The company management discovers that due to lack of model for allocation of money, the liability of the company is not checked and money is mismanaged. This can be seen in the selling and distribution expenses of the company since it can be reduced, if trains are used for movement of goods instead of company truck and trailer in areas accessible by train. Again, if the running capital of the company is managed well there will be no need for borrowing

money and interest paid on loan will reduce resulting into cheaper cost of production.

ii. The current production capacity of the company is 600 tons per day and there is ready market for its product in thirteen different countries thus sales volume and price are fixed

iii. The director of the company is interested in increasing the profit of the company and this can be done by reducing liability, employer benefit and cost of production.

iv. The director wants the asset own by the company to increase so as to increase productivity.

v. The management of the Firm is interested in increment of employer benefit due to the newly introduced 30,000 Naira minimum wage.

Beta Glass Plc. is a subsidiary of Frigo Glass Industries Nigeria Limited. The company produces and sells glassware in the high growth markets of West Africa. The company has two production plants and three furnaces with production capacity exceeding 600 tons of glass containers per day. The company provides superior packaging solutions to a variety of customers operating in the beer, spirit, cosmetics, soft drinks and pharmaceutical market segments.The manufacturing plants of the company are located at Agbara in Ogun state and also at Ughelli in Delta state. The company export it product to over 13 countries which include Angola, Burkina Faso, Benin, Cameron, Gabon, Ghana, Gambia, Guinea, Liberia, Mauritius, Rwanda, Sierra Leone and Togo

Data Collection and Analysis

Data on the Operating cost was obtained from the secondary source of the Firm's Published Annual Report and Account for 5 years of 2013 – 2017. The Pre-emptive Goal Programing method for goal formulation will be used.The table below shows the Constraints components and their respective target objectives.

Table 1: Components of the Objective Function

ITEM	INCORPORATE	GOAL
Company revenue	Revenue and other income	Increase
Expenses	Fuel, gas, advertising cost, legal and professional fee, other factory overhead cost, sales and distribution expenses, electricity bill,	Reduce
Asset	Intangible asset, trade and other receivable, cash and cash equivalent	Increase
Employer benefit	Wages, salary and all benefit provided by the company	Increase

Total	Sum of revenue, expenses, asset for the year	Reduce

Table 2: Firm's Operating Cost Estimate for Five Years

Item (Goal)	2013	2014	2015	2016	2017
Income	14,096,123,000	16,632,879,000	15,953,224,000	19,091,192,000	22,186,258,000
Expenses	1,443,263,000	1,677,410,000	1,870,269,000	1,393,130,000	1,504,997,000
Asset	1,297,354,000	2,199,825,000	2,077,161,000	3,896,839,000	3,670,150,000
Employer Benefit	2,207,563,000	1,855,181,000	2,017,952,000	2,265,330,000	2,071,883,000
Total	19,044,303,000	22,365,295,000	21,466,588,000	26,646,491,000	29,433,288,000

Source: www.african-markets.com/en/stock-markets/ngse/listed-companies

Coded Budget Estimate Overthe Period of Five Years (2015 – 2017) and Assignment of Weights

The budget estimate is coded in Table 3 to enable one to work with smaller figures in the analysis.The table below gives the coded budget estimate for five years of Beta Glass Plc.

The objective function coefficient for the variables associated with the goal $i$is called the weight for the goal i. The most important goal has the largest weight. Let w_i be the weight for goal i that could range from $2, 4, 6, ...$ with the most important goal having the highest weight (Ezekiel &Onuoha, 2013).

Table 3: Coded Operating Cost Estimates with Weights

Item (Goal) N'000 000 000	2013	2014	2015	2016	2017	Weight
Income (Revenue)	14.10	16.63	15.95	19.09	22.19	10
Liability (Expenses)	1.44	1.68	1.87	1.39	1.50	2

Assets	1.30	2.20	2.08	3.90	3.67	6
Employer Benefit	2.21	1.86	2.02	2.27	2.07	4
Total	19.04	22.37	21.47	26.65	29.43	8

Expected or Target Value of Goals of the Firm

The following are the assumed target goals of Beta Glass Plc:

i. Increase the Firm's Revenue to at least 30.5 billion Naira annually
ii. Reduce the company expenses to at most 4 billion Naira annually
iii. Increase Firm's Asset up to at least 8 billion Naira annually
iv. Increase employer benefit up to at least 3.5 billion Naira annually.
v. Reduce total up to at most 50 billion Naira annually

Goal Model Formulation

Let x_1, x_2, x_3, x_4, x_5 be amount allocated in the year 2013, 2014, 2015, 2016 and 2017 respectively. x_1, x_2, x_3, x_4, x_5 are the decision variable for this problem.

$14.10x_1 + 16.63x_2 + 15.95x_3 + 19.09x_4 + 22.19x_5 \geq 30.50$ (revenue)

$1.44x_1 + 1.68x_2 + 1.87x_3 + 1.39x_4 + 1.50x_5 \leq 4.00$ (expenses)

$1.30x_1 + 2.20x_2 + 2.08x_3 + 3.90\ x_4 + 3.67x_5 \geq 8.00$ (asset)

$2.21x_1 + 1.86x_2 + 2.02x_3 + 2.27x_4 + 2.07x_5 \geq 3.50$ (employment benefit)

$19.04x_1 + 22.37x_2 + 21.47x_3 + 26.65x_4 + 29.43x_5 \leq 50.00$ (Total constraint)

Let d_j^+ = positive deviation for over achieving the j^{th} goal.

d_j^- = negative deviation for under achieving the j^{th} goal. For j = 1, 2,3,4,5.

The weighted goal programing problembecomes

Minimize $Z = 10d_1^+ + 2d_2^+ + 6d_3^- + 4d_4^- + 8d_5^+$

Subject to: $14.10x_1 + 16.63x_2 + 15.95x_3 + 19.09x_4 + 22.19x_5 + d_1^- - d_1^+ = 30.50$

$1.44x_1 + 1.68x_2 + 1.87x_3 + 1.39x_4 + 1.50x_5 + d_2^- - d_2^+ = 4.00$

$1.30x_1 + 2.20x_2 + 2.08x_3 + 3.90\ x_4 + 3.67x_5 + d_3^- - d_3^+ = 8.00$

$2.21x_1 + 1.86x_2 + 2.02x_3 + 2.27x_4 + 2.07x_5 + d_4^- - d_4^+ = 3.50$

$19.04x_1 + 22.37x_2 + 21.47x_3 + 26.65x_4 + 29.43x_5 + d_5^- - d_5^+ = 50.00$

$x_1, x_2, x_3, x_4, x_5\ d_1^+, d_1^-, d_2^+, d_2^-, d_3^+, d_3^-, d_4^+, d_4^-, d_5^+, d_5^- \geq 0.$

It is important to note that $X_6 = d_1^+$, $X_7 = d_2^+$, $X_8 = d_3^+$, $X_9 = d_4^+$, $X_{10} = d_5^+$, $X_{11} = d_1^-$, $X_{12} = d_2^-$, $X_{13} = d_3^-$, $X_{14} = d_4^-$ and $X_{15} = d_5^-$

RESULTSAND DISCUSSIONS

Using TORA Optimization Package, the Big M-Method of Simplex Algorithm yield the result shown in Table 4

Table 4: Solution by TORA package Using Simplex Method (Big M Method)

Optimal solution		Z	10.61
2013		X_1	0
2014		X_2	0
2015		X_3	0
2016		X_4	1.60
2017		X_5	0
Positive deviation toward Revenue constraint	d_1^+	X_6	0
Positive deviation toward Expenses constraint	d_2^+	X_7	0
Positive deviation toward Asset constraint	d_3^+	X_8	0
Positive deviation toward Employer benefit constraint	d_4^+	X_9	0.13
Positive deviation toward Total constraint	d_5^+	X_{10}	0
Negative deviation toward revenue constraint	d_1^-	X_{11}	0
Negative deviation toward Expenses constraint	d_2^-	X_{12}	1.78
Negative deviation toward Asset constraint	d_3^-	X_{13}	1.77
Negative deviation toward Employer benefit constraint	d_4^-	X_{14}	0

Negative deviation toward Total constraint	d_5^-	X_{15}	7.42

Since the value of Z is not equal to zero, the solution satisfies goals 1 and 4 which are to increase the Firm's Revenue to at least 30.5 Billion Naira Annually and to increase employer benefit to at least 3.5 Billion Naira Annually respectively. However, the model fails to satisfy goals 2, 3 and 5 which are expenses, asset and total goals.

Principally, for $d_2^- = 1.78$ means that Expenses for the Firm's target of 4 Billion Naira per Annum falls short by 1.78 Billion Naira and should actually be 5.78 Billion Naira per Annum. For $d_3^- = 1.77$, it means that theAssets goal level (target) of 8 Billion Naira exceedsby 1.77Billion which indicate that the actual asset should be 6.23 Billion Naira per Annum. For $d_5^- = 7.42$ means that the Total goal of 50Billion Naira has a shortfall of 7.42 Billion Naira and should actually be 57.42 Billion Naira per Annum.

Considering the Statistics of the solution as $Z = 10.61$, $x_1 = 0$, $x_2 = 0$, $x_3 = 0$, $x_4 = 1.60$, $x_5 = 0$, $d_1^+ = 0$, $d_2^+ = 0$, $d_3^+ = 0$, $d_4^+ = 0.13$, $d_5^+ = 0$, $d_1^- = 0$, $d_2^- = 1.78$, $d_3^- = 1.77$, $d_4^- = 0$ and $d_5^- = 7.42$; if our optimal result were zero, it would mean that all the goals are satisfied. But since it is not equal to zero in this case, it indicates that at least one of the goals is not satisfied which are goals 2, 3 and 5. The value of the Zis the weighted sum associated with meeting up the annual budget requirements.The value of Z = 10.61 shows that if goals 1 and 4 were to be satisfied, the Firm will not have to go below the minimum of10.61Billion Naira. Hence the minimum expectation of the Firm in the next year should be 10.61 Billion and should review upwardly annually.

CONCLUTION AND RECOMMENDATION

The study examines the problem of finding optimal solution to conflicting goals of Beta Glass Plc. Each of the inequalities in the goal programing formulation represents each goal the company wishes to satisfy. However, since these goals are conflicting, we need to find a compromise solution among the goals. And the method of finding this compromised solution is to convert each inequality into flexible goal in which the constraints may be violated.

The result shows that the Revenue and Employer benefit were met. With this, the Firm can pay the newly introduced 30,000 Naira minimum wage and the revenue generated by the company can also be increased.

Recommendations

Based on the result of this study, the following recommendation were made

1. The revenue generated by the company should be increased to at least 30.5 billion naira annually.
2. The expenses of the company annually should be 5.78 billion naira annually.
3. The increase in the company'sAssets should be 6.23 billion naira annually
4. The employer benefit should be increase to at least 3.5 billion naira annually
5. The least expected total of revenue, asset, employer benefit and expenses annually should be 57.42 billion naira
6. The company should set up an OperationsResearch Group to assist with Optimization techniques for allocation of resources and proper management and utilization of resources.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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