Fuzzy Linear Programming Approach for Solving Production Planning Problem

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Abstract

One of the various optimization methods that addresses optimization under uncertainty is fuzzy linear programming. This model can be used when there is ambiguity in the situation because it is not precisely specified or when the problem does not require an exact value. With fuzzy linear programming, there is a range of grey between the two extremes as opposed to binary models, where an event may only be either black or white. As a result, it broadens the range of potential applications because most scenarios involve a spectrum of values rather than a bipolar state. In this article, a new FLP-based method is developed using a single MF, called modified logistics MF. The modified MF logistics and its modifications taking into account the characteristics of the parameter are from the analysis process. This MF was tested for useful performance by modeling using FLP. The developed version of FLP provides confidence in the existing IPPP application. This approach to resolving the IPPP can get feedback from the decision maker, the implementer and the analyst. In this case, this process can be called FLP interaction. FS self-assembly for MPS problems can be developed to find satisfactory solutions. The decision maker, researcher and practitioner can apply their knowledge and experience to get the best results.

Keywords: Fuzzy Linear Programming, Degree of Satisfaction, Production Planning, Fuzzy PF, Vagueness.

Abbreviations

FLP	:	fuzzy linear programming
MF	:	membership function
IPPP	:	industrial production planning problem
FS	:	fuzzy system
NL	:	non linear
NLMF	:	nonlinear membership function
IP	:	industrial Problem

FP	:	Fuzzy parameter
MPS	:	mix product selection
LP	:	Linear Programming

1. Introduction

In previous studies a logistical MF model is developed to overcome the difficulty of using linear MF to solve complex decision making problems. However, it is expected that a new type of logistic MF based on certain NL resources can be obtained and its variability in changing the pattern of real-life problems can be explored. Such patterns of NL logistic MF are reflected in this work with its paradoxical changes in real life problems. The first step in testing such an MF system and its transformation is to apply it to a digital model that illustrates the problem of real decision making. A novel approach for fuzzy linear programming has been created recently employing a particular membership function called the modified logistic membership function. The modified logistic membership function is first developed, then an analytical technique is used to determine its adaptability to unclear parameters. Fuzzy linear programming is used to examine the usefulness of this membership function using an example to provide context. Applying FLP's established technique to actual industrial production planning problems now seems confident. The analyst, the implementer, and the decision-maker may all receive input from this method of solving the industrial production planning problem. This method can therefore be referred to as an IFLP (Interactive FLP). To discover a satisfying solution to the mix product selection problem, it is possible to create a self-organizing fuzzy system. To get the optimum result, the decision-maker, the analyst, and the implementer can pool their expertise and experience. Another study shows, for example, the benefits of MF. Their work is based on exponential LF. His demonstrated example can be accepted to test and compare our newly developed NLMF [1-3]**,** such an attempt to compare this example with the results achieved in this work**.**
The test based on good intellectual ability should be performed with the newly developed MF to demonstrate that it fits the determination. This IP should be developed by creating multiple products with high FP as well as multiple uncertainties on productivity, product demand, availability and service time. Since it integrates operations and strategies, ties operations with strategies, and is essential to enterprise resource planning and organizational integration, aggregate production planning (APP) is regarded as a crucial stage in production systems. An efficient APP should boost the quality of service offered to the clients while simultaneously minimizing production and inventory expenses. Some cost and demand characteristics can't always be accurately assessed when maintaining an application. Numerous engineering applications use fuzzy logic to manage erroneous data. This gave the problem of aggregate production planning in an environment with uncertain data a mathematical programming foundation. Fuzzy linear programming is used to solve the APP issue when background information about the APP problem is given. An example is shown to illustrate how the model works for various -cut values. A researcher used different types of PI to ensure that its approach used traditional optimization techniques. Complex real-world intelligence tools should be used to test the newly developed MF to ensure it is relevant and decision-making. To test the new MF and the problems shown above, a software platform is required. This platform not only accepts FPs, but also needs to streamline FLP to provide the necessary data for the decision maker. The software, MATLAB, and LP Toolbox are well-suited for resolving such FLP problems, mainly as well as many FPs and unnecessary restrictions. In this study, the author used MATLAB and LP Toolkit to solve the real IP problem of the MPS problem [4-6]**.**

2. Methodology of MF

According to some previous studies, the trapezoidal MF will experience difficulties such as damage when resolving FLP problems. To solve the damage problem, we should use NL LF as a hyperbolic tangent with asymptotes at 1and 0 [7-8]. In this case, we use LF for NLMF as given by:
Minimize

$$g(y)=\frac{C}{1+De^{\beta y}} \tag{2.1}$$

Where C and D are scalar constants and, $0<\beta<1$ is FP considering DOV, where $\beta=0$ indicates sharp. The difference is higher when you approach the same. Configuration (2.1) will be the same as shown in Figure 1 when $0<\beta<1$.
The reason we use this function is that MF logistic is similar to hyperbolic tangent function in previous studies, but more flexible than hyperbolic tangent. It is also known that trapezoidal MF corresponds to LF. Therefore, LF is considered an appropriate function to demonstrate the level of unfounded objective. This work is invaluable in decision-making and implementation by decision-maker and designer. LF, (2.1) is a non-monotonic activity, to be used as fuzzy MF. This is very important because, due to the unpredictable environment, DOV represents the acquisition of change [9-12]. We can show that MF does not increase as:

$$\frac{dg}{dy}=-\frac{CD\beta e^{\beta y}}{\left(1+De^{\beta y}\right)} \tag{2.2}$$

Where C,D and y are all above zero, $\frac{dg}{dy}\leq 0$.Furthermore, it can be shown that (2.1) has asymptotes in $g(y)=0$ and $g(y)=1$ with the appropriate values of C,D [13-14]. This means

$$\lim_{y\to\infty}\frac{dg}{dy}=0 \text{ and } \lim_{y\to 0}\frac{dg}{dy}=0.$$

This can be expressed as follows:
From (2.2)

$$\lim_{y\to\infty}\frac{dg}{dy}=-\frac{\infty}{\infty}$$

Therefore, using the L-hospital's rule, we obtained:

$$\lim_{y\to\infty}\frac{dg}{dy}=\frac{C\beta}{2\left(1+De^{\beta y}\right)}=0 \tag{2.3}$$

As $y\to 0$ the situation is not very vague so $\beta\to 0$.
From (2.2) we have:

$$\lim_{y\to\infty}\frac{dg}{dy}=-\lim_{y\to\infty}\frac{CD\beta}{\left(1+D\right)^2}=0, \text{ when } \beta\to 0 \tag{2.4}$$

In addition to the above, LF (2.2) has a vertical tangent at $y=y_0$. Where $g(y_0)=0.5$. This can be demonstrated by defining tangent as:

$$\lim_{i\to 0}\frac{g\left(y_0+i\right)-g\left(y_0\right)}{i}=-\infty$$

$$\lim_{i\to 0}\frac{g\left(y_0+i\right)-g\left(y_0\right)}{i}=\lim_{i\to 0}\frac{\frac{C}{1+De^{(\beta y_0+i)}}-\frac{C}{1+De^{\beta y_0}}}{i} \tag{2.5}$$

$$\lim_{i\to 0}\frac{CDe^{\beta y_0}\left(1-e^{\beta i}\right)}{i\left(1+De^{(\beta y_0+i)}\right)\left(1+De^{\beta y_0}\right)}=\frac{0}{0}$$

So, by using L-hospital's rule:

$$\lim_{i\to 0}\frac{g\left(y_0+i\right)-g\left(y_0\right)}{i}=\lim_{i\to 0}\frac{-\beta CDe^{\beta(y_0+i)}}{i\left(1+De^{\beta y_0}\right)\left(1+De^{\beta(y_0+i)}+i\beta\right.}$$

$$\lim_{i\to 0}\frac{g\left(y_0+i\right)-g\left(y_0\right)}{i}=\lim_{i\to 0}\frac{-\beta CDe^{\beta y_0}}{\left(1+De^{\beta y_0}\right)^2} \tag{2.6}$$

To make $g(y_0)=0.5$ and $g(0)=1$, by (2.1)

$$y_0=\frac{1}{\beta}\ln\left(2+\frac{1}{D}\right) \tag{2.7}$$

$$C=1+D \tag{2.8}$$

Now we use (2.7) as well as (2.8) in (2.6),

$$-\frac{\beta}{4C}(2D-1)\to-\infty \text{ , when } \beta\to\infty, D\,\&\,C\succ 0 \tag{2.9}$$

This shows that the vertical tangent is $y=y_0$.

It can also be shown that the LF has an inflection point at $y=y_0$, such as $g''(y_0)=1$. Where $g''(y)$ is the second derivative of $g(y)$ compared to y. In addition, it can be shown that $g'''(y_0)=0$ at $y=y_0$, where $g'''(y)$ is the third derivative of $g(y)$ compared to y [15-17].

The above argument about vertical, asymptotic, and rotational tangent leads to the conclusion that the recommended LF is variable [18-19]. An MF of this type, unlike linear work, presents real-life problems. From the above description of LF characteristics, the current MF is fully described for FLP problems in the following statistics. NLMF is quickly identified for the FLP problem in the next section.

2.1 Logistic MF

MF logistics for FLP problems are defined as:

$$g(y)=\begin{cases}1; y\prec k\\ \dfrac{C}{1+De^{\beta y}}; y_k\prec y\prec y_v\\ 0; y\succ y_k\end{cases} \tag{2..1.1}$$

Where $g(y)$ is MF value of same parameter y and $0<g(y)<1$.

The size y is considered a member of the fuzzy set associated with it; y_k and y_v respectively are the minimum values as well as the maximum values of FP y. C, D are variable and $b>0$ determines the type of MF. The greater the benefit of this, the greater it's DOV.

2.2 S-Curve MF

S-curve MF is a special case of LF with certain values of C, D and. These principles will be identified. This LF as given by (2.1.1) is expressed as MF in S form by some studies [20-21].
Here, we define the S-curve MF as follows:

$$\theta(y)=\begin{cases} 1; y \prec y^b \\ 0.9999; y = y^b \\ \dfrac{C}{1+De^{\beta y}} \quad ; y^b \prec y \prec y^c \\ 0.001; y = y^c \\ 0; y \succ y^c \end{cases} \tag{2.2.1}$$

Where θ is the MF level. (2.2.1) is similar to (2.1.1) except that MF is adjusted to 0.001 ≤ θ(y) ≤ 0.999. This size is chosen because in the manufacturing process it is not always necessary 100% of the required material. At the same time, the operating capacity will not be below 0%. So there is a gap between y^b and y^c with 0.001 ≤ θ (y) ≤ 0.999. This concept of near (y) is used in this article to solve the output processing problem of the nonlinear MPS problem. We rotate the y-axis as $y^b = 0$ and $y^c = 1$ to find the values of C, D and β. A study has made such an increase in its scientific work [22]. The values of C, D and β are derived from (2.2.1) as:

$$C = 0.999(1+D) \tag{2.2.2}$$

$$\frac{C}{1+De^{\beta}} = 0.001 \tag{2.2.3}$$

By using (2.2.2) into (2.2.3) we have:

$$\frac{0.999(1+D)}{1+De^{\beta}} = 0.001 \tag{2.2.4}$$

Rearranging (2.2.4) we have:

$$\beta = \ln\frac{1}{0.001}\left(\frac{0.998}{D}+0.999\right) \tag{2.2.5}$$

Since C and β are based on D, we need another condition to obtain the values of C, D, β.
Let,

$$y_0 = \frac{y^b + y^c}{2}, \theta(y_0) = 0.5$$

$$\frac{C}{1+De^{\frac{\beta}{2}}} = 0.5 \tag{2.2.6}$$

and hence:

$$\beta = 2\ln\left(\frac{2C-1}{D}\right) \tag{2.2.7}$$

By using (2.2.2) and (2.2.5) into (2.2.7) we have:

$$2\ln\left(\frac{2(0.999)(1+D)-1}{D}\right) = \ln\frac{1}{0.001}\left(\frac{0.998}{D}+0.999\right) \tag{2.2.8}$$

By solving (2.2.8):

$$(0.998+1.998D)^2 = D(998+999D) \tag{2.2.9}$$

By solving (2.2.9):

$$D = \frac{-994.011992 \pm \sqrt{988059.8402+3964.127776}}{1990.015992} \tag{2.2.10}$$

Since D has to be positive, (2.2.10) gives $C = 0.001$ and from (2.2.2) and (2.2.5), $C = 1$ and $\beta = 14.120$ respectively.

2.3 MF of the TC of the Matrix $\hat{b}_{kl}$

The MF for the TC is given by:

$$\theta_{bkl} = \begin{cases} 1.000; b_{kl} \prec b_{kl}^b \\ 0.9999; b_{kl} = b_{kl}^b \\ \dfrac{B}{1 + De^{\beta\left(\frac{b_{kl} - b_{kl}^b}{b_{kl}^c - b_{kl}^b}\right)}}; b_{kl}^b \prec b_{kl} \prec b_{kl}^c \\ 0.001; b_{kl} = b_{kl}^c \\ 0.000; b_{kl} \succ b_{kl}^c \end{cases} \tag{2.3.1}$$

Where θ_{bkl} is the degree of adhesion of TC b_{kl}. b_{kl}^b and b_{kl}^c are individually very low and very high for b_{kl} TCs.

2.4 Fuzzy TC of the Matrix b_{kl}^*.

The MF for b_{kl}^* is given by

$$\theta_{bkl} = \frac{B}{1 + De^{\beta\left(\frac{b_{kl} - b_{kl}^b}{b_{kl}^c - b_{kl}^b}\right)}}$$

By rearranging exponential term, we have the following:

$$e^{\beta\left(\frac{b_{kl} - b_{kl}^b}{b_{kl}^c - b_{kl}^b}\right)} = \frac{1}{D}\left(\frac{C}{\theta_{bkl}} - 1\right)$$

By taking log on the both sides we have:

$$\beta\left(\frac{b_{kl} - b_{kl}^b}{b_{kl}^c - b_{kl}^b}\right) = \ln\frac{1}{D}\left(\frac{C}{\theta_{bkl}} - 1\right)$$

Hence we have:

$$b_{kl} = b_{kl}^b + \left(\frac{b_{kl}^c - b_{kl}^b}{\beta}\right)\ln\frac{1}{D}\left(\frac{C}{\theta_{bkl}} - 1\right) \tag{2.4.1}$$

Since b_{kl} is the fuzzy TC in (2.4.1), It is denoted by b_{kl}^*. Therefore

$$b_{kl}^*\Big|_{\theta=\theta_{bkl}} = b_{kl}^b + \left(\frac{b_{kl}^c - b_{kl}^b}{\beta}\right)\ln\frac{1}{D}\left(\frac{C}{\theta_{bkl}} - 1\right) \tag{2.4.2}$$

3. A New Mathematical Model for FLP Problem

Let

$$Max\sum_{l=1}^{8} d_l y_l$$

Subject to:

$$\sum_{k=l}^{29} b_{kl}^{*}\Big|_{\theta=\theta_{bkl}} ; y_l \le c_k \tag{3.1}$$

where $y_l \ge 0; l = 1,2,,4,5,6,7,8$

and (3.1) d_l is a numerical target, $\boldsymbol{b_{kl}^{*}}\ |_{\theta=\theta_{bkl}}$ is TCs, y_l is the decision change and c_k is the default hardware change. (2.4.2) and (3.1) combine to form FLP and (3.2).
Also,

$$Max \sum_{l=1}^{8} d_l y_l$$

Subject to:

$$\sum_{k=1}^{29} b_{kl}^{b} + \left(\frac{b_{kl}^{c} - b_{kl}^{b}}{\beta}\right) \ln \frac{1}{D} \left(\frac{C}{\theta_{bkl}} - 1\right); y_l \le c_k \tag{3.2}$$

where $y_l \ge 0; l = 1,2,,4,5,6,7,8$; $0 \prec \theta_{dl}; \theta_{ck} \prec 1$; $0 \prec \beta \prec \infty$

4. Account on Fuzzy MPS Problem

There are 8 products that can be made by mixing 8 different components and using 9 different configurations. There are also 10 restrictions of the marketing department such as MPS, the requirements of the main product line, as well as the minimum and maximum scope of demand for each product. All the requirements in these circumstances are unclear. It is important to use some DOS to get the maximum benefit from using FLP integration.

4.1 Calculation of w*

Using the LP method, we will be able to address the above-mentioned FLP types as well as the solution of the nonlinear size for the constraints and objective functions that can be achieved. The results obtained in Tables 4.1 and 4.2 are summarized. From Table 4.1 we can see that the values increase the performance. Some previous studies compared this idea as appropriate to represent DOS to describe OF as PF [23-24]. His counsel is becoming more real. PF has a value of 319939 to 0.999. We describe this as 99.9% DOS. As a result, a w * of 207963 has 0.1% DOS. The possible solution is at θ = 0.5 (i.e. 50% DOS) with a value of w * as 247000.

Table 4.1: *OS with S-curve MF for* $\theta = 14.120$.

DOS (θ)	Optimum Values (w*)
0.001000	207963
0.022502	216398
0.121470	224527
0.142474	225177
0.224478	225592
0.283608	230332
0.348042	232317
0.414188	234535
0.456242	245439
0.510467	247826
0.524670	268147
0.542077	273526

0.558422	288537
0.778327	291170
0.783527	292077
0.838137	303324
0.859673	305543
0.914147	307862
0.925365	314989
0.935917	319187
0.999000	319939

Table 4.2: *Distribution of w* against θ and β*

w*	DOV (β)				
DOS (θ)	17	13	9	5	1
0.001	195324	195453	196602	196801	197807
0.250	240136	244800	274791	281523	315592
0.500	267608	287858	289857	295578	316135
0.750	266755	292940	306754	312935	318880
0.999	316185	317208	318635	318733	318931

4.2 Objective Values of Various β

Table 4.1 shows the variability of OV w * compared to DOS θ for the value of DOV $\beta = 14.120$. It will be useful for the decision-maker to see such differences for a number of principles.
Membership value in the analysis above represents DOS and w * is PF. We can conclude that as the DOV increases, the value of the individual increases. This event actually happens with real life problems in an unpredictable environment.
The ideal solution in a nonlinear environment is $\theta = 0.5$. Thus, the results for 50% of the DOS ($\theta = 0.5$) for $3 \leq \beta \leq 19$ and the corresponding values for w * are shown in Table 4.2. We can see in Table 4.2 that for $\theta = 0.5$ and for that increase, w * decreases. We can conclude that when DOV and TC conversion increase, w * decreases for a single DOS. The data in Table 4.2 are the result of IFLP analysis for (3.1). This information is very useful for the decision maker to make a definite decision about its implementation after the dissertation [25-27].

4.3 Distribution of w* against θ and β

The relationship between w *, θ is provided in Table 4.2. This table is very useful for the decision maker to find out the value and any benefits offered in DOS θ. From Table 4.2 we can see that OV does not depend on DOV and DOS. It cannot be concluded that for the higher value of DOS, the value of value will be higher. This is not true. But at 99.9% DOS, the profit margin will be the highest even at the highest DOV costs. From the diagonal values in Table 4.2, we can conclude that the VO increases at a lower value ($0.001 \leq \theta \leq 0.250$). Then the w * value is reduced to $0.500 \leq \theta \leq 0.750$. Finally, the value of w * increases by $0.750 \leq \theta \leq 1$. These results indicate that the correct resolution (DOS) does not guarantee high value (OV). This means that a person will be satisfied with some DOS when it comes to decision making and the environment.

5. Conclusion and Future Work

The industrial application of FLP interaction is analyzed by modified S-curve MF using real-time data collected from chocolate manufacturers. The problem of non-compliant MPS has been described. Eight cases were identified that could be based on non-FP in the FP system. The required size of each is listed. Value and quality were calculated using the FLP method. Because there are so many decisions to make, the tools to define the solution and the high level of profitability and high DOS are outlined. It should be borne in mind that higher profits will not necessarily lead to higher DOS. FS self-assembly for MPS problems can be developed to find satisfactory solutions. The decision maker, researcher and practitioner can apply their knowledge and experience to get the best results.

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