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Optimal Financial Resource Allocation Using Multiobjective Decision-Making Model

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Abstract

The management of every industry needs to contain financial goals relating to capital structure, dividend policy, and earnings growth. This research uses a multi-goal decision-making model to provide a framework for determining how to allocate financial resources most effectively. The Saudi British Bank has a list of goals that need to be accomplished, and the purpose of this research was to establish a preemptive goal programming approach to help achieve those goals. First, we examined the most recent annual financial report that Saudi British Bank released. After that, the Bank's budgeting procedure focused of this examination. According to the findings, Bank has unlimited potential for success; however, to realize that potential, the Bank will need to lower the amount of financial risk. As a direct consequence, Saudi British Bank is successfully growing its total capital. In addition, an analysis was done to determine how successful the study was in meeting its objectives. According to the findings, the objectives of the study were successfully accomplished. Because of the adaptability of this model, a wide variety of sectors and financial institutions can use it to find workable answers to a wide variety of budgetary challenges. In addition, the model that has been provided may help create procedures for dealing with various economic frameworks and making financial judgments.

Key Words: Assets, Equity, Goal Programming, Liabilities, Net Income, Operating Income, Saudi Arabia.

Mathematical Subject Classification: 90C29, 90C90.

1. Introduction

The goal programming program is frequently seen as a multi-objective, multi-decision program that addresses complex institutional or industrial problems involving allocation, budgeting, allocation, and choice. Goal programming can be used as a framework to examine different facets of company performance, including costs, productivity, and profitability. A distance-based strategy goal programming models maximize progress toward numerous targets by reducing how those objectives deviate from the decision maker's ideal (DM). When the model's deviations are minimized to zero, the model's intended outcomes are realized. Conversely, positive, and negative deviations indicate either goal over- or under-attainment when exposed to various constraints. First introduced by Charnes et al. (1955) as an addition to linear programming models, GP models are given a more thorough analysis by Charnes and Cooper (1961).

The management of assets and liabilities focuses primarily on liquidity and interest rates as two primary concerns. In addition, for the bank to get a result to its liking, it needs to consider several other goals. Afterward, goal programming can be utilized to handle the challenge of making decisions based on several priorities. The fundamental objective of this study is to develop an approach that will permit Saudi British Bank (SABB) in the Kingdom of Saudi Arabia to maximize the profitability of their organizational structure. SABB, founded in 1978, is one of the five major Saudi banks in terms of deposits. SABB has over eighty branches around Saudi Arabia and one in London. In May 2018, SABB announced its intention to acquire Alawwal Bank, the Saudi banking sector's first merger in twenty years, in response to recent modifications to Vision 2030 economic reforms (SABB, Accessed 17 February 2023). When creating PGP, it is essential to consider the organization's goals thoroughly. Assumed that the following are the particular goals of the research:

a) Increasing the asset value to at least SAR 0.5 trillion per year
b) Limitation of liability to at most SAR0.4 trillion per year.
c) Attaining a total equity of at least SAR 0.05 trillion per year.
d) Achieve a total operating income of at least SAR 0.01 trillion per year.
e) Achieving a net income of at least SAR 0.004 trillion per year.
f) Increase the value of financial statement managing constraint at least by SAR 0.964 trillion per year.

In today's world, goal programming is alive more than ever, supported by a network of researchers and practitioners continually improving its theoretical development and applications. Goal Programming is more flexible for modeling the estimation process; Goal programming is alive more than ever today, supported by a network of researchers and practitioners constantly feeding it with theoretical developments and applications, all of which have experienced great success. As a result, many scientific papers cover an impressive range of fields (Mirzaee et al, 2018; Ho, 2019; Torres-Ruiz and Ravindran, 2019).

Multiple Objective Programming is also known as multi-attribute-optimization, vector optimization, multi-criteria-optimization, and Pareto optimization. Mathematically optimized solutions for multi-objective problems are derived using this. These sorts of decision-making are also used in daily life to make more informed and effective choices. However, multiple objective programming is challenging due to its complexity and contradicting standards. For instance, the Pareto border is computationally costly and depends on the Decision Maker's desire to discern between plausible options (Kacem et al., 2021; Afriadi et al., 2022). A prototype for examining the structure of the Saudi Basic Industries Company (SABIC) was developed in a recent study by Alam (2022). This prototype envisioned accelerating budget optimization through cost savings, increased fixed assets, and equity share growth. This concept offered prospective advantages and features for Saudi Arabian industrial entities. Mathematical modeling for "asset-liability optimal management" of the bank was the subject of research conducted by Naderi et al. (2013). The Goal Programming Method was utilized in the deliberation that Halim et al. (2015) had over managing bank financial statements. Kosmidou and Zopounidis (2002) created an optimal development technique for managing bank assets and liabilities. According to Kruger M. A. (2011), a GPA was utilized to plan the administration of bank balance sheets. Charnes and colleagues established an optimal evaluation of decision-making rewards based on LPP in 1955. Chambers and Charles (1961) were among the first to propose a deterministic linear programming model for assets and liabilities. This model was published in the year 1961. In their model, the needs of bank examiners were considered to establish the ideal portfolio that a particular bank should hold over a given time.

In addition, in many managerial difficulties, decision-makers articulated many criteria; hence, the linear programming model can only incorporate some criteria simultaneously because of this limitation. As a consequence of this, in order to address problems involving many objectives, a method known as goal programming was developed. Ignizio (1976) proposed using goal programming to examine several competing objectives while considering the decision-makers limitations and preferences. In later years, Ignizio (1983) developed generalized goal programming, a method for multiobjective mathematical programming that is beneficial and trustworthy. This study provided the fundamental concept of the approach and the specific subclass of models and procedures that constitute the approach as a whole. Pati et al. (2008) created a mixed integer goal programming model to assist in the appropriate management of the paper recycling logistics system. Al Qahtani et al. (2019) researched a multichoice multiobjective transportation problem in which at least one of the objectives has several aspirations. Both the components of supply and demand are inherently unpredictable random variables. The model analyzed the many ways in which to meet. The supply and demand factors are unpredictably random variables. The model looked at how the various purposes of a recycled paper delivery network interacted with one another. Approaches from goal programming have been implemented in a wide range of industries, such as sustainable multi-objective production planning (Alam, 2023), banking financial management (Arewa et al., 2013; Halim et al., 2015; Lam et al., 2017, AlArjani & Alam, 2021), the production of rubber (Hassan et al., 2013), scheduling (Todovic et al., 2015), tourism management (Nasruddin & Halim, 2012), and many more.

A mathematical model of asset and liabilities management utilizing a goal programming was designed by Jamshidinavid and Mehri (2016). Giokas and Vassiloglou (1991) detailed establishing and putting a goal programming model into practice at the Commercial Bank of Greece. This model considered the most important considerations regarding the institution's finances, the law, and bank policy. An Indian bank's assets and liabilities were optimized through goal programming by Tanwar et al. (2021), and the results revealed that goal programming might help optimize and boost profitability. In addition, Garcia et al. (2010) proposed several goal programming methods for determining the weights of business performance measures by employing constrained regression. Tamiz et al. (1995) analyzed the key developments that have been made in the field of goal programming. These developments included

the evaluation of algorithms, applications, normalization techniques, and utility modeling methodology. The study that Siew et al. (2017) carried out was of the utmost significance since it helps determine the possibility for each bank to grow its total liability, profit, earnings, and goal achievement to meet the benchmark target value for future development. This is important because the benchmark target value will play a significant role in how the world evolves in the years to come. Zadeh and Khalili (2017) developed a multi-objective model for managing liquidity based on an approach known as goal programming. Multi-objective optimization methods, such as pre-emptive goal programming (PGP), are more suited for problem-solving in complicated decision-making scenarios than traditional optimization techniques. The PGP is an extension of linear programming, which was initially presented by Charnes and Cooper (1977) and has since been presented by others, including Ignizio (1976, 1983, and 1985), amongst others. Under the framework of LP, this method was developed to handle instances involving many criteria simultaneously.
As a result of this study, a pre-emptive goal programming (PGP) model was established to assess the performance of SABB Bank. In addition, to establish the model, this study used the data that was observed on the financial statements of the Bank.

2. Methodology

2.1. Goal programming

The concept of goal programming is a strategy for assessing numerous aspects of a company's performance, such as its expenses, revenues, levels of productivity, and levels of profitability. In this research, a goal programming model is constructed to locate a solution optimal for a total of six goals. The relevance of concurrently achieving several goals has been brought to light due to the completion of a few of those goals. A mathematical model is necessary to locate an optimal solution for these challenges. The goal programming approach is frequently utilized in simultaneously solving issues with many objectives to accomplish all of the goals. Consequently, the bank must achieve contradicting aims, such as increasing its assets while decreasing its liabilities. In this aspect, the Goal Programming methodology is the most effective strategy for solving the problem (Ijiri, 1965; Lee, 1972 and others).

2.2 Model Formulation

One of the most well-liked approaches for multi-objective mathematical programming is called goal programming, and a particular type of goal programming is called pre-emptive priority goal programming. In most cases, the person tasked with finding a solution to the problem can rank the various goals in order of importance. A priority factor, denoted by the notation ϱ_i $(i = 1,2,\dots,n)$, is allotted to the deviational variables connected with the goals. This is known as "lexicographic ordering," and it's quite self-explanatory. The preemptive goal programming (PGP) model, as defined by Ignazio (1983), can be discussed in terms of the following:

$$min \sum_{i=1}^{n} \varrho_i \ (\partial_i^- + \partial_i^+) \tag{1}$$

Subject to,

$$\sum_{j=1}^{m} \alpha_{ij} \ x_j \ + \ \partial_i^- - \ \partial_i^+ = \zeta_i \tag{2}$$

$$\text{and } x_j \, , \, \partial_i^-, \ \partial_i^+ \geq \ 0 \, , \ for\ all\ \ i,j;\ i = 1,2,\dots,n,\ and\ j = 1,2,\dots.,m \tag{3}$$

It is necessary for at least one of the deviational variables to be zero because it is impossible to attain the goal under and over the desired level simultaneously. Another way of putting it

$$\partial_i^- \ * \ \partial_i^+ \ = 0 \tag{4}$$

Here, n stands for the number of goal constraints, ζ_i for the ith goal's target level, x_j for the vector of m-decision variables, α_{ij} for the decision variables' coefficients, and ∂_i^- & ∂_i^+ for the under- and over-deviational variables. The deviations ∂_i^- (or ∂_i^+) is added to the constraints as a target is under (or over)-achieved.

The deviation variables are used to establish if each target has been overachieved or underachieved (Winston & Goldberg, 2004; Tanino et al., 2003). The six financial objectives for the Bank's performance evaluation have been outlined in the illustration. In the PGP model of the Bank's performance management, the following notations are defined:

2.3 Notations

x_j : Variables in decision making,
ϱ_i : Each target is assigned a preemptive priority level in order of preference,
∂_i^- : Variable with a negative deviation (underachievement),
∂_i^+ : Variable with a positive deviation (over-achievement),
α_{ij} : Decision variable coefficients,
ζ_i : ith goal's target levels,

2.4 Determine the goals' priority

We must decide which objectives to prioritize as the first, second, or even last in preemptive goal programming. As listed in Table 1, the goals of this study are therefore prioritized.

Table 1: "Goals' priority"

Targets	Prioritized
Total asset maximization per year	ϱ_1
Total liabilities reduction per year	ϱ_2
Total equity maximization per year	ϱ_3
Increasing operating profit per year	ϱ_4
Net income maximization per year	ϱ_5
Optimizing the total number of goals achieved per year	ϱ_6

2.5 Establishing decision variables

In light of equation (2), x_j (j=1, 2, …., 5) represents the total quantity for each component in each year as shown below.

x_1 = Totals for each component's value in the financial statement for 2018,
x_2 = Totals for each component's value in the financial statement for 2019,
x_3 = Totals for each component's value in the financial statement for 2020,
x_4 = Totals for each component's value in the financial statement for 2021,
x_5 = Totals for each component's value in the financial statement for 2022,

2.6 Set goal limitations

The structural constraint and goal components are the two essential components used in this study's Goal Programming model. The following goal constraints were investigated in order to formulate the problem model in this study.

Total asset,

$$\alpha_{11}x_1 + \alpha_{12}\,x_2 + \alpha_{13}\,x_3 + \alpha_{14}\,x_4 + \alpha_{15}\,x_5 \le \zeta_1 \tag{5}$$

Total liability,

$$\alpha_{21}x_1 + \alpha_{22}\,x_2 + \alpha_{23}\,x_3 + \alpha_{24}\,x_4 + \alpha_{25}\,x_5 \ge \zeta_2 \tag{6}$$

Total equity,

$$\alpha_{31}x_1 + \alpha_{32}\,x_2 + \alpha_{33}\,x_3 + \alpha_{34}\,x_4 + \alpha_{35}\,x_5 \le \zeta_3 \tag{7}$$

Total operating income,

$$\alpha_{41}x_1 + \alpha_{42}\,x_2 + \alpha_{43}\,x_3 + \alpha_{44}\,x_4 + \alpha_{45}\,x_5 \le \zeta_4 \tag{8}$$

Total net income,

$$\alpha_{51}x_1 + \alpha_{52}\, x_2 + \alpha_{53}\, x_3 + \alpha_{54}\, x_4 + \alpha_{55}\, x_5 \leq \zeta_5 \qquad (9)$$

Total goal achievements,

$$\alpha_{61}x_1 + \alpha_{62}\, x_2 + \alpha_{63}\, x_3 + \alpha_{64}\, x_4 + \alpha_{65}\, x_5 \leq \zeta_6 \qquad (10)$$

All other goals are maximized in bank financial management, but only liability is minimized. As the variables are uncertain, positive, and negative deviations are applied to the constraints to determine growth or reduction in the goals.

2.7 Objective function

The objective function is now defined as follows:

$$\text{minimize:}\ \partial_1^- \in \varrho_1 + \partial_2^+ \in \varrho_2 + \partial_3^- \in \varrho_3 + \partial_4^- \in \varrho_4 + \partial_5^- \in \varrho_5 + \partial_6^- \in \varrho_6 \qquad (11)$$

Accordingly, the PGP model is based on the established goal constraints and is formulated as follows.

$$min\ \ \partial_1^- + \partial_2^+ + \partial_3^- + \partial_4^- + \partial_5^- + \partial_6^- \qquad (12)$$

Subject to,

$$\alpha_{11}x_1 + \alpha_{12}\, x_2 + \alpha_{13}\, x_3 + \alpha_{14}\, x_4 + \alpha_{15}\, x_5 + \partial_1^- - \partial_1^+ = \zeta_1 \qquad (13)$$

$$\alpha_{21}x_1 + \alpha_{22}\, x_2 + \alpha_{23}\, x_3 + \alpha_{24}\, x_4 + \alpha_{25}\, x_5 + \partial_2^- - \partial_2^+ = \zeta_2 \qquad (14)$$

$$\alpha_{31}x_1 + \alpha_{32}\, x_2 + \alpha_{33}\, x_3 + \alpha_{34}\, x_4 + \alpha_{35}\, x_5 + \partial_3^- - \partial_3^+ = \zeta_3 \qquad (15)$$

$$\alpha_{41}x_1 + \alpha_{42}\, x_2 + \alpha_{43}\, x_3 + \alpha_{44}\, x_4 + \alpha_{45}\, x_5 + \partial_4^- - \partial_4^+ = \zeta_4 \qquad (16)$$

$$\alpha_{51}x_1 + \alpha_{52}\, x_2 + \alpha_{53}\, x_3 + \alpha_{54}\, x_4 + \alpha_{55}\, x_5 + \partial_5^- - \partial_5^+ = \zeta_5 \qquad (17)$$

$$\alpha_{61}x_1 + \alpha_{62}\, x_2 + \alpha_{63}\, x_3 + \alpha_{64}\, x_4 + \alpha_{65}\, x_5 + \partial_6^- - \partial_6^+ = \zeta_6 \qquad (18)$$

and

$$x_1,\ x_2,\ x_3,\ x_4,\ x_5, \partial_1^-, \partial_1^+, \partial_2^-, \partial_2^+, \partial_3^-, \partial_3^+, \partial_4^-, \partial_4^+, \partial_5^-, \partial_5^+, \partial_6^-, \partial_6^+ \geq 0 \qquad (19)$$

2.8 Steps of Procedures

The following steps are required to solve the suggested model:
Step 1: Determine the goals' priority,
Step 2: Establishing decision variables,
Step 3: Set goal limitations,
Step 4: Establishing deviation variables,
Step 5: Develop the objective function,
Step 6: Solve the developed model using LINGO,

The following case study has been considered to demonstrate the significance of the proposed PGP model.

3. Case Study

The Saudi British bank stands as the case study for this specific study. The Saudi Exchange portal searched for data between 2018 and 20202, including total assets, liabilities, total equity, total operational income, and net income (www.saudiexchange.sa, 2023). Table 2 summarizes the information presented in detail, while Figure 1 provides a graphical representation.

Table 2: "Data for the fiscal year (January–December; totals in SAR' trillion)"

Goal	2018	2019	2020	2021	2022	Targeted value for the next year
Total Assets	0.175	0.266	0.276	0.272	0.314	0.500
Total Liabilities	0.142	0.210	0.226	0.219	0.260	0.400
Total Equity	0.032	0.056	0.051	0.053	0.055	0.050
Total Operating Income	0.007	0.009	0.009	0.008	0.010	0.010
Net Income	0.003	0.003	0.004	0.003	0.005	0.004
Total goal achievements	0.359	0.544	0.566	0.556	0.643	0.964

A multiple-objective decision-making model has been established and implemented. This model was based on the findings that were obtained from an analysis of the financial information that was gathered from the financial statement of Saudi British, which is provided in Table 2.

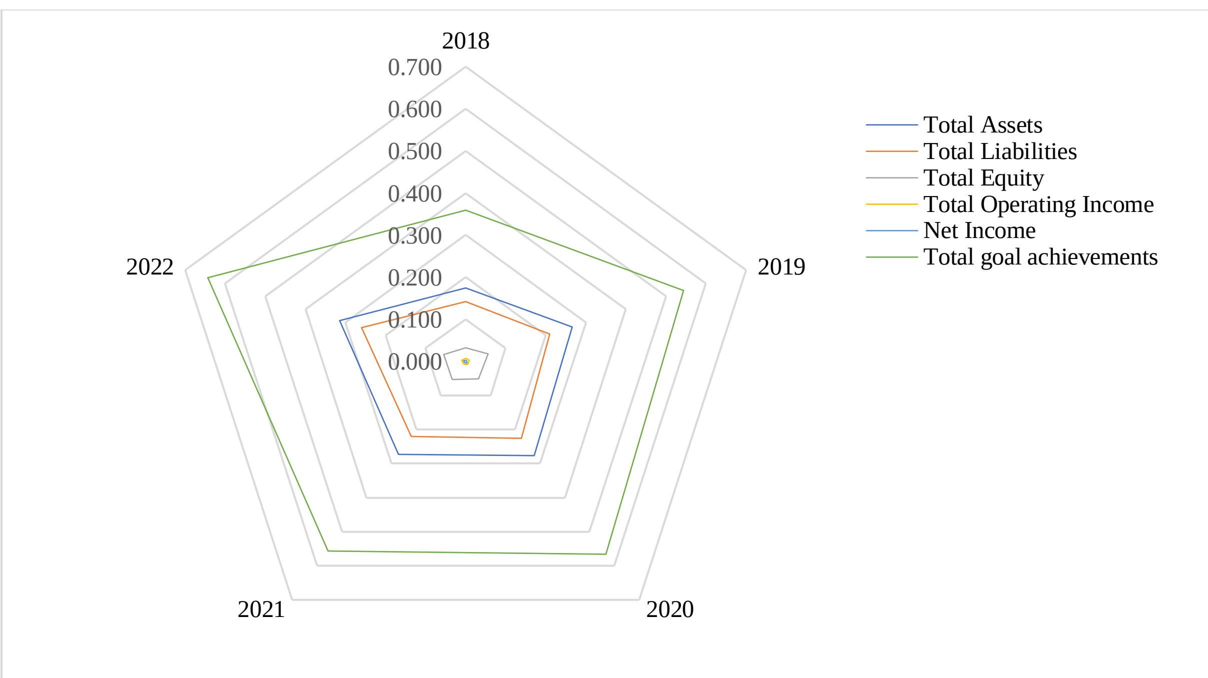

Figure 1: Fiscal year data

At this point, we have presented the formulation of the financial data as a preemptive goal programming problem.

$$Min \ \ \partial_1^- \in \varrho_1 + \partial_2^+ \in \varrho_2 + \partial_3^- \in \varrho_3 + \partial_4^- \in \varrho_4 + \partial_5^- \in \varrho_5 + \partial_6^- \in \varrho_6 \tag{20}$$

Subject to,

$$0.175\, x_1 + 0.266\, x_2 + 0.276\, x_3 + 0.272\, x_4 + 0.314\, x_5 + \partial_1^- - \partial_1^+ = 0.500$$

$$0.142\, x_1 + 0.210\, x_2 + 0.226\, x_3 + 0.219\, x_4 + 0.260\, x_5 + \partial_2^- - \partial_2^+ = 0.400 \tag{22}$$

$$0.032\, x_1 + 0.056\, x_2 + 0.051\, x_3 + 0.053\, x_4 + 0.055\, x_5 + \partial_3^- - \partial_3^+ = 0.050 \tag{23}$$

$$0.007\, x_1 + 0.009\, x_2 + 0.009\, x_3 + 0.008\, x_4 + 0.010\, x_5 + \partial_4^- - \partial_4^+ = 0.010 \tag{24}$$

$$0.003\, x_1 + 0.003\, x_2 + 0.004\, x_3 + 0.003\, x_4 + 0.005\, x_5 + \partial_5^- - \partial_5^+ = 0.004 \tag{25}$$

$$0.359\, x_1 + 0.544\, x_2 + 0.566\, x_3 + 0.556\, x_4 + 0.643\, x_5 + \partial_6^- - \partial_6^+ = 0.964 \tag{26}$$

and $$x_1, x_2, x_3, x_4, x_5, \partial_1^-, \partial_1^+, \partial_2^-, \partial_2^+, \partial_3^-, \partial_3^+, \partial_4^-, \partial_4^+, \partial_5^-, \partial_5^+, \partial_6^-, \partial_6^+ \geq 0 \tag{27}$$

During this phase, LINGO version 18.0 x64 was utilized to achieve a solution for the preemptive goal programming model (20-27). In addition, the next section will be devoted to discussing the results of accomplishing one's objectives.

4. Results

Table 3 outlines the results that were achieved as a direct consequence of the objectives being successfully accomplished, and we can see that all of the ρ_i ($i =$ 1,2,3,4,5,6) values are zero. These results were gained directly from the objectives being successfully fulfilled. Because of this, the bank has successfully fulfilled all of its goals, and we can declare that all of our objectives have been reached with certain increment deviational variables. As a direct result, Saudi British Bank has continually achieved exceptional success within the banking industry.

Table 3: “Achievement of Goals”

Goals Priority	Outcomes	Goals Achievement
$\boldsymbol{\varrho_1}$	$\partial_1^- = 0.000$	Completely Achieved
$\boldsymbol{\varrho_2}$	$\partial_2^+ = 0.000$	Completely Achieved
$\boldsymbol{\varrho_3}$	$\partial_3^- = 0.000$	Completely Achieved
$\boldsymbol{\varrho_4}$	$\partial_4^- = 0.000$	Completely Achieved
$\boldsymbol{\varrho_5}$	$\partial_5^- = 0.000$	Completely Achieved
$\boldsymbol{\varrho_6}$	$\partial_6^- = 0.000$	Completely Achieved

Table 4: “Deviational variable findings (values in SAR' trillion)”

Goals Priority	$(\boldsymbol{\partial_i^-})$	$(\boldsymbol{\partial_i^+})$	*Targeted Value per year*
$\boldsymbol{\varrho_1}$	0.000	0.000	0.500
$\boldsymbol{\varrho_2}$	0.000	0.000	0.400
$\boldsymbol{\varrho_3}$	0.000	0.050	0.050
$\boldsymbol{\varrho_4}$	0.000	0.0054321	0.010
$\boldsymbol{\varrho_5}$	0.000	0.001555	0.004
$\boldsymbol{\varrho_6}$	0.000	0.058222	0.964

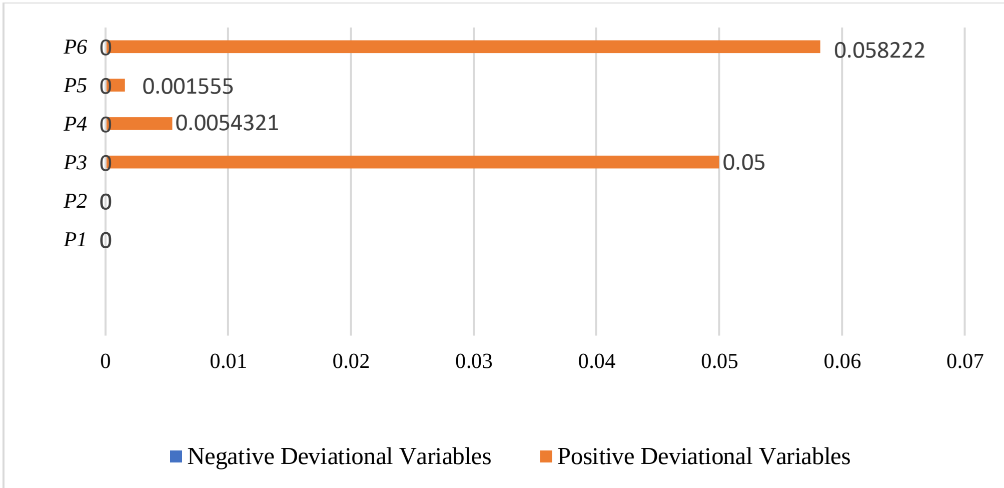

Figure 2: Deviational variable outcomes

Table 4 and Figure 2 illustrate the possibility for the value to be improved further than it already is, based on the optimal solution of the PGP model. These advancements are in connection with four different goals. It is feasible to determine whether an increment or a decrement has occurred by examining the positive values of the deviational variables. In a manner analogous to that of the maximizing scenario, the increment can be computed by making use of a deviational variable whose magnitude is positive. A deviational variable with a negative magnitude can be used in the calculation of the decrement, just like one would do in the case of minimization. The following points can be construed in the following ways, according to their order of priority for achieving their goals:

i. Priority (ρ_3) should be given to achieving the highest possible level of the bank's total equity. The conclusion drawn from this is that the value for negative deviation, denoted by ∂_3^-, is zero, while the value for positive deviation, denoted by ∂_3^+ , is 0.050. This suggests that Bank has the potential to improve its overall performance by increasing its total equity by SAR 0.050 trillion each year.

ii. The value of ∂_4^- for priority (ρ_4) is 0, whereas the value of ∂_4^+ is 0.0054321. This demonstrates that the total operating income goal was successfully accomplished, and the overall operating income of the bank has the potential to rise by SAR 0.0054321 trillion per year.

iii. For priority (ρ_5), the value of ∂_5^- is 0, whereas the value of ∂_5^+ is 0.001555. This demonstrates that the whole net income goal was met, and the bank's overall net income can increase by SAR 0.001555 trillion per year.

iv. After that, since ∂_6^- is equal to zero and ∂_6^+ equals 0.058222, the priority (ρ_6) goal of maximizing the overall number of goals completed has also been accomplished. This demonstrates that there is scope for an annual increase of SAR 0.058222 trillion in total goal achievements in the financial statement.

5. Conclusions

This research study focused on the Saudi British Bank as its subject. The study aimed to investigate and improve the bank's performance management by developing a pre-emptive goal programming model. The model was created as part of this research study. The outcomes of the study indicate that Bank is able to achieve all of its goals, as predicted by the model's best-case scenario, which was taken into account in the analysis. The Bank will construct the following improvements as a result of using the proposed model:

- With an annual increase in total equity of SAR 0.050 trillion, Bank will have the potential to perform better overall.
- The Bank's total operational income might increase by SAR 0.0054321 trillion annually.
- Bank's total net income may rise by SAR 0.001555 trillion annually.
- The financial statement has scope for a potential annual increase in total objective accomplishments of SAR 0.058222 trillion.

But the financial institution will need to develop measures to lower the total amount of its liabilities to achieve that. Moreover, Bank has the chance to accomplish all of its goals and raise the value of its equity. As a result, the research's findings help to define new target values for the Bank's ongoing development. Financial institutions can therefore utilize this model as a foundation to guide their decision-making and strategy created in response to various economic conditions.

Data Availability Statement

Data and descriptions are all available at the Saudi Exchange portal from 2018 until 2022: https:// www.saudiexchange.sa

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