

Decision making with linear membership function. Case study “GETEX-SPA” unit of Maghnia

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Abstract :

This research paper aims to present the application of fuzzy goal programming in GETEX company unit of Maghnia. The usefulness of this technique is to help this unit to minimize the cost of production and to determine an optimal production plan. Then, it can also help the decision making where there are lacks of information. This model is solved by Lingo computer software.

Keywords: Goal programming, fuzzy goal programming, membership function, decision making.

Jel Classification Codes C61, C52, C44.

Introduction

Recently, quantitative methods have been applied in the decision making process instead of traditional or old theoretical methods. The reason for this is due to the current economic life, which has become largely dependent on technology, making it characterized by accuracy, speed, and quality at the same time. Among the quantitative methods that have been widely used in many fields, we find the Goal programming model (GP). This technique is the oldest and the most widely used multi criteria decision making approach (MCDM) after the second world war².

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²- M. Victoria Rodrigues, R. C. (2002). Meta-Goal Programming. European Journal of Operational Research , 422

The current business world, which has grown complex and dynamic as a result of the quick advancement of technology and the profound changes it has brought about in people's lifestyles, is the rationale for using these kinds of techniques. It has become crucial to become familiar with these methods and receive training in their application for making various decisions in light of the various circumstances that the institution may face. This is because Algeria is constantly working to diversify its economy and move away from oil dependency through a set of strategies it has recently adopted, the most significant of which is Law 1275, which opened the door for a significant segment of youth to enter the business world through a new training method during graduation.

The problem of the study

Based on the above, we will try to answer the following problem:

How does the Zimmerman model contribute to determining the production mix and decision-making in the Genax institution?

Study hypothesis

To answer the problem posed, we have formulated the following hypothesis :

The goal programming model with linear membership function is a flexible model that can be relied upon to establish the organization's production mix, even with insufficient information to create a mathematical model that help to understand and answer for the issue

The importance of the study

The importance of studying the goal programming model with membership functions comes from the role it plays in helping in decision making. In addition to this, we are trying to introduce this model, which has been widely accepted by many researchers, and to draw attention to the need to use such methods and not rely on them as paper research only.

Objective of the study

The research tries to present the model's capability to assist in decision-making across various areas, particularly in applying computers programs in adopting operational research models.

Methodology

The study relied on the descriptive analytical approach, where we presented some concepts and analyzed them, then applied these concepts in GETEX – Spa in the form of a case study.

Decision making

Decision-making has become one of the most important challenges facing managers today, especially with the increase use of technology. Therefore, many definitions are given to this concept, some of them are mentioned below:

As stated by Shahsavarani and Abadi³, decision making is a problem-solving activity that concludes when an acceptable solution is found; hence, This

³- A. M. Shahsavarani, E. A. M. Abadi (2015), The Bases, Principles, and Methods of Decision-Making: A Review of Literature. International Journal of Medical Reviews, 2 (1) 214-225.

can be understood as a rational process that encompasses reasoning or emotions, which may be either implicit or explicit assumptions⁴.

According to (Wang and Ruhe 2007)⁵ and (Bateman and Mace 2020)⁶, decision-making involves choosing one alternative from multiple options.

These options can vary from individual circumstances to decisions made within an organization. When you choose an option from all the available choices, the process is known as decision-making⁷.

We can say that decision-making is the set of steps through which we choose the appropriate or optimal alternative among a group of other alternatives based on the information collected in order to solve the problem under study.

Goal programming

Industrialists tested the models, which proved effective in addressing their challenges. Industrialists discovered that the methods of Operational research can effectively be used to address industrial issues. Subsequently, different models of Operational research such as Goal Programming have been created to address industrial challenges. Indeed, Goal programming models assist managers in addressing numerous issues they encounter in their daily operations. These models aim to reduce production costs, boost productivity, and utilize available resources wisely for sustainable industrial development⁸.

The GP is one of the various models created to address multiple objectives in decision making issues⁹. This technique is an extension of linear programming in which one or more goals are set as constraints, while the objective functions focus on minimizing the overall sum of the absolute deviations from these goals¹⁰.

Goal Programming offers a method for identifying one optimal solution for opposing objectives at the same time. The straightforwardness and user-friendliness of GP have led to its increased popularity across various domains, including human resource management, transportation, site selection, production, accounting and

⁴- Hardi Mulyono, Nelvitia Purba*, Arief Hadian, Abd. Rasyid Syamsuri, and Mhd. Zulkifli Hasibuan (2020). « Decision-Making Culture in Organizations ». *Advances in Social Science, Education and Humanities Research*, volume 536. *Proceedings of the First International Conference on Science, Technology, Engineering and Industrial Revolution (ICSTEIR)*

⁵- Wang Y, Ruhe G (2007). The cognitive process of decision making. *International Journal of Cognitive Informatics and Natural Intelligence (IJCINI)*. 1(2): 73-85.

⁶- Bateman IJ, Mace GM (2020). The natural capital framework for sustainably efficient and equitable decision making. *Nature Sustainability*. Vol 3(10): 776-783.

⁷- Hamed Taherdoost1, Mitra Madanchian (2023). « Decision Making: Models, Processes, Techniques ». *Cloud Computing and Data Science. Volume 5 Issue 1*.

⁸- Nabeel Muhammed1 , Vaidehi Jobiraj2 , Dona Jose(2022). « Goal Programming ». *International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)*. Vol 2.Issue 3. 2581-9429

⁹- Belaid Aouni, Ossama Kettani (2001). « Goal Programming model : Aglorious history and a promising future ». *European Journal of Operational Research* 133. 225-231.

¹⁰- Aoife Ahren, G. A. (2007). Railway projects prioritisation for investment: Application of Goal Programming. *Transport policy* , 70.

financial management, marketing and quality assurance, agriculture and forestry, as well as telecommunication¹¹

The birth of this technique goes back to researchers Charnes and al in 1955. Soon after, a number of publications related to GP appeared, among which the books by Ijiri (1965), Lee (1972) and Ignizio (1976).

GP was devoted to real applications. Apart from the aforementioned publications, many other specific applications can be found¹².

A classical structure of the GP model is¹³:

$$(1) \begin{cases} \min |f_i(x) - g_i| \\ \text{Sous: } Cx \leq c \\ x_j \geq 0 \quad (j = 1, 2, \dots, n) \end{cases}$$

$f_i(x)$ is the level of aspiration and g_i is the level of realization of the objective j

x_j represents decision variables,

a_{ij} represents technological factors,

Cx represents matrix of coefficients of constraints,

c represents a right-hand side values of model.

The formulation (1) can be written as¹⁴ :

$$(2) \begin{cases} \min \sum_{i \in I} (\delta_i^+ + \delta_i^-) \\ \text{st:} \\ \sum_{j=1}^n a_{ij}x_j - \delta_i^+ + \delta_i^- = b_i \\ \delta_i^+, \delta_i^- \geq 0 \quad i \in I \end{cases}$$

GP design aims to find a solution that reduces the disparity between the current levels of objective achievement and their established targets¹⁵.

¹¹- K Vasantha Lakshmi, Harish Babu G A and Uday Kumar K N(2021). « Application of goal programming model for optimization of financial planning: case study of a distribution company ». Palestine Journal of Mathematics. Vol. 10(Special Issue I) , 144–150

¹²- Rafael Caballero, Trinidad Golmez and Francisco Ruiz (2009). « Goal Programming: Realistic Targets for the Near Future ». Journal of multi-criteria decision Analysis.(16) 79–110

¹³- Cooper, C. a. (1968). A goal programming model for media planning, management science. 425-427.

¹⁴- A. Charnes, W.W. Cooper (1975). « Goal programming and multiple objective optimizations (Part I) ». Center for cybernetic studies The University of Texas Austin. Texas 78712.

¹⁵- Belaid Aouni, F. B. (2005). Decision-maker's preferences modeling in the stochastic goal programming. European Journal of Operational Research , 610.

Fuzzy Goal Programming

The GP model has received several criticisms due to the difficulty of obtaining accurate and complete information, especially in the current environment¹⁶. After Zadeh introduced the theory of "Fuzzy Sets" in 1965, Bellman and Zadeh proposed the concept of Decision Making in a Fuzzy Environment in 1970, which significantly advanced various methodologies in Goal Programming methods similar to Linear Programming

The fuzzy goal programming model was developed to optimize decision-making by minimizing the lower deviation variable. This model combines inaccuracies in data input and the level of target objectives with a hierarchy of objectives based on the analysis of fuzzy relationships between paired interests between objectives¹⁷

Multiple studies have sought to tackle the fuzziness problem : Lee and al (2008) utilized the FGP method to assess the impacts of carbon taxes across various sectors while concurrently determining an ideal carbon tax situation. Bravo and Gonzalez (2009) introduced a stochastic GP (SGP) model for water usage planning¹⁸. In 1995, Mohanty and Vijayaraghavan converted a multi-objective programming issue into a corresponding goal programming problem by employing a fuzzy approach¹⁹.

Zimmermann (1976) was the first to present fuzzy linear programming as a form of conventional LP. He investigated (LP) problems characterized by fuzzy objectives and fuzzy constraints, employed linear membership functions along with the minimum operator as an aggregator for these functions, and formulated a corresponding LP problem for (FLP)²⁰

The FGP model proposed by Zimmermen is²¹

$$(3) \begin{cases} \text{opt } Z^k \cong CX \\ \text{subject to: } AX_i \preceq b_i \\ x \geq 0 \end{cases}$$

¹⁶- Nurullah Umarusman.(2018) « Fuzzy Goal Programming Problem Based on Minmax Approach for Optimal System Design ». alphanumeric journal. The Journal of Operations Research, Statistics, Econometrics and Management Information Systems Volume 6, Issue 1. 177-192.

¹⁷- Aulia Ishak, Poltak Nababan. (2020) « The fuzzy goal programming approach to production planning of intermediate gear spare parts : a case study ». Jurnal Sistem dan Manajemen Industri Vol 4 No 2 December, 137-143

¹⁸- Amin Hocine, Mohammed Seghir Guellil , Eyup Dogan, Samir Ghouali , Nouredine Kouaissah (2020). « A fuzzy goal programming with interval target model and its application to the decision problem of renewable energy planning ». Environmental and Ecological Statistics 27:527–547

¹⁹- R. ARORA and K. GUPTA (2020). « Fuzzy goal programming technique for multi-objective indefinite quadratic bilevel programming problem ». Archives of Control Sciences Volume 30(LXVI), No. 4, pages 683–699

²⁰- M. R. Safi, H. R. Maleki and E. Zaeimazad (2007). « A note on the Zimmerman method for solving fuzzy linear programming problems ». *Iranian Journal of Fuzzy Systems* Vol. 4, No. 2, pp. 31-45

²¹- Zimmermann. (1978). Fuzzy programming and linear programming with several objective functions. Fuzzy set Syst

The symbol $\cong$ signifies the fuzzy counterpart of $=$ and represents the fuzzy suction level

The theory of fuzzy sets is frequently utilized in contemporary studies. A fuzzy set A can be defined by a membership function, typically represented as μ , which allocates to each element of a domain its level of membership in A ²².

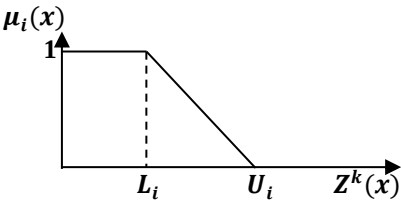
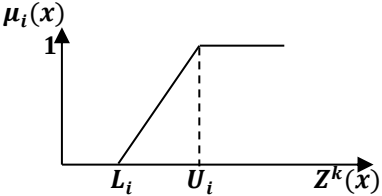
Definition : A fuzzy number is an upper semicontinuous and convex function. $\mu_A: R^k \rightarrow [0,1]$, and is also denoted as $\tilde{A}$. The function μ_A is referred to as the membership function. For $k = 1$ we will refer to a fuzzy number, and for $k > 1$ we will discuss a multidimensional fuzzy number²³.

To address this model, we utilize the subsequent membership functions, aware that:

$$Z^k = CX, \quad G_i = AX \quad \text{et} \quad \lambda = \mu_1(Z^k(x))$$

The types of linear membership function (based on Zimmerman 1978) used in our work are as follows²⁴:

Table 1: types of linear membership function

Membership function	Analytical definition
 The graph shows a membership function $\mu_i(x)$ on the y-axis (ranging from 0 to 1) against $Z^k(x)$ on the x-axis. The function is constant at 1 for $Z^k(x) \leq L_i$. At $Z^k(x) = L_i$, it begins to decrease linearly, reaching 0 at $Z^k(x) = U_i$. A dashed vertical line marks the point L_i on the x-axis.	$\mu_i = \lambda = \begin{cases} 1 & \text{if } Z^k(x) \leq L_i \\ \frac{U_i - Z^k(x)}{U_i - L_i} & \text{if } L_i \leq g_i(x) \leq U_i \\ 0 & \text{if } Z^k(x) \geq U_i \end{cases}$
 The graph shows a membership function $\mu_i(x)$ on the y-axis (ranging from 0 to 1) against $Z^k(x)$ on the x-axis. The function is 0 for $Z^k(x) \leq L_i$. At $Z^k(x) = L_i$, it begins to increase linearly, reaching 1 at $Z^k(x) = U_i$, and then remains constant at 1 for $Z^k(x) \geq U_i$. A dashed vertical line marks the point L_i on the x-axis.	$\mu_i = \lambda = \begin{cases} 1 & \text{if } Z^k(x) \geq U_i \\ \frac{Z^k(x) - L_i}{U_i - L_i} & \text{if } L_i \leq g_i(x) \leq U_i \\ 0 & \text{if } Z^k(x) \leq L_i \end{cases}$

Source: Sahidul Islam, Tapan Kumar Roy (2006).

Model implementation

In this section, we will attempt to address a decision-making issue within the Textiles company « GETEX-Spa » unit of Maghnia. It is an industrial corporation listed on the stock exchange, specializing in the production and distribution of textile products. While we were at the Maghnia facility, the product manager and the

²²- Azzabi Lotfi, Ayadi Dorra, Bachar Kaddour, Kobi Abdessamad (2014). « Fuzzy goal programming to optimization the multi-objective problem ». Science Journal of Applied Mathematics and Statistics. 2(1): 14-19

²³- S. Chanas and Dorota Kuchta. (2002) « Fuzzy goal programming - one notion, many meanings ». Control and Cybernetics vol. 31. No. 4. 871-890

²⁴- Linag-Hsuan Chen, F.-C. T. (2001). Fuzzy goal programming with different importance and priorities. European Journal of Operational Research, 550

marketing manager gave us some information on the production operation as follows.

During this period, the unit was preparing a production plan for 3 types of outfits as follows: traditional costume, bass suit and blouse.
We were able to obtain the following information:

Table 2: The data provided by GETEX – Spa” unit:

Product	Unit time (mn)	Unit cost (DZD)	Unit profit (DZD)	fabric usage for each unit	Use of accessories (zip) for each unit
Traditional costume	56.00	1900.39	380.07	2.66	0.13
Bass suit	55.00	1954.76	390.95	2.75	0.2
Blouse	28.47	1250.14	250.02	2.10	0.7

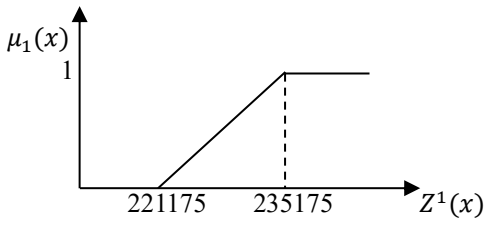
Source: prepared by authors

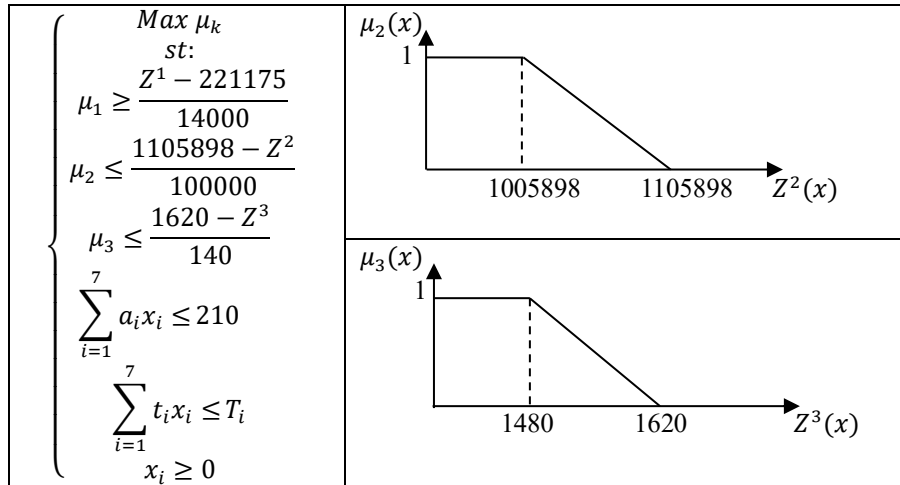
The unit aims to achieve the following objectives:

- Maximize its profit where the unit must not have a profit less than 221175um (um equal 1000 DZD) and it is preferable to have a profit greater than 235175um
- Minimize the production costs of which it must not exceed a total cost of 1105898 um and it aims to have a total cost less than 1005898.
- Do not exceed an overall working time equal to 12740, 12197 and 5470 mn for each product respectively
- Minimize the consumption of fabric of which it must not exceed 1620 and it aims to have a total consumption less than 1480 meter.
- The available quantity of accessories in this period is 210 meter.

The appropriate model using FGP is as follows:

Table 3: mathematical model of FGP

Mathematical model	Linear membership function of each goal
	



Source: prepared by authors

$$Z^1 = \sum_{i=1}^3 p_i x_i$$

p_i : unit profit

$$Z^2 = \sum_{i=1}^3 c_i x_i$$

c_i : unit cost

$$Z^3 = \sum_{i=1}^3 f_i x_i$$

f_i : unit fabric

a_i : Accessories used for each unit

t_i : The time required for each unit

T_i : The time available for each type of product

x_i : the product $i \quad i=1,2,3$

This model is solved by using Lingo computer software, the solution is:

$$x_1 = 227.4 \quad x_2 = 221.7 \quad x_3 = 192$$

$$Z^1 = 221177 \quad Z^2 = 1105545 \quad Z^3 = 11613$$

Conclusion

The results obtained have shown that the company was able to avoid the increase in costs or the decrease in profit but this remains insufficient because the company has the possibility of reaching a lower level of costs compared to the current level and it can also improve the level of profits. Moreover we can say that the FGP was able to deal with a decision-making problem despite the insufficiency of the company's information. This tells us that this model is flexible for current economic problems. Therefore it is necessary to develop more models which represent current economic cases which contain quantitative and qualitative variables including quality control especially for a textile company. For this, it is necessary to have an intermediary unit at the company level to have coherence and integration between the company and the university.

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