University of Baghdad
College of Engineering
JOURNAL OF ENGINEERING

Journal of Engineering

journal homepage: www.joe.uobaghdad.edu.iq

Volume 29 Number 5 May 2023

Optimization of Inventory Inflation Budget Based on Spare-parts and Miscellaneous Costs of a Typical Automobile Industry

Oluwaseun Ojo *
Ph.D.
College of Engr.,
Bells Univ. of Technology,
Ota, Nigeria
ooojo@bellsuniversity.edu.ng

Anthony Oyerinde
Ph.D. student
Faculty of Engr., Adeleke Univ.,
Ede, Nigeria
anthony.oyerinde@adelekeuniversity.edu.ng

Basil Akinnuli
Prof.,Ph.D.
School of Engr and Engr. Technology,
Federal Univ. of Technology,
Akure, Nigeria
boakinnuli@futa.edu.ng

ABSTRACT

Brainstorming has been a common approach in many industries where the result is not always accurate, especially when procuring automobile spare parts. This approach was replaced with a scientific and optimized method that is highly reliable, hence the decision to optimize the inventory inflation budget based on spare parts and miscellaneous costs of the typical automobile industry. Some factors required to achieve this goal were investigated. Through this investigation, spare parts (consumables and non-consumables) were found to be mostly used in Innoson Vehicle Manufacturing (IVM), Nigeria but incorporated miscellaneous costs to augment the cost of spare parts. The inflation rate was considered first due to the market's price increase. Different types of vehicles were used to implement the Non-preemptive goal programming model and to predict the cost of procurement of the spare parts and miscellaneous and the profit for the current year. The result proved that the solution did not fully achieve the goals since the objective function is not equal to zero, but deviations for going below the profit goal and above the cost of procurement goal were significantly minimized.

Keywords: Budget allocation, multi-criteria optimization, strategic decisions, non-preemptive goal programming, inflation rate.

*Corresponding author
Peer review under the responsibility of University of Baghdad.
https://doi.org/10.31026/j.eng.2023.05.01

Article received: 22/08/2022
Article accepted: 18/10/2022
Article published: 01/05/2023

تحسين ميزانية تضخم المخزون بناءً على قطع الغيار والتكاليف المتنوعة لصناعة السيارات النموذجية

اوليواسيون اويو *
دكتوراه
كلية الهندسة, جامعة بيلز للتكنولوجيا
أوتا ، نيجيريا
ooojo@bellsuniversity.edu.ng

أنتوني أويريند
طالب دكتوراه
كلية الهندسة، جامعة اديليك
ايد ، نيجيريا
anthony.oyerinde@adelekeuniversity.edu.ng

باسل أكينولي
استاذ، دكتوراه
كلية الهندسة وتكنولوجيا الهندسة
الجامعة الفيدرالية للتكنولوجيا
أكور ، نيجيريا
boakinnuli@futa.edu.ng

الخلاصة

لقد كان العصف الذهني نهجًا شائعًا في العديد من الصناعات حيث لا تكون النتيجة دقيقة دائمًا خاصة عندما يتعلق الأمر بشراء قطع غيار السيارات .تم استبدال هذا النهج بطريقة علمية ومحسّنة موثوقة للغاية ، ومن هنا جاء قرار تحسين ميزانية تضخم المخزون استنادًا إلى قطع الغيار والتكاليف المتنوعة لصناعة السيارات النموذجية .تم التحقيق في بعض العوامل المطلوبة لتحقيق هذا الهدف .من خلال هذا التحقيق ، تم العثور على قطع الغيار(المواد الاستهلاكية وغير الاستهلاكية) المستخدمة في الغالب في شركة Innoson لتصنيع المركبات (IVM) ، نيجيريا ، ولكنها أدرجت تكاليف متنوعة لزيادة تكلفة قطع الغيار .تم اعتبار معدل التضخم في المقام الأول بسبب ارتفاع الأسعار في السوق .تم استخدام أنواع مختلفة من المركبات لتنفيذ نموذج برمجة الهدف غير الاستباقي والتنبؤ بتكلفة شراء قطع الغيار والمتنوعة ، وربح العام الحالي .من النتيجة ، ثبت أن الحل لم يحقق الأهداف بشكل كامل لأن الوظيفة الموضوعية لا تساوي الصفر ولكن الانحرافات لتخفيض هدف الربح وفوق تكلفة هدف الشراء تم تقليلها بشكل كبير.

الكلمات المفتاحية :تخصيص الميزانية ، التحسين متعدد المعايير ، القرارات الإستراتيجية ، برمجة الأهداف غير الوقائية ، معدل التضخم.

1. INTRODUCTION

Spare parts are machines' replacements of failed parts required to maintain reliability above the goal level. To ensure that machines operate in good condition, spare parts and accessories are needed for effective production in the industry **(Ojo et al., 2020; Eberhard, 2022).** Giliyana and Kalaiarasan, and Coetzee added that "spare parts are regarded as vital signs for the maintenance of machines and need to be controlled efficiently by procuring the correct quantity with the suitable quality at the appropriate time with the limited budget" (**Coetzee, 2004; Giliyana and Kalaiarasan, 2015).** The economic stability of an industry depends solely on a well-managed spare parts inventory. To ensure the availability of spare parts in the stock, forecasting plays an important role, leading to budgeting as one of the most powerful tools for planning and controlling limited available resources **(Osueke et al., 2015).** While Chakrabarti gave his opinion that a project engineer coordinating a project should be familiar with the financial aspects of a project to avoid loss **(Chakrabarti, 2022). Gershon (2015)** emphasized that "budget planning is fundamental for an industry to survive especially amidst a highly technical and competitive environment and that failure to plan may affect operational level which may result in less profit planning" **(Gershon, 2015).**

Because of that, budgetary control cannot exist if there is no budget. The basic problem that a decision-maker usually faces is ascertaining a means of achieving a given objective and then accomplishing the objective most efficiently, subject to constraints on the means **(Nielsen, 2006).** He added that, in programming terminology, the problem is to optimize the value of the objective function, subject to any resource and/or other constraints such as environment, legal, input, and behavioural restrictions. Depending on the nature of the problem, the term optimize means either minimizing or maximizing the value of the objective function **(Raouf and Hezam, 2017).**

1.1 Non-preemptive Goal Programming (NPGP)

In this line of method to goal programming GP, relative weights are allocated to the detrimental deviations. This is applicable in the area where there is a failure to meet a stated goal; a unit penalty is attached. To use these weights, changing the GP model into a linear programming (LP) model is essential to minimize the total weighted deviations from the goals **(Chung, 2015).**

1.2 Pre-emptive Goal Programming (PGP)

The PGP approach is slightly different from NPGP. This method compels the decision-maker (DM) to rank their goals into different levels of importance (1, 2 … etc.), each containing one or more goals. A priority level can be weighted similarly to non-preemptive goal programming if it has two or more goals **(Özdamar and Yazgaç, 2016).** The notion behind the PGP method is that higher-priority goals are satisfied first before lower-priority level goals – are pre-empted **(Keisler, 2015).** The optimal solution to the least-priority problem is the optimal solution to the GP problem **(Clemen and Reilly, 2016; Diaz et al., 2021).**

The major developments in Nigeria's automobile industry have been examined (**Ugwueze et al., 2020)** since 1960. The argument was that consistent auto-policy implementation could promote the interests of indigenous manufacturers to increase local production. While other researchers emphasized the immense dynamics of spare parts as important motivating factors for providing control in manufacturing companies **(Unekwe et al., 2012; Zhang et al., 2021).** Also, some researchers mentioned that "In the vast technological environment of today, the complexities of spare-parts inventory control enjoy more insights from analysts (in the Management Science, Information Technology, and Industrial/Mechanical Engineering fields)" (**Den Boer et al. 2020; Frandsen et al., 2020)**. Furthermore, Eze expressed his opinion on the challenge of development and economic growth over budget and policy prescriptions in the automobile sector in Nigeria **(Eze, 2020).** If the spare parts budget and inventory are controlled appropriately, operations will run smoothly, and customers' needs will be satisfactorily met.

Planning goes a long way in engineering management, keeping the industry moving. Spare-part, regarded as the heart of the industry, should not be taken for granted. A decision-maker ensures that spare parts are available at all times. This is determined by the rate of consumption and working conditions of the machines, thus, a close range on the inventory to avoid inventory obsolesce or under-stock of spare parts as well as considering inflation that used to devalue money and its power of purchase. Hence the development of this model and its software to proffer a solution to this problem. This study aimed to optimize the inventory inflation budget based on spare parts and miscellaneous costs of the typical automobile industry. The objectives of this study were to identify the strategic decisions for the typical automobile industry, evaluate the inflation rate of the selected decisions, optimize the profits and costs of the procurement of the strategic decisions, and use software applications for their implementation. In this study, decision-making using the scientific method will enable the decision-maker to select the best options, predict the optimum profits even with the limited available resources, and improve the industry's economic growth. This study is limited to optimizing the profits and costs of procuring spare parts and miscellaneous using the Goal programming model, enabling the decision-maker to predict the worth of the limited financial resources.

2. THEORY

2.1 Manufacturing Operation Process in IVM, Nigeria

The first phase in the vehicle production process in Innoson Vehicle Motors (IVM) is known as the welding section. In the industry, the Engineers bend, fold and file the sheet metals, then cut them up with the appropriate dimensions using design analysis. After they process the sheet metals, they place it firmly on a jig and hold it down with clamps. The parent jig accommodates the car's whole frame, and there is a side jig for different sides of the vehicle or bus. When the cars are placed on the jig, the sheet metals and the sparks are into pieces by a spot welding machine to mold the car frame. When they complete the welding, they drop the car's frame from the parent jig for filing and smoothing all the rough edges. Mite steel is usually used for finishing due to its low carbon qualities. To avoid the application of much filler when the car is subjected to extreme conditions like temperature, cracks, or fault lines, filing to smoothness is very important. So it must be done well so that little or no fillers will be needed. The next stage is painting, when the bodywork is completed. In the painting section, the first attempt is to smoothen the car's body, to improve paint adhesion before it is coated twice. Then the second coat is applied a few seconds after the first to avoid ugly paint runs. To implement the plans in Innoson Vehicle Manufacturing (IVM), Nigeria, the following procedures were considered: ascertain the required strategic decisions for optimization; development of mathematical models; integration of the developed models to form a logic of the model (flowchart) for the required program; development of software package for decision making; and application of the developed software for decision making. These plans are also extended to the industry procuring spare parts for machinery equipment.

2.2 Model Development Using Strategic Decisions

After a proper literature review and visitation to manufacturing industries, strategic decisions such as Spare parts and Miscellaneous were identified for optimization. The spare parts were subdivided into consumables or non-repairable and non-consumables or repairable spare parts. This process would enable the industry to predetermine the profit and find the cost of procurement of these decisions based on what is available in the inventory stock to enhance the production line.

2.3 Model Formulation

(Maku and Adelowokan, 2013; Zuerl, 2022) mentioned the importance of the inflation factor in cost estimates. (**Ojo et al., 2020)** adopted the inflation model method for procuring machines, accessories, spare parts, and miscellaneous, a quadruple scenario. This method is also applicable for a tri-objective scenario where the procurement of consumables, non-consumables spare parts, and miscellaneous are required. Therefore,

$$S_T = S(1 + j)^m \quad (1)$$

where:
S_T is regarded as the total inflated estimated cost
S is known as the base estimated cost
j is known as the inflation rate
m is defined as the difference between the base year and the selected year
$(1 + j)^m$ is the inflation factor

$$j = \frac{current\ cost - previous}{cost} \times 100 \quad (2)$$

Eqs. (1) and (2) determine each year's inflation factor and total inflated estimated costs, respectively.

2.3.1 Programming Application Goal on the Strategic Decisions

Table 1 shows data collected from Innoson Vehicle Manufacturing (IVM), Nigerian, to test run the advanced goal programming and its software for performance evaluation. Based on the available budget for budgeting, the previous cost of procurement was selected to form the coefficient associated with decision variables. x_3, x_4, and x_5.
In this study, it was understood that the production line from the industry includes Heavy Duty Vehicles (HDV), Middle-Level Bus (MLB), and High-Level Bus (HLB). These vehicles were selected because they are customers' major and most demanding vehicles. Hence, the procurement of these strategic decisions to keep the vehicles at optimum satisfaction for their customers. From **Table 1**, spare parts are broadly classified into consumables (non-repairable) and non-consumables (or repairable). The cost of procurement of these parts differs due to different functions but with the same goal in the industry. For example, consumables (non-repairable) spare parts are the parts required to replace failed parts, while the non-consumables (repairable) spare parts are the parts that can either be replaced or repaired if the existing parts are failed.
Miscellaneous is the additional tons of the parts required to augment the number of spare parts for the year 2022. Analysis of inflation was incorporated in this study to optimize the number of tons of spare parts and miscellaneous. The data will also help to predict the profit and cost of procurement using the goal programming technique.

Table 1. Available Data from IVM, Nigerian on Spare-parts and Miscellaneous

Type of Vehicles	Strategic Decisions			Available cost (₦)	Inflation rate at 25% yearly
	Spare parts (tons)		Miscellaneous (tons) x_5		
	Consumables (tons) x_3	Non-consumables (tons) x_4			
HDV	4,500	3,000	1,500	1,000,000	1,250,000
MLB	4,000	5,000	1,500	1,200,000	1,500,000
HLB	3,000	3,750	1,650	1,100,000	1,375,000
Predicted Profit for the year 2022 (₦)	120,000	100,000	50,000	**60,000,000**	
Predicted Cost for the year 2022 (₦)	50,000	60,000	25,000	**24,000,000**	

2.3.1.1 Non-preemptive goal programming formulation

The study intends to maximize the profit and minimizes the cost of procurement. Therefore, to achieve the optimal solution, the deviations should be minimized below the profit and above the cost of procurement. These goals are equally ranked. Let the number of consumables to be procured be x_3, that for non-consumables be x_4, and that of Miscellaneous to be procured be x_5. So the goals can be evaluated as follows:

Goals:

$120{,}000x_3 + 100{,}000x_4 + 50{,}000x_5 \geq 60{,}000{,}000$ **(Profit Goal)** (3)

$50{,}000x_3 + 60{,}000x_4 + 25{,}000x_5 \leq 24{,}000{,}000$ **(Cost of Procurement Goal)** (4)

$4500x_3 + 3000x_4 + 1500x_5 \leq 1250000$ **(HDV)** (5)

$4000x_3 + 5000x_4 + 1500x_5 \leq 1500000$ **(MLB)** (6)

$3000x_3 + 3750x_4 + 1650x_5 \leq 1375000$ **(HLB)** (7)

Constraints: $x_3, x_4, x_5 \geq 0$ (8)

2.3.1.2 Linear programming formulation

Let G_1 denotes the profit to be maximized, and; Let G_2 denotes the cost to be minimized therefore:

$G_1 = d_1^-$ i.e., minimize the deviations below the profit goal (9)

$G_2 = d_2^+$ i.e., minimize the deviations above the cost of a procurement goal (10)

These goals are non-preemptive goal programming because maximizing the profit is equally ranked as the goal of minimizing the cost of procurement for the current year. (**Orumie and Ebong, 2011)** established that "there is no single optimal solution in this type of optimization; rather, an interaction among different objectives gives rise to a set of compromised solutions known as Pareto-optimal solutions." The Linear programming formulation from **Table 1.** is given by:

Min $G_1 = {d_1}^-$ **(Satisfy Profit Goal)** (11)
Min $G_2 = {d_2}^+$ **(Satisfy Cost of Procurement Goal)** (12)
Min $Z = G_1 + G_2 = {d_1}^- + {d_2}^+$ **(Objective Function)** (13)

Subjected to the following constraints:

$y_{a1}x_1 + y_{a2}x_2 + y_{a3}x_3 - {d_1}^+ + {d_1}^- = g_a$ (Profit Goal Constraint)
$y_{b1}x_1 + y_{b2}x_2 + y_{b3}x_3 - {d_2}^+ + {d_2}^- = g_b$ (Procurement Goal Constraint)
$y_{13}x_3 + y_{14}x_4 + y_{15}x_5 + S_1 = g_1$ (HDV Constraint)
$y_{23}x_3 + y_{24}x_4 + y_{25}x_5 + S_2 = g_2$ (MLB Constraint)
$y_{33}x_3 + y_{34}x_4 + y_{35}x_5 + S_3 = g_3$ (HLB Constraint)

where,
y_{a1}, y_{a2}, y_{a3} are the associated coefficients with variables x_1, x_2, x_3 in the profit goal.
y_{b1}, y_{b2}, y_{b3} are the associated coefficients with variables x_1, x_2, x_3 in the cost of procurement goal.
y_{13}, y_{14}, y_{15} are the associated coefficients with variables x_3, x_4, x_5 in the HDV constraint.
y_{23}, y_{24}, y_{25} are the associated coefficients with variables x_3, x_4, x_5 in the MLB constraint.
y_{33}, y_{34}, y_{35} are the associated coefficient with variables x_3, x_4, x_5 in the HLB constraint.
${d_i}^- {d_i}^+$ are the negative and positive deviational variables from i target value.
S_i is the slack variable added to the constraint of HDV, MLB, and HLB (unused amount).
x_j is the decision variable.
g_i is the target.
So Eqs. 3 to 8 can be written as:

$120{,}000x_1 + 100{,}000x_2 + 50{,}000x_3 - {d_1}^+ + {d_1}^- = 60{,}000{,}000$
$50{,}000x_1 + 60{,}000x_2 + 25{,}000x_3 - {d_2}^+ + {d_2}^- = 24{,}000{,}000$
$4500x_3 + 3000x_4 + 1500x_5 + S_1 = 1250000$
$4000x_3 + 5000x_4 + 1500x_5 + S_2 = 1500000$
$3000x_3 + 3750x_4 + 1650x_5 + S_3 = 1375000$
Nonnegativity constraints:
$x_3, x_4, x_5, {d_1}^+, {d_1}^-, {d_2}^+, {d_2}^-, S_1, S_2, S_3 \geq 0$

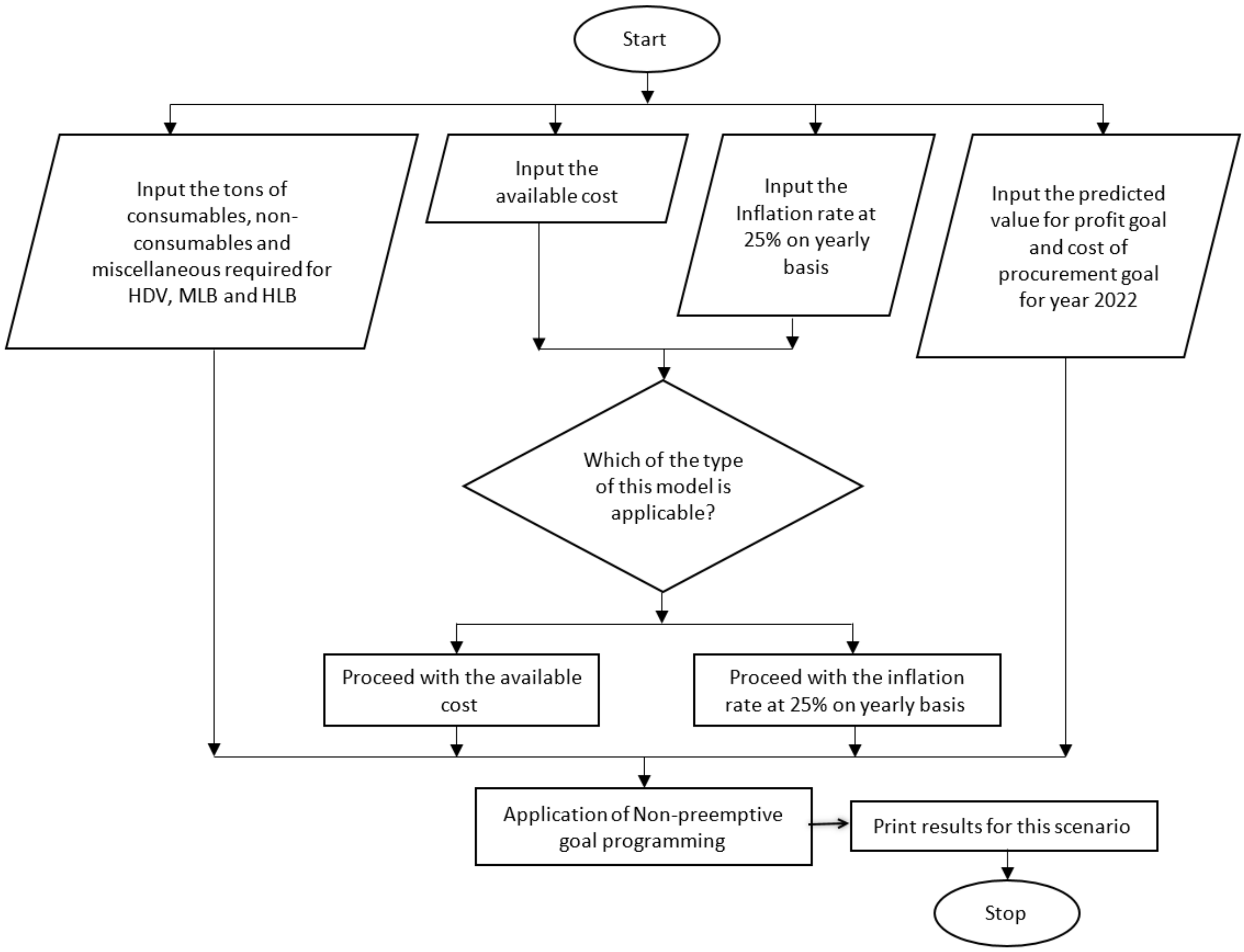

Figure 1. Flowchart for Development of Goal Programming Model

3. RESULTS AND DISCUSSION

Based on the availability of cost allotted for the HDV, MLB, and HLB to procure these spare parts and for miscellaneous, the respective values for the "Inflation rate at 25% yearly" were used as constraints to avoid devaluing of money or procurement of low quality or quantity of tons of consumables, non-consumables or miscellaneous. Though in the results illustrated by **(Kumar et al., 2018)**, the decision-makers can select the Priority Weighted Goal Programming model compared to Linear Programming and Chebyshey Goal Programming. This study developed a Non-preemptive Goal Programming model to optimize Goal constraint. The results are shown in **Table 2 (a, b, c, and d).**

3.1 Analysis of Linear Programming Problem

Table 2 explains the computations of the Goal programming problem using the Gauss – Jordan method in simplex technique, which states that:

$$\text{New pivot equation} = \frac{old\ pivot\ equation}{pivot\ element} \quad (14)$$

Table 2a. Goal Programming Computation.

Basis	x_3	x_4	x_5	d_1^-	d_1^+	d_2^-	d_2^+	S_1	S_2	S_3	b_o	Ratio
d_1^-	**120,000**	100,000	50,000	1	−1	0	0	0	0	0	60,000,000	500
HDV	**4,500**	**3,000**	**1,500**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1,250,000**	277.78
MLB	**4,000**	5,000	1,500	0	0	0	0	0	1	0	1,500,000	375
HLB	**3,000**	3,750	1,650	0	0	0	0	0	0	1	1,375,000	458.33
d_2^+	**50,000**	60,000	25,000	0	0	1	−1	0	0	0	24,000,000	480

Table 2b. Goal Programming Computation

Basis	x_3	x_4	x_5	d_1^-	d_1^+	d_2^-	d_2^+	S_1	S_2	S_3	b_o	Ratio
d_1^-	0	**20,000**	10,000	1	−1	0	0	−26.6667	0	0	26,666,666.6667	1,333.3333
x_3	1	**0.6667**	0.3333	0	0	0	0	0.0002	0	0	277.7778	416.6459
MLB	**0**	**2,333.3333**	**166.6667**	**0**	**0**	**0**	**0**	**−0.8889**	**1**	**0**	**388,888.8889**	166.6667
HLB	0	**1,750**	650	0	0	0	0	−0.6667	0	1	541,666.6667	309.5238
d_2^+	0	**26,666.6667**	8,333.3333	0	0	1	−1	−11.1111	0	0	10,111,111.1111	379.1667

Table 2c. Goal Programming Computation

Basis	x_3	x_4	x_5	d_1^-	d_1^+	d_2^-	d_2^+	S_1	S_2	S_3	b_o	Ratio
d_1^-	0	0	**8,571.4283**	1	−1	0	0	−19.0476	−8.5714	0	23,333,333.2857	2,722.2223
x_3	1	0	**0.2857**	0	0	0	0	0.00045	−0.00029	0	166.6611	583.3430
x_4	0	1	**0.0714**	0	0	0	0	−0.00038	0.00043	0	166.6667	2,334.2675
HLB	**0**	**0**	**524.9910**	**0**	**0**	**0**	**0**	**−2.4990**	**−0.7500**	**1**	**249,999.9959**	476.1986
d_2^+	0	0	**6,428.5710**	0	0	1	−1	−0.9522	−11.4286	0	5,666,666.5975	881.4815

Table 2d. Goal Programming Computation

Basis	x_3	x_4	x_5	d_1^-	d_1^+	d_2^-	d_2^+	S_1	S_2	S_3	b_o
d_1^-	0	0	0	1	−1	0	0	21.7531	3.6737	−16.3268	19,251,630.86
x_3	1	0	0	0	0	0	0	0.00181	0.00012	−0.00054	30.6112
x_4	0	1	0	0	0	0	0	−4.0130	0.000532	−0.000136	132.6661
x_5	0	0	1	0	0	0	0	−0.00476	−0.00143	0.0019	476.1986
d_2^+	0	0	0	0	0	1	−1	29.6483	−2.2448	−12.2451	2,605,389.883

Having considered the approach of Non-preemptive goal programming and linear Programming model, the study determined the values for the profit goal, the goal of the cost of procurement, and the constraint (i.e., costs) in purchasing the tons of the consumables, non-consumables, and the miscellaneous for HDV, MLB, and HLB. From the computations, the optimal solution for the linear programming model has ${d_1}^- =$ 19,251,630.86; $x_3 = 30.6112$; $x_4 = 132.6661$; $x_5 = 476.1986$ and ${d_2}^+ = 2{,}605{,}389.8830$. The non-preemptive goal programming showed that the solution did not fully achieve the goals since the objective function of $Z = {d_1}^- + {d_2}^+ \neq 0$. In satisfying the profit goal, the deviation of ${d_1}^- = 19{,}251{,}630.86$ is being minimized by 1,514.86 below the 60,000,000, implying that the expected profit goal for 2022 would be 59,998,485.14. Also, in satisfying the cost of procurement goal, the deviation of ${d_2}^+ = 2{,}605{,}389.8830$ is being minimized by 880.88 above the 24,000,000, which implies that the expected cost of procurement goal for the current year 2022 would be 24,000,880.88. It was observed that the rate at which both the profit and procurement goals costs were minimized below and above was not much. This means that if 24,000,880.88 were the budget for the cost of procurement for the year 2022, then the expected profit goal for the same year would be 59,998,485.14. Moreover, the lower limit of HDV, MLB, and HLB was 1,250,000, 1,500,000, and 1,375,000, with the surplus. $S_1 = 46.6$, $S_2 = 73.2$, and $S_3 = 59.17$, respectively. The surplus for each constraint is minimal, and the total value for procuring the tons of consumables, non-consumables, and miscellaneous parts for HDV, MLB, and HLB does not affect the budget for the year. With this value, a decision maker can increase the tons of spare parts for the type of vehicle and decide with software programming. The results obtained would help the decision maker to check and balance procurement activities against the available budget in the industry to avoid inventory obsolesce or under-stock of inventory. It would also help to predict the following activities. This can be done with the aid of scientific applications rather than brainstorming. Software application using Java programming language was recommended to evaluate the performance of the manual application.

4. CONCLUSIONS

The application of scientific tools for equipment procurement was established. The study was able to identify Heavy duty vehicles (HDV), Middle-Level Buses (MLB), and High-Level Buses (HLB) as the strategic decisions necessary for budget allocation and optimization of the cost of procurement and the profit goal for the year 2022. The data was collected from Innoson Vehicle Manufacturing (IVM) for decision-making, which was analyzed to predict the amount for procurement and the profit goal for 2022. Inflation was also considered to avoid a continuous rise in the price level. Since the study considered the equal rank of the cost of procurement and the profit goal, the Non-preemptive goal programming model was adopted and improved for their evaluation using the tons of consumables, non-consumables, and miscellaneous for the HDV, MLB, and HLB as decision variables. Based on the calculated value, it was discovered that the solution was not fully achieved, and there were deviations above and below the target value but with a minimal value. Also, the slack variables S_i The constraints of HDV, MLB, and HLB were evaluated even though they are unused amounts. This study would help the decision maker solve the problem of allocating a limited available budget for equipment procurement in the industry and inform a decision maker beforehand of the expected amount for the procurement by applying a scientific technique. The software was implemented for quick and accurate decision-making in the industry in the area where there is a problem with equipment procurement. If inflation is considered before procurement for the selected decisions, it will enable a decision-maker to procure quality and meet customers' needs when due. This would help the company avoid loss and prevent problems from arising regarding income distribution and purchasing power. This study can further consider the allocation of penalty weight to the set goals since there is a deviation from achieving the goals. However, the goals can only be assigned by the management according to the availability of resources. The decision maker or a Procurement Engineer can use Non-preemptive goal programming or Preemptive goal programming according to the order of preference.

REFERENCES

Chakrabarti, S., 2022. Financial aspects of project engineering. Project Engineering Primer for Chemical Engineers. Springer, Singapore. Doi:10.1007/978-981-19-0660-2_5.

Chung, W., 2015. Applying large-scale linear programming in business analytics. IEEE International Conference on Industrial Engineering and Engineering Management, pp. 1860-1864. doi:10.1109/IEEM.2015.7385970

Clemen, R.T. and Reilly, T., 2016. Correlations and copulas for decision and risk analysis". Management Science, 45, 2016, pp. 208–224. doi:10.1287/mnsc.45.2.208

Coetzee, J., 2004. Maintenance, Trafford Publishing, Canada.

Den Boer, J., Lambrechts, W., and Krikke, H., 2020. Additive manufacturing in military and humanitarian missions: advantages and challenges in the spare parts supply chain. J. Clean. Prod. 257, 120301. doi:10.1016/j.jclepro.2020.120301

Diaz, C.A.B., Fathi, M., Aslam, T., and Amos, H.C., 2021. Optimizing reconfigurable manufacturing systems: a simulation-based multi-objective optimization approach". 54th CIRP Conference on Manufacturing Systems. Elsevier, Procedia CIRP 104, 1837-1842. doi:10.1016/j.procir.2021.11.310

Eberhard, L., 2022. Operation, maintenance, and turnarounds. Life Cycle of a Process Plant, chapter 8, pp. 157-186, Elsevier. Doi:10.1016/B978-0-12-813598-3.00006-9.

Eze, O., 2020. The budget, policy and the automobile sector. www.//punchng.com/the-budget-policy-and-the-automobile-sector/. 2020.

Frandsen, C. S., Nielsen, M. M., Chaudhuri, A., Jayaram, J., Govindan, K., 2019. In search for classification and selection of spare parts suitable for additive manufacturing: a literature review. Int. J. Prod. Res. 58, 970-996. doi:10.1080/00207543.2019.1605226

Gershon, K., 2015. ATS Budget Manual (ATS Server)".

Giliyana, S. A., and Kalaiarasan, R., 2015. Maintenance strategy according to the Professional Maintenance methodology as part of World Class Manufacturing, Mälardalen University, Sweden.

Keisler, J., 2004. Value of information in portfolio decision analysis. *Decision analysis*, *1*(3), pp.177-189. . doi:10.1287/deca.1040.0023

Kumar, P.P., Vinodkumar, O. and Yugandhar, T., 2018. An optimization techniques on the managerial decision making. *International Journal of Mechanical and Production Engineering Research and Development*, *8*(6), pp.507-516. doi:10.24247/ijmperddec201854

Maku, A.O. and Adelowokan, O.A., 2013. Dynamics of inflation in Nigeria: An autoregressive approach. *European Journal of Humanities and social sciences*, *22*(1), pp.1175-1184.

Nielsen, H. B., 2006. Uctp problems for unconstrained optimization. Technical Report, Technical University of Denmark.

Ojo, O.O., Farayibi, P.K. and Akinnuli, B.O., 2020. Modified goal programming model for limited available budget a location for equipment procurement under inflation condition. *Adv. Res*, *21*(4), pp.25-35. Doi:10.9734/AIR/2020/v21i430198

Orumie, U.C. and Ebong, D.W., 2011. An alternative method of solving goal programming problem. *Nigerian Journal of Operations Research*, *2*, pp.68-90.

Osueke, C.O., Akinnuli, B.O., and Ojo, O.O., 2015. Modeling equipment procurement strategic decisions competing for limited available budget under redundant accessory cost. *Engineering Management Research*, 4(2), pp 80.

Özdamar, L. and Yazgaç, T., 2016. A hierarchical planning approach for a production distribution system. *International Journal of Production Research*, 37, pp. 3759–3772.

Raouf, O.A., and Hezam, I.M., 2017. Sperm motility algorithm: a novel metaheuristic approach for global optimisation. *International Journal of Operational Research*, 28(2), pp. 143.

Ugwueze, M.I., Ezeibe, C.C., and Onuoha, J.I., 2020. The political economy of automobile development in Nigeria. *Review of African Political Economy*, 2020, pp. 1-11.

Unekwe, C., Ekechukwu, B., and Nwokoye, H., 2012. Model Development for Auto Spare Parts Inventory Control and Management. *West African Journal of Industrial and Academic Research*, 5(1), 2012.

Zhang, S., Huang, K., Yuan, Y., 2021. Spare parts inventory management: A literature review. *Sustainability*, 13, 2460. Doi:10.3390/su13052460.

Zuerl, K., 2022. Cost break down and cost structure analysis. in: effective cost cutting in Asia. *Management for Professionals*. Springer, Cham. Doi:10.1007/978-3-030-82782-3_6.