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Investigating the effect of Multi-choice Goal programming in project Portfolio Analysis

Olokoyo Felicia ^{1,*}, Adurogbola Temitayo Elizabeth ¹ and Owoh Emeka ¹

¹ Department of Banking and Finance, Covenant University, Ota, Nigeria

* Correspondence: felicia.olokoyo@covenantuniversity.edu.ng; TEL.: +2348023948641

Abstract: The study sought to investigate the effect of Multi-choice Goal programming in project Portfolio Analysis, using Lagos State Project Portfolio from between 2017-2021 as a study case. Specifically, the objectives examined the effectiveness of multi-choice goal programming in analyzing the project Portfolio of Lagos State Government and investigated the possible lapses in the use of Multi-choice Goal programming in analyzing the project Portfolio of Lagos State Government. Data were gathered from the State financial Statements and analyzed using Lingo-17 Software. Based on the analysis, the study discovered that the goals formulated can be optimally and minimally attained as the positive deviational and negative deviational variables depict zero. This indicates that the cost incurred on the project portfolio was absolutely minimized during the period and at the same time; Lagos State Government derived the most preferred benefits from it. The study therefore concluded that the State minimized the project costs and at the same time maximized benefits while meeting its overall objectives.

Keywords: Multi-Choice Model; Goal Programming; Project Portfolio; Goal Target; Project Cost

1. Introduction

Projects are recognized as the engine and catalyst for development, whereas adequate financing and funding are simply the fuel that keeps the engine (projects) running. Such projects are typically initiated by public organizations (government), private organizations (investors), or a partnership of both, collectively referred to as clients. Many projects may be running concurrently in some cases, each with its own budget and duration; some may be similar while others are completely different; all are meant to serve the objectives of a business or a specific organization. A program, and to a lesser extent a portfolio, is a collection of projects.

A portfolio is also a grouping of projects, programs, and other types of work (whether or not they are linked), which enables efficient administration of the grouped work to achieve the strategic business objectives. The portfolio selection problem describes a scenario in which a decision-maker in project management chooses a subset of projects from a small pool of alternatives while keeping in mind time, resources, cost, and other constraints, and then creates a group that can meet the desired and most advantageous organizational goals (Korotkov, & Wu, 2019). Portfolio selection is an integral part of business strategic decision-making as well as an essential step in arranging project management. Organizations can benefit from effective portfolio management by fulfilling their strategic objectives, improving their competitiveness in the market, and promoting the long-term expansion of their companies. Poor portfolio selection will diminish the competitive edge, which will cause major losses for enterprises in addition to complicating project portfolio implementation and wasting a large amount of resources. The enterprise multi-objectives are therefore the cornerstone for comprehending how to optimize the project portfolio, since they appear to be essential for the survival and expansion of the organization. (Su-Lan, Xiao-Lan, Sheng-Yuan, & Tong, 2021). In light of limited resources and current organizational strategies, project portfolio selection can be defined as a dynamic decision-making process for evaluating, selecting, and prioritizing a project or collection of projects for implementation (Khalili-Damghani, Sadi-Nezhad, Lotfi, & Tavarna, 2013). While making multiple-choice decisions, mathematical optimization techniques are used to assist the decision-maker in identifying appropriate and workable solutions to real-world issues that entail

multiple-choice objective functions that must be optimized simultaneously. When faced with multiple options, decision-makers frequently rely on hazy information and/or questionable facts since they typically lack a thorough understanding of the objectives and limits.

In addition, the growing use of mathematical models by organizations to analyze projects and programs in order to implement business strategy has increased the demand for knowledge of project portfolio management (Koh, 2011). Organizations are interested in increasing efficiency through project portfolio management as they battle with heightened performance pressures (Müller, 2008). The reality that, managing multi-choice projects more strategically boosts efficiency and effectiveness while enhancing organizational outcomes is attested to by many current successful firms (Itigi, 2015). A project portfolio is a tool that some businesses use to successfully manage ongoing programs and projects with many objectives (PMI, 2017).

In 1952, Markowitz presented a bi-criterion portfolio selection model where the manager seeks to maximize the expected portfolio return and to minimize financial risk. In other words, we look for the portfolio that enables investors to make more money while reducing the chance of suffering financial losses. It is clear that these two requirements clash and cannot both be optimized at the same time. Hence, in order to find the most gratifying portfolio, the manager must make some concessions. In this study, we are interested in investigating the effect of Multi-choice Goal programming in project Portfolio Analysis. Goal programming, at its core, is a goal-oriented optimization technique for multi-objective decision-making in a clear-cut decision environment. When dealing with multi-objective optimization, when the distinct objectives are frequently at odds with one another, it is a variation of linear programming (Hadeel, Ali, Maha, & Aisha, 2019). As a result, goal programming may manage a sizable number of variables, restrictions, and objectives. The model's defined goals can be achieved when the deviations are reduced to zero. Moreover, deviations might be positive or negative, denoting overachievement or underachievement of the goals subject to certain limitations. Goal programming's capacity to generate non-Pareto efficient solutions is a contentious flaw. This goes against the core tenet of choice theory, which holds that no reasonable person will consciously pick a course of action that is Pareto inefficient. However, there are methods for recognizing when this happens and appropriately projecting the solution onto the Pareto efficient solution (Romero, 1991; Hannan, 1980; Tamiz, Mirrazavi, & Jones 1999).

Statement of the Problem

The premise that managing a multi-choice project portfolio promotes efficiency and effectiveness while also boosting organizational performance is supported by several current successful firms. To the prejudice of restricted resources, the majority of companies in Nigeria, it seems, are contending with rising demand and consistently shifting consumer tastes. To improve the portfolio structure, an effective and efficient project selection criterion is required. The majority of hiring managers base their decisions on past performance. As a result, many organizations wind up funding projects that yield lower returns. In this study, goal programming technique was used to pick the project portfolio for the Lagos State Project Portfolio from 2017 to 2021 as a study case.

Aim and Objectives of the study

In the research, it is aimed to investigate the effect of Multi-choice Goal programming in project Portfolio Analysis, using Lagos State Project Portfolio from between 2017-2021 as a study case. Specifically, the objectives of the study are to:

1. Examine the effectiveness of Multi-choice Goal programming in analyzing the project Portfolio of Lagos State Government
2. Investigate the possible lapses in the use of Multi-choice Goal programming in analyzing the project Portfolio of Lagos State Government

Review of Literature

Goal programming, according to Chowdary and Slomp (2002), is a very powerful and adaptable technique for decision making analysis of a contemporary decision maker who is tasked with fulfilling numerous competing objectives under complicated environmental constraints. Multi Goal Programming, according to, is a method frequently employed to discover a compromise solution in order to achieve several competing goals (Chandra, 2020). A well-known method for resolving particular kinds of multi-objective optimization issues is goal programming (Roa, 2020). The most potent multi-objective decision-making technique that has been applied to solve a range of decision-making issues is goal programming (Wiguna, & Sudiarta, 2021). It is a method for handling scenarios with several objectives in decision-making. The method allows the decision maker to describe the amount of multi-choice desire for each target that may be avoided, preventing anyone from underestimating the decision (Wiguna, & Sudiarta, 2021). Goal-programming is more advantageous for issues with conflicting objective functions. Goal-programming seeks to reduce deviations from the predetermined aims to a minimum (Hussain, & Kim, 2020).

The earliest goal programming formulations categorized the undesirable deviations into priority levels, with the minimization of a deviation at a higher priority level being infinitely more essential than any deviations at a lower priority level. Lexicographical or pre-emptive goal programming is what this is. Ignizio (1976) provides a method demonstrating how to solve a lexicographic target program as a collection of linear programs. When the objectives to be accomplished have a distinct priority ordering, lexicographic goal programming is utilized. Weighted or non-pre-emptive goal programming should be employed if the decision maker is more interested in direct comparisons of the goals. In this instance, the accomplishment function is created by adding all of the undesirable deviations together and multiplying them by weights that represent their relative importance. Due to the phenomena of incommensurability, deviations measured in various units cannot be easily totaled. In general, there are two types of goal programming models:

The Lexicographic Goal Programming Model;

The arrangement of the undesirable deviations was caused by the initial goal programming formulations. Minimizing deviations at higher priority levels is much more crucial than at lower priority levels. Hence, lexicographic (preemptive) or non-Archimedean goal programming are examples of preemptive paradigms.

$$Z_{\min} = \sum_{i=1}^m \phi(\partial_i^+ + \partial_i^-) \dots \dots \dots (1)$$

Subject to:

Constraint

$$Goal_1 = \sum_{j=1}^n \alpha_{ij} \lambda_j - \partial_i^+ + \partial_i^- = \gamma_i \quad \forall i = 1, 2, \dots, n \dots \dots \dots (2)$$

Constraint

$$System = \sum_{j=1}^n \alpha_{ij} \lambda_j = \vartheta_i, \quad \forall i = m + 1, \dots, p \dots \dots \dots (3)$$

$$\partial_i^+, \partial_i^-, \lambda_j \geq 0, \quad \forall i = 1, \dots, m \text{ and } \forall j = 1, \dots, n \dots \dots \dots (4)$$

$$\partial_i^+ (\partial_i^-) = 0$$

Weighted Goal Programming Model

When a decision-maker wishes to evaluate objectives side by side, they should use a weighted goal programming approach. The following non-preemptive model demonstrates how considering deviational factors at the same priority level might help establish each deviation's relative relevance:

$$Z_{\min} = \sum_{j=1}^n \omega_j^+ (\partial_j^+) + \omega_j^- (\partial_j^-) \dots\dots\dots(5)$$

Subject to the equation 2 to 4 conditions

Modern Portfolio Theory

The modern portfolio theory (MPT) emphasizes that increased risk comes with higher reward and describes how risk-averse investors might build portfolios to optimize or maximize expected return based on a given degree of market risk. Harry Markowitz's theories from 1952 laid the groundwork for the notion. According to the theory, it is possible to create an effective frontier of optimal portfolios that deliver the highest predicted return for a specific amount of risk. The theory's key idea is that an investment's risk and return characteristics should not be considered in isolation, but rather should be assessed in light of how the investment influences the risk and return of the entire portfolio.

According to modern portfolio theory, an investor can put together a portfolio of several assets to optimize returns for a particular amount of risk. Similar to this, an investor can create a portfolio with the lowest risk feasible given a certain level of projected return. The return on a particular investment is less significant than how the investment performs when seen in the context of the overall portfolio, according to statistical measurements like variance and correlation.

The Markowitz Portfolio Theory also makes the assumption that, given a specific set of conditions, all investors will have the same expectations and make the same decisions. According to the hypothesis of homogenous expectations, every investor will have similar expectations for the inputs required to create effective portfolios, such as asset returns, variances, and covariances. Investors will, for instance, select the investment strategy with the best return if presented with many investment strategies offering various returns at a specific risk. Similar to this, if investors are presented with plans that have various risks but the same profits, they will pick the one with the lowest risk. According to McClure (2017), a portfolio's risk can be decreased by investing in multiple stocks, which is one of the benefits of diversification. The advantages of diversity, commonly referred to as not placing all of one's eggs in one basket, are quantified.

2. Methodology

Goal Programming: Optimizations and Minimization Formulation

The existing multi goal programming model can be expressed as:

$$Z_{\min} = \sum_{i=1}^m (\partial_i^+ - \partial_i^-) \dots\dots\dots(6)$$

Subject to:

Constraint

$$Goal_1 = \sum_{j=1}^n \alpha_{ij} \lambda_j - \partial_i^+ + \partial_i^- = \gamma_i \quad \forall i = 1, 2, \dots, n$$

Constraint

$$System = \sum_{j=1}^n \alpha_{ij} \lambda_j = \vartheta_i, \quad \forall i = m + 1, \dots, p$$

From the above functions, M-goals and p-system as well as n-decision exist

Where:

Z_{\min} = Objective function/ Summation of all deviations

α_{ij} = the coefficient associated with j^{th} variable in i^{th} Goal/constraint

X_j = the j^{th} decision variable

γ_i = the right hand side value of i^{th} goal

ϑ_i = the right hand side value of i^{th} constraint

∂_i^- = negative deviational variation from i^{th} goal (under achievement)

∂_i^+ = positive deviational variation from i^{th} goal (over achievement)

Based on the critics of the above model, the improved Multi-choice Goal Programming was designed.

Equation (1) above was redefined to have:

$$Z_{\min} = \sum_{i=1}^m (\partial_i^+ - \partial_i^-) / \gamma_i \dots \dots \dots (7)$$

Constraint

$$Goal_1 = \sum_{j=1}^n \alpha_{ij} \lambda_j - \partial_i^+ + \partial_i^- = \gamma_i \quad \forall i = 1, 2, \dots, \dots, n$$

Constraint

$$System = \sum_{j=1}^n \alpha_{ij} \lambda_j \begin{matrix} [\geq] \\ [=] \\ [\leq] \end{matrix} \vartheta_i, \quad \forall i = m+1, \dots, \dots, p$$

$$\partial_i^+, \partial_i^-, \lambda_j \geq 0, \quad \forall i = 1, \dots, \dots, m \quad \text{and} \quad \forall j = 1, \dots, \dots, n$$

$$\partial_i^+ (\partial_i^-) = 0$$

Case Study

Goal programming was used in this study to track the performance of the Lagos State Government from 2017 to 2021. Her financial records for the specified years were used to compile information on a number of project portfolios that were carried out in the state in order to monitor or improve performance. This study applies a goal-programming methodology to ten projects carried out over a five-year period by the Lagos State Government (2017-2021).

Table 1. Project Portfolio of Lagos State, Nigeria.

Portfolio	2017	2018	2019	2020	2021
Agric Project	2,950,699	2,114,882	1,341,008	7,814,527	10,175,949
Construction and Rehabilitation	19,787,898	22,976,320	8,993,492	5,672,168	15,384,376
LAMATA BRT Project	25,354,578	36,353,883	4,039,138	14,145,225	8,097,857
Health Projects	0	0	0	484,298	777,923
Multilateral Funding Projects	7,716,605	0	1,469,547	1,300,311	5,535,337
Conservation Projects	0	0	2,278	6,796	33,926
Oil and Gas Project	117,504	73,582	95,249	651,505	42,062
Schools Furniture	0	0	0	665,496	927,309
Entrepreneurial Skill	409,444	476,876	214,336	1,691,054	1,594,278
Emergency Rescue Equipment	4,163,105	1,582,244	2,968,086	1,859,292	2,245,517

Source: Lagos State, Annual Report

The Model Targets

λ_1 : Is the total quantity of project portfolio in 2017 financial statements of Lagos State

λ_2 : Is the total quantity of project portfolio in 2018 financial statements of Lagos State

λ_3 : Is the total quantity of project portfolio in 2019 financial statements of Lagos State

λ_4 : Is the total quantity of project portfolio in 2020 financial statements of Lagos State

λ_5 : Is the total quantity of project portfolio in 2021 financial statements of Lagos State

Agric Project Goal Constraint

The following equation is developed for agric project goal constraint

$$= \sum_{j=1}^n \alpha_{ij} \lambda_j - \partial_i^+ + \partial_i^- = \gamma_i \quad \forall i = 1, 2, \dots, n$$

$$= \alpha_{11} \lambda_1 + \alpha_{12} \lambda_2 + \alpha_{13} \lambda_3 + \alpha_{14} \lambda_4 + \alpha_{15} \lambda_5 + \partial_i^- - \partial_i^+ = \tau_1 \dots \dots \dots (8)$$

Construction and Rehabilitation Goal Constraint

The equation determines the construction and rehabilitation goal constraint

$$= \alpha_{21} \lambda_1 + \alpha_{22} \lambda_2 + \alpha_{23} \lambda_3 + \alpha_{24} \lambda_4 + \alpha_{25} \lambda_5 + \partial_2^- - \partial_2^+ = \tau_2 \dots \dots \dots (9)$$

LAMATA BRT Project Goal Constraint

The following equation is developed for LAMATA BRT goal constraint

$$= \alpha_{31} \lambda_1 + \alpha_{32} \lambda_2 + \alpha_{33} \lambda_3 + \alpha_{34} \lambda_4 + \alpha_{35} \lambda_5 + \partial_3^- - \partial_3^+ = \tau_3 \dots \dots \dots (10)$$

Health Projects Goal Constraint

The following equation determines the health project goal constraint

$$= \alpha_{41} \lambda_1 + \alpha_{42} \lambda_2 + \alpha_{43} \lambda_3 + \alpha_{44} \lambda_4 + \alpha_{45} \lambda_5 + \partial_4^- - \partial_4^+ = \tau_4 \dots \dots \dots (11)$$

Multilateral Funding Projects Goal Constraint

The equation develops for multilateral funding goal constraint

$$= \alpha_{51} \lambda_1 + \alpha_{52} \lambda_2 + \alpha_{53} \lambda_3 + \alpha_{54} \lambda_4 + \alpha_{55} \lambda_5 + \partial_5^- - \partial_5^+ = \tau_5 \dots \dots \dots (12)$$

Conservation Projects Goal Constraint

The equation develops for conservation project goal constraint

$$= \alpha_{61} \lambda_1 + \alpha_{62} \lambda_2 + \alpha_{63} \lambda_3 + \alpha_{64} \lambda_4 + \alpha_{65} \lambda_5 + \partial_6^- - \partial_6^+ = \tau_6 \dots \dots \dots (13)$$

Oil and Gas Project Goal Constraint

$$= \alpha_{71}\lambda_1 + \alpha_{72}\lambda_2 + \alpha_{73}\lambda_3 + \alpha_{74}\lambda_4 + \alpha_{75}\lambda_5 + \partial_7^- - \partial_7^+ = \tau_7 \dots \dots \dots (14)$$

Schools Furniture Goal Constraint

$$= \alpha_{81}\lambda_1 + \alpha_{82}\lambda_2 + \alpha_{83}\lambda_3 + \alpha_{84}\lambda_4 + \alpha_{85}\lambda_5 + \partial_8^- - \partial_8^+ = \tau_8 \dots \dots \dots (15)$$

Entrepreneurial Skill Goal Constraint

$$= \alpha_{91}\lambda_1 + \alpha_{92}\lambda_2 + \alpha_{93}\lambda_3 + \alpha_{94}\lambda_4 + \alpha_{95}\lambda_5 + \partial_9^- - \partial_9^+ = \tau_9 \dots \dots \dots (16)$$

Emergency Rescue Equipment Goal Constraint

$$= \alpha_{10,1}\lambda_1 + \alpha_{10,2}\lambda_2 + \alpha_{10,3}\lambda_3 + \alpha_{10,4}\lambda_4 + \alpha_{10,5}\lambda_5 + \partial_{10}^- - \partial_{10}^+ = \tau_{10} \dots \dots \dots (17)$$

As was previously stated, the objective of this study is to maximize the project portfolio of the Lagos State Government for the specified period while minimizing costs, so it is necessary to add positive and negative deviations to the constraints in order to assess whether the objectives are expanding or contracting.

Objective Function

The objective function is defined in the following manner:

$$Z_{\min} : \partial_1^- \partial_1^+ \in \tau_1 + \partial_2^- \partial_2^+ \in \tau_2 + \partial_3^- \partial_3^+ \in \tau_3 + \partial_4^- \partial_4^+ \in \tau_4 + \partial_5^- \partial_5^+ \in \tau_5 + \partial_6^- \partial_6^+ \in \tau_6 + \partial_7^- \partial_7^+ \in \tau_7 + \partial_8^- \partial_8^+ \in \tau_8 + \partial_9^- \partial_9^+ \in \tau_9 \\ + \partial_{10}^- \partial_{10}^+ \in \tau_{10} \dots \dots \dots (18)$$

Based on the established goal constraints, the GP model (18) is created and formulated as follows.

$$\text{Min: } \partial_1^-(\partial_1^+) + \partial_2^-(\partial_2^+) + \partial_3^-(\partial_3^+) + \partial_4^-(\partial_4^+) + \partial_5^-(\partial_5^+) + \partial_6^-(\partial_6^+) + \partial_7^-(\partial_7^+) + \partial_8^-(\partial_8^+) + \partial_9^-(\partial_9^+) + \partial_{10}^-(\partial_{10}^+)$$

Subject to :

$$\begin{aligned}
&= \alpha_{11}\lambda_1 + \alpha_{12}\lambda_2 + \alpha_{13}\lambda_3 + \alpha_{14}\lambda_4 + \alpha_{15}\lambda_5 + \partial_i^- - \partial_i^+ = \tau_1 \\
&= \alpha_{21}\lambda_1 + \alpha_{22}\lambda_2 + \alpha_{23}\lambda_3 + \alpha_{24}\lambda_4 + \alpha_{25}\lambda_5 + \partial_2^- - \partial_2^+ = \tau_2 \\
&= \alpha_{31}\lambda_1 + \alpha_{32}\lambda_2 + \alpha_{33}\lambda_3 + \alpha_{34}\lambda_4 + \alpha_{35}\lambda_5 + \partial_3^- - \partial_3^+ = \tau_3 \\
&= \alpha_{41}\lambda_1 + \alpha_{42}\lambda_2 + \alpha_{43}\lambda_3 + \alpha_{44}\lambda_4 + \alpha_{45}\lambda_5 + \partial_4^- - \partial_4^+ = \tau_4 \\
&= \alpha_{51}\lambda_1 + \alpha_{52}\lambda_2 + \alpha_{53}\lambda_3 + \alpha_{54}\lambda_4 + \alpha_{55}\lambda_5 + \partial_5^- - \partial_5^+ = \tau_5 \\
&= \alpha_{61}\lambda_1 + \alpha_{62}\lambda_2 + \alpha_{63}\lambda_3 + \alpha_{64}\lambda_4 + \alpha_{65}\lambda_5 + \partial_6^- - \partial_6^+ = \tau_6 \\
&= \alpha_{71}\lambda_1 + \alpha_{72}\lambda_2 + \alpha_{73}\lambda_3 + \alpha_{74}\lambda_4 + \alpha_{75}\lambda_5 + \partial_7^- - \partial_7^+ = \tau_7 \\
&= \alpha_{81}\lambda_1 + \alpha_{82}\lambda_2 + \alpha_{83}\lambda_3 + \alpha_{84}\lambda_4 + \alpha_{85}\lambda_5 + \partial_8^- - \partial_8^+ = \tau_8 \\
&= \alpha_{91}\lambda_1 + \alpha_{92}\lambda_2 + \alpha_{93}\lambda_3 + \alpha_{94}\lambda_4 + \alpha_{95}\lambda_5 + \partial_9^- - \partial_9^+ = \tau_9 \\
&= \alpha_{10,1}\lambda_1 + \alpha_{10,2}\lambda_2 + \alpha_{10,3}\lambda_3 + \alpha_{10,4}\lambda_4 + \alpha_{10,5}\lambda_5 + \partial_{10}^- - \partial_{10}^+ = \tau_{10}
\end{aligned}$$

$$\forall \lambda_n, \partial_n^-, \partial_n^+ \geq 0$$

.....(19)

Table 2. Target achievement.

	Goal	Outcomes	Target
Min/Max Agric Project	γ_1	$\partial_1^-, \partial_1^+$	Achievement
Min/Max Construction and Rehabilitation	γ_2	$\partial_2^-, \partial_2^+$	Achievement
Min/Max LAMATA BRT Project	γ_3	$\partial_3^-, \partial_3^+$	Achievement
Min/Max Health Projects	γ_4	$\partial_4^-, \partial_4^+$	Achievement
Min/Max Multilateral Funding Projects	γ_5	$\partial_5^-, \partial_5^+$	Achievement
Min/Max Conservation Projects	γ_6	$\partial_6^-, \partial_6^+$	Achievement
Min/Max Oil and Gas Project	γ_7	$\partial_7^-, \partial_7^+$	Achievement
Min/Max Schools Furniture	γ_8	$\partial_8^-, \partial_8^+$	Achievement
Min/Max Entrepreneurial Skill	γ_9	$\partial_9^-, \partial_9^+$	Achievement
Min/Max Emergency Rescue Equipment	γ_{10}	$\partial_{10}^-, \partial_{10}^+$	Achievement

Source: Self-developed

Project Portfolio of Lagos State, Nigeria

In the table below, the cost of each project appears in Billion Naira. But for convenience, the values are further divided by 1,000,000 and rounded to 3-significant to have the current state.

Table 3. Lagos State Project Cost (Billion of Naira).

Targets	2017	2018	2019	2020	2021	Total
Agric Project	2.951	2.115	1.341	7.815	10.176	24.398
Construction and Rehabilitation	19.788	22.976	8.994	5.672	15.384	72.814
LAMATA BRT Project	25.355	36.354	4.039	14.145	8.098	87.991
Health Projects	0	0	0	0.484	0.778	1.262
Multilateral Funding Projects	7.717	0	1.470	1.300	5.535	16.022
Conservation Projects	0	0	0.002	0.007	0.034	0.043
Oil and Gas Project	0.118	0.074	0.095	0.652	0.042	0.981
Schools Furniture	0	0	0	0.666	0.927	1.593
Entrepreneurial Skill	0.410	0.477	0.214	1.691	1.594	4.386
Emergency Rescue Equipment	4.163	1.582	2.968	1.859	2.246	12.818
Total	60,499,833	63,577,787	19,123,134	34,290,672	44,814,534	

Source: Lagos State, Annual Report

Then, the project portfolio of Lagos State government for the period of 5 years can now be applied to the proposed model (19) above:

Subject to :

$$2.951\lambda_1 + 2.115\lambda_2 + 1.341\lambda_3 + 7.815\lambda_4 + 10.176\lambda_5 + \partial_i^- - \partial_i^+ = \mathbf{24.398}$$

$$19.788\lambda_1 + 22.976\lambda_2 + 8.994\lambda_3 + 5.672\lambda_4 + 15.384\lambda_5 + \partial_2^- - \partial_2^+ = \mathbf{72.814}$$

$$25.355\lambda_1 + 36.354\lambda_2 + 4.039\lambda_3 + 14.145\lambda_4 + 8.098\lambda_5 + \partial_3^- - \partial_3^+ = \mathbf{87.991}$$

$$0\lambda_1 + 0\lambda_2 + 0\lambda_3 + 0.484\lambda_4 + 0.778\lambda_5 + \partial_4^- - \partial_4^+ = \mathbf{1.262}$$

$$7.717\lambda_1 + 0\lambda_2 + 1.470\lambda_3 + 1.300\lambda_4 + 5.535\lambda_5 + \partial_5^- - \partial_5^+ = \mathbf{16.022}$$

$$0\lambda_1 + 0\lambda_2 + 0.002\lambda_3 + 0.007\lambda_4 + 0.034\lambda_5 + \partial_6^- - \partial_6^+ = \mathbf{0.043}$$

$$0.118\lambda_1 + 0.074\lambda_2 + 0.095\lambda_3 + 0.652\lambda_4 + 0.042\lambda_5 + \partial_7^- - \partial_7^+ = \mathbf{0.981}$$

$$0\lambda_1 + 0\lambda_2 + 0\lambda_3 + 0.666\lambda_4 + 0.927\lambda_5 + \partial_8^- - \partial_8^+ = \mathbf{1.593}$$

$$= 0.410\lambda_1 + 0.477\lambda_2 + 0.214\lambda_3 + 1.691\lambda_4 + 1.594\lambda_5 + \partial_9^- - \partial_9^+ = \mathbf{4.386}$$

$$= 4.163\lambda_1 + 1.582\lambda_2 + 2.968\lambda_3 + 1.859 + 2.246\lambda_5 + \partial_{10}^- - \partial_{10}^+ = \mathbf{12.818}$$

$$\forall \lambda_n, \partial_n^-, \partial_n^+ \geq 0 \text{ (Non-negative constraint)}$$

The goal programming model defined above was solved using LINGO 17.0 x32 versions (20). Goal-setting is also covered in the sections that follow:

3. Results

The table below shows the summary of the outcomes of meeting the targets. The value of τ_i is zero for $i = 1, 2, \dots, 10$). This result shows that the Lagos State Government's overall performance was in line with its set goals.

Table 4. Goal Accomplishment.

Goal	Outcomes	Target
γ_1	$\partial_1^-, \partial_1^+ = 0$	Accomplished
γ_2	$\partial_2^-, \partial_2^+ = 0$	Accomplished
γ_3	$\partial_3^-, \partial_3^+ = 0$	Accomplished
γ_4	$\partial_4^-, \partial_4^+ = 0$	Accomplished
γ_5	$\partial_5^-, \partial_5^+ = 0$	Accomplished
γ_6	$\partial_6^-, \partial_6^+ = 0$	Accomplished
γ_7	$\partial_7^-, \partial_7^+ = 0$	Accomplished
γ_8	$\partial_8^-, \partial_8^+ = 0$	Accomplished
γ_9	$\partial_9^-, \partial_9^+ = 0$	Accomplished
γ_{10}	$\partial_{10}^-, \partial_{10}^+ = 0$	Accomplished

The possible progress toward the target worth utilizing the best solution from the GP model is shown in Table 4 above. Three potential improvements are beneficial to the aim. The initial step in identifying potential increases or decreases will be to look for positive values of the deviation variables. We show that a positive deviation variable can be utilized to compute the increment for a maximizing issue, for instance. On the other hand, it is possible to determine the reduction in a minimization issue using a negative deviation variable.

Table 5. Outcomes of Deviation Variables.

Goal	Positive Deviation Variables	Negative Deviation Variables
γ_1	0	0
γ_2	0	0
γ_3	0	0
γ_4	0	0
γ_5	0	0
γ_6	0	0
γ_7	0	0
γ_8	0	0
γ_9	0	0
γ_{10}	0	0

4. Discussion of Result

The results of Table 5 above demonstrate that both the maximum and minimum goals may be achieved because both the positive and negative deviational variables indicate zero. This shows that the cost of the project portfolio was significantly reduced during the time period, and the Lagos State Government also benefited much from it. As a result, the results closely aligns with those of Angele (2008) and Macheiel (2010). (2011). Without a doubt, it can be said that the Lagos State Government thrives effectively on benefit and cost maximization through proper monitoring and oversight of the project activities.

5. Conclusion

Assessing the impact of multi-choice goal programming in project portfolio analysis is the goal of this study. The Lagos State Government can accomplish all of the listed goals in this study based on the optimal solution produced after this study examined the project portfolio performance for a period of 5 years (2017-2021). The State can achieve its overall goals while minimizing costs and maximizing benefits from its project portfolio. Additionally, this paradigm gives governments the ability to plan ahead and take action in response to shifting economic situations.

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Appendix I

Local optimal solution found.

Objective value:	0.000000
Infeasibilities:	0.000000
Total solver iterations:	5
Elapsed runtime seconds:	1.02

Model Class:	QP
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Total variables:	27
Nonlinear variables:	20
Integer variables:	0

Total constraints:	11
Nonlinear constraints:	1

Total nonzeros:	81
Nonlinear nonzeros:	10

	Variable	Value	Reduced
Cost			
0.000000	D1MINUS		0.000000
0.000000	D1PLUS		0.000000

0.000000	D2MINUS	0.000000
0.000000	D2PLUS	0.000000
0.000000	D3MINUS	0.000000
0.000000	D3PLUS	0.000000
0.000000	D4MINUS	0.000000
0.000000	D4PLUS	0.000000
0.000000	D5MINUS	0.000000
0.000000	D5PLUS	0.000000
0.000000	D6MINUS	0.000000
0.000000	D6PLUS	0.000000
0.000000	D7MINUS	0.000000
0.000000	D7PLUS	0.000000
0.000000	D8MINUS	0.000000
0.000000	D8PLUS	0.000000
0.000000	D9MINUS	0.000000
0.000000	D9PLUS	0.000000
0.000000	D10MINUS	0.000000
0.000000	D10PLUS	0.000000
0.000000	Λ_1	1.000000
0.000000	Λ_2	1.000000
0.000000	Λ_3	1.000000

0.000000	Λ_4	1.000000
0.000000	Λ_5	1.000000
0.000000	DMIN	1.234568
0.000000	DPLUS	1.234568

Price	Row	Slack or Surplus	Dual
1.000000	1	0.000000	-
0.000000	2		0.000000
0.000000	3		0.000000
0.000000	4		0.000000
0.000000	5		0.000000
0.000000	6		0.000000
0.000000	7		0.000000
0.000000	8		0.000000
0.000000	9		0.000000
0.000000	10		0.000000
0.000000	11		0.000000