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Evaluation of the Effectiveness of Fuzzy Logic Sensitivity Analysis in Matlab Works for Evaluating the EOQ Production Inventory Model with Variable Demand with the Lagrangian and Kuhn-Tucker Methods

S. Swathi[1], K. Kalaiarasi[2], N. Sindhuja[3]
[1, 3]Phd Research Scholar, PG and Research Department of Mathematics, Cauvery College for Women (Autonomous), (Affiliated to Bharathidasan University), Tiruchirappalli-620018
[2]Assistant Professor, PG and Research Department of Mathematics, Cauvery College for Women (Autonomous), (Affiliated to Bharathidasan University), Tiruchirappalli-620018
[2]D.Sc(Mathematics) Researcher Fellow, Srinivas University, Surathkal, Mangaluru, Karnataka-574146

Abstract: To mirror the real world, the various inventory cost characteristics are also shown as interval numbers. The assumption is that the relationship between the product's demand and selling price is linearly descending. The supply chain has been optimized in this article using these two techniques with random demand. These two approaches have been compared, and a potential machine-learning strategy combining these two approaches has also been offered. The demand is thought to be random. Crisp and fuzzy models were utilized in this study to fix perishable products in the manufacturing process. The proposed model is solved using both the nonlinear mathematical Programming Lagrangian and Kuhn-tucker Methods. The Grade Mean Integration Representation technique is used to defuzzify data in the Fuzzy Inventory Model, which uses a Trapezoidal Fuzzy Number to determine the lowest prices. To support the solution process, a numerical example that includes sensitivity analysis is done at the end. Lagrangian, Kuhn-Tucker, and fuzzy logic analysis are used to analyze the Economic Order Quantity (EOQ) for changeable demand in this study. This research compares and contrasts their approaches, and the findings demonstrate the superiority of fuzzy logic over traditional approaches. To explore the price-dependent coefficients with variable demand and unit purchase cost over variable demand, trapezoidal fuzzy numbers are used in this research. The outcomes closely resemble the clean output. To validate the model, sensitivity analysis in Matlab was additionally carried out.
Keywords: Fuzzy logic, Lagrangian method, Kuhn-tucker method, Economic order quantity, Total cost, Graded mean integration method, Defuzzification, Matlab.

I. INTRODUCTION

Industries and businesses are focusing their supply chains on environmental performance by increasing service and cost. For a company or an industry, the most important factor is lot sizing or ordering quantity. Due to stronger and more frequent extreme weather events, global warming and the greenhouse effect have received a lot of attention. This was known as the Kyoto Protocol, which aimed to reduce the greenhouse impact. Three flexible procedures were also proposed by the protocol: international emissions trading, cooperative implementat0ion, and clean development mechanism. Trading emissions is one of the most efficient market-based strategies under the Kyoto Protocol (also known as Cap-and-Trade). With the help of this mechanism, all industries are forced to adhere to a cap on their carbon emissions, and they are also given the option to purchase or sell emission rights. Several developed nations have taken either regulatory action or other steps to reduce their emissions to meet the targets for the emissions decrease established by the Kyoto Protocol. Since emission is a fundamental component of fossil fuels, reducing emissions results in cost savings. The three main greenhouse gases—Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O)—are responsible for both atmospheric emissions and removals. Human activities including the usage of automobiles, the production of energy, and the burning of fossil fuels during industrialization are the main causes of greenhouse gas emissions.

From an international economic perspective, the industry directly affects the economy. As a result, carbon emissions cannot be eliminated. The biggest challenge for any industry is to invest in green technologies to decrease emissions and combat global warming.

Green technology may help to minimize emissions. A sustainable technology, sometimes known as "green technology," has a "green" application. Nature refers to the color green, but in general, "green technology" refers to any innovation that considers both an invention's immediate and long-term effects on the environment. Due to its simplicity, the EPQ (Economic Production Quantity) model has been widely used in exercises. The classic EPQ model does, however, make certain additional assumptions, and several academics have attempted to develop it from various angles. The conventional EPQ model has recently been expanded in several ways. A different partial back-ordering example for a deterministic EPQ formula was addressed by Pentico et al. in 2009. With their unique EPQ formula in their model, they analyzed and studied the prior literature on EPQ models. By taking into account a partial back ordering example under how the effects of advance payments in profit operate, Taleizadeh (2014) extends the work of Pentico et al. (2009) after more than five years. They developed the single-objective function of carbon emissions as it relates to sustainable development. They then used multi-criteria decision analysis to expand their model to a multi-echelon sustainable order quantity. To create an inventory model, Benjaafar et al. (2013) linked several decision variables under the cost function and carbon footprint to various carbon emission metrics. They looked at the impact of emission restrictions on the price of emissions. By making some operational improvements, such as investing in carbon-reducing technologies, they expanded their model to account for carbon reduction. With the aid of order quantities, Chen et al. (2013) created an EOQ model for lower emissions. Then, they analyzed issues affecting emission reduction and overall cost increase while assuming some conditions for the decrease in carbon emissions. Hu and Zhou (2014) investigated the manufacturer's shared price and carbon emission reduction strategy under a carbon emission trade. They created their model utilizing the Stackelberg game method for the best price and pollution reduction effort. To maximize profit, they looked into the effects of a carbon emission policy. Sarkar et al. created a single-stage production model with reworking (2014). They suggested the backorder and random defective rate in his study. A multi-stage production system was enhanced by Kim and Sarkar (2017) using a quality improvement policy and lead time-dependent ordering costs. A production model with quality improvement and variable backorder costs was created by Sarkar and Moon in 2014. They demonstrated how crucial the setup cost cut was for long-term production. In a sustainable EPQ or non-sustainable EPQ situation, taking into account controllable or uncontrollable carbon emissions and various shortage cases led to the development of a new model that is more applicable and useful in a real-world setting. Additionally, optimization and machine learning are closely related since many learning problems are phrased as the minimization of a loss function on a training set of samples. The gap between the model's predictions and the actual problem occurrences is expressed by loss functions.

II. METHODOLOGY

A. Grade Mean Integration Represented Technique [22]

Let grade mean of $\tilde{X}$ is defined as

$$P(\tilde{X}) = \int_0^{w_A} \frac{h\left(\frac{L^{-1}(h) + R^{-1}(h)}{2}\right)dh}{\int_0^{w_A} hdh}$$

Let grade mean of $\tilde{Y}$ is defined as

$$P(\tilde{Y}) = \int_0^{1} \frac{h\left(\frac{q_1 + q_4 + (q_2 - q_1 - q_4 + q_3)h}{2}\right)dh}{\int_0^{1} hdh}$$

$$= \frac{q_1 + 2q_2 + 2q_3 + q_4}{6}$$

This method is based on the integral of the grade mean h-level of the generalized fuzzy number for defuzzying. Werner Leekwijck and Kerre [22] proposed a defuzzy approach.

III. PRELIMINARIES

Some basic definitions are necessary before proceeding on to the fuzzy inventory models.

A. *Crisp Set [24]*

A classical (crisp) set is typically defined as a collection of finite, countable, or over countable items or objects, $x \in X$.
$A \subseteq X$ is a set of elements that can either belong to or not belong to each other. In this statement, "x belongs to A" is correct, however, in the other is incorrect.

B. *Fuzzy Set [24]*

Let X is a group of objects, A fuzzy set Z in X is a set of ordered pairs,
where $\tilde{Z} = \{(x, \mu_{\tilde{Z}}(x)) | x \in X\}$, $\mu_{\tilde{Z}}(x)$ is the membership function or grade of membership function of x in $\tilde{Z}$ that maps X to the membership space M (When M incorporates only two points, 0 and 1).
And $\tilde{Z}$ is the same as a nonfuzzy set characteristic function.

C. *Trapezoidal Fuzzy Number [3]*

The membership function of Trapezoidal Fuzzy Number A as $A = (a_1, a_2, a_3, a_4)$ will be interpreted as follows

$$\mu_A(x) = \begin{cases} 0, & x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1}, & a_1 \le x \le a_2 \\ 1, & a_2 \le x \le a_3 \\ \dfrac{a_4 - x}{a_4 - a_3}, & a_3 \le x \le a_4 \\ 0, & x > a_4 \end{cases}$$

D. *Defuzzification [22]*

Defuzzification was introduced by Werner Leekwijck and Kerre.[22]
Defuzzification is the process of converting Fuzzy values to Crisp values. We applied defuzzification approaches that have been studied for a long time to defuzzify Fuzzy systems.

IV. FORMULATION OF THE INVENTORY MODEL FOR PERISHABLE PRODUCTS

Sepehri [19] given Deteriorating Item Inventory Model
Consider,

The integrated Inventory total cost is

$$TP = \frac{Tp(a - bp + k\lambda)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp + k\lambda)$$

Now we differentiate partially with respect to T

$$\frac{\partial TP}{\partial T} = \frac{p(a - bp + k\lambda)I_e}{2} - \frac{O}{T^2} - \frac{C}{T^2}(a - bp + k\lambda)$$

and equate it to zero, then we obtain the crisp quantity

$$Put\ \frac{\partial TP}{\partial T} = 0,$$

$$T = \sqrt{\frac{2(O + C(a - bp + k\lambda))}{p(a - bp + k\lambda)I_e}}$$

Hence T is the optimal order quantity of the proposed inventory model.
Now, Taha [20] described how to use the Lagrange conditions to solve a Nonlinear Programming problem with inequality constraints.. The Nonlinear Fuzzy Inventory Model was solved using the Lagrangian Method by Kalaiarasi [9], and Alsaraireh [1] provided the procedures for solving the Lagrangian Method.

A. Lagrangian Method to the Optimization of the EOQ Model for Perishable Products

Assume the following is the problem:

Minimize $y = f(x_1, x_2, \dots, x_n)$

Subject to $g_i(x_1, x_2, \dots, x_n) \geq b_i, i = 1,2, \dots, m$

$$x_1, x_2, \dots \dots, x_n \geq 0$$

where $x_1, x_2, \dots, x_n \in R^n, b_i \in R^m$.

The Lagrangian is $L(x_j, \lambda_i) = f(x_j) + \sum_{i=1}^{m} \lambda_i [g_i(x_j) - b_i]$ with $\lambda_i \in R^m$.Each component of $\lambda_i$is called a Lagrange multiplier.

Step 1: $(x_j, \lambda_i) = f(x_j) + \sum_{i=1}^{m} \lambda_i [g_i(x_j) - b_i]$

Step 2:

$$\frac{\partial L}{\partial x_j} = \frac{\partial F}{\partial x_j} + \frac{\partial}{\partial x_j}\left(\sum_{i=1}^{m} \lambda_i [g_i(x_j) - b_i]\right) = 0$$

Step 3:

$$\frac{\partial L}{\partial \lambda_i} = \frac{\partial F}{\partial \lambda_i} + \frac{\partial}{\partial \lambda_i}\left(\sum_{i=1}^{m} \lambda_i [g_i(x_j) - b_i]\right) = 0$$

Step 4: $\bar{\lambda}_i [g_i(\bar{x}_j)] = 0$

1) Crisp sense of Lagrangian method to the optimization of the EOQ model for Perishable products

Consider,

The integrated total cost of Inventory Model is

$$TP = \frac{Tp(a - bp + k\lambda)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp + k\lambda)$$

Now we differentiate partially with respect to T

$$\frac{\partial TP}{\partial T} = \frac{p(a - bp + k\lambda)I_e}{2} - \frac{O}{T^2} - \frac{C}{T^2}(a - bp + k\lambda)$$

and equate it to zero, then we obtain the crisp quantity

$$Put\ \frac{\partial TP}{\partial T} = 0,$$

$$T = \sqrt{\frac{2(O + C(a - bp + k\lambda))}{p(a - bp + k\lambda)I_e}}$$

By applying our total cost in this formula. Taking 'p' and 'λ' are fuzzy parameter

$$TP(T) = \frac{1}{6}\left(\begin{array}{c} \frac{Tp_1(a - bp_1 + k\lambda_1)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_1 + k\lambda_1) \\ +2\left(\frac{Tp_2(a - bp_2 + k\lambda_2)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_2 + k\lambda_2)\right) \\ +2\left(\frac{Tp_3(a - bp_3 + k\lambda_3)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_3 + k\lambda_3)\right) \\ + \frac{Tp_4(a - bp_4 + k\lambda_4)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_4 + k\lambda_4) \end{array}\right)$$

By differentiating those equation with respect to *T*

$$T = \sqrt{\frac{\begin{array}{c} 2[O + C(a - bp_1 + k\lambda_1)] + 4[O + C(a - bp_2 + k\lambda_2)] \\ +4[O + C(a - bp_3 + k\lambda_3)] \\ +2[O + C(a - bp_4 + k\lambda_4)] \end{array}}{\begin{array}{c} p_1(a - bp_1 + k\lambda_1)I_e + 2p_2(a - bp_2 + k\lambda_2)I_e \\ +2p_3(a - bp_3 + k\lambda_3)I_e + p_4(a - bp_4 + k\lambda_4)I_e \end{array}}}$$

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2) Fuzzy sense of Lagrangian method to the optimization of the EOQ model for Perishable products

Taking ‘p’ and ‘λ’ are fuzzy parameter

$$T = \sqrt{\frac{\begin{array}{c}2[O + C(a - bp_1 + k\lambda_1)] \ + 4[O + C(a - bp_2 + k\lambda_2)] \\ +4[O + C(a - bp_3 + k\lambda_3)] \\ +2[O + C(a - bp_4 + k\lambda_4)]\end{array}}{\begin{array}{c}p_1(a - bp_1 + k\lambda_1)I_e + 2p_2(a - bp_2 + k\lambda_2)I_e \\ +2p_3(a - bp_3 + k\lambda_3)I_e + p_4(a - bp_4 + k\lambda_4)I_e\end{array}}}$$

By differentiating those equation with respect to T

$$TP(T) = \frac{1}{6}\left(\begin{array}{c}\frac{Tp_1(a - bp_1 + k\lambda_1)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_1 + k\lambda_1) \\ +2\left(\frac{Tp_2(a - bp_2 + k\lambda_2)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_2 + k\lambda_2)\right) \\ +2\left(\frac{Tp_3(a - bp_3 + k\lambda_3)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_3 + k\lambda_3)\right) \\ +\frac{Tp_4(a - bp_4 + k\lambda_4)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp_4 + k\lambda_4)\end{array}\right)$$

$$\widetilde{T^*} = \sqrt{\frac{\begin{array}{c}2\big(O + C(a - bp_4 + k\lambda_4)\big) + 4\big(O + C(a - bp_3 + k\lambda_3)\big) + 4\big(O + C(a - bp_2 + k\lambda_2)\big) + \\ 2\big(O + C(a - bp_1 + k\lambda_1)\big)\end{array}}{\begin{array}{c}p_1(a - bp_1 + k\lambda_1)I_e + 2p_2(a - bp_2 + k\lambda_2)I_e \\ +2p_3(a - bp_3 + k\lambda_3)I_e + p_4(a - bp_4 + k\lambda_4)I_e\end{array}}}$$

B. Kuhn-Tucker method to the optimization of the EOQ model for Perishable products

The Kuhn-Tucker conditions are used to figure out a solution to a nonlinear optimization problem with constraints. The Lagrange Method is used to develop the Kuhn-Tucker conditions.

Assume the situation is given by

Minimize x = f (y)

Subject to g_i (y) $\geq 0, i = 1,2, \dots . n$

Constraints on non-negativity y ≥ 0, if any, it will include in the n constraints.

Using nonnegative surplus variables, the inequality constraints can be converted into equations. Let P_i^2 be the surplus quantity added to the i^{th} constraints g_i (y) ≥ 0.

Let $\theta = (\theta_1, \theta_2, \dots \dots \dots, \theta_n), g(y) = (g_1(y), g_2(y), \dots \dots \dots, g_n(y)$

&$P_2 = (P_1^2, P_2^2, P_n^2)$

The Kuhn – Tucker conditions require k and h to be the minimization problem's stable endpoints.

$$\left\{\begin{array}{c}\theta \leq 0 \\ \nabla f\,(y) - \theta\,\nabla g\,(y) = 0, \\ \theta_i g_i(y) = 0, \quad i = 1,2, \dots \dots n \\ g_i(y) \geq 0, i = 1,2, \dots \dots n\end{array}\right\}$$

1) Crisp sense of Kuhn-Tucker method to the optimization of the EOQ model for Perishable products

Consider,

The integrated total cost of Inventory Model is

$$TP = \frac{Tp(a - bp + k\lambda)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a - bp + k\lambda)$$

Now we differentiate partially with respect to T

$$\frac{\partial TP}{\partial T} = \frac{p(a-bp+k\lambda)I_e}{2} - \frac{O}{T^2} - \frac{C}{T^2}(a-bp+k\lambda)$$

and equate it to zero, then we obtain the crisp quantity

$$Put\ \frac{\partial TP}{\partial T} = 0,$$

$$T = \sqrt{\frac{2\big(O + C(a-bp+k\lambda)\big)}{p(a-bp+k\lambda)I_e}}$$

By applying our total cost in this formula. Taking 'p' and 'λ' are fuzzy parameter

$$TP(T) = \frac{1}{8}\begin{pmatrix} \frac{Tp_1\mu_1(a-bp_1+k\lambda_1)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_1+k\lambda_1) \\ +2\left(\frac{Tp_2\mu_2(a-bp_2+k\lambda_2)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_2+k\lambda_2)\right) \\ +2\left(\frac{Tp_3\mu_3(a-bp_3+k\lambda_3)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_3+k\lambda_3)\right) \\ +2\frac{Tp_4\mu_4(a-bp_4+k\lambda_4)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_4+k\lambda_4) \\ +\frac{Tp_5\mu_5(a-bp_5+k\lambda_5)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_5+k\lambda_5) \end{pmatrix}$$

By differentiating these equation with respect to T

$$T = \sqrt{\frac{\begin{matrix} 2(O + C(a-bp_1+k\lambda_1)\mu_1) + 4(O + C(a-bp_2+k\lambda_2)\mu_2) \\ +4(O + C(a-bp_3+k\lambda_3)\mu_3) + \\ +4(O + C(a-bp_4+k\lambda_4)\mu_4) + 2(O + C(a-bp_5+k\lambda_5)\mu_5) \end{matrix}}{\begin{matrix} p_1(a-bp_5+k\lambda_5)I_e + 2p_2(a-bp_4+k\lambda_4)I_e \\ +2p_3(a-bp_3+k\lambda_3)I_e + 2p_4(a-bp_2+k\lambda_2)I_e + p_5(a-bp_1+k\lambda_1)I_e \end{matrix}}}$$

2) Fuzzy sense of Kuhn-Tucker method to the optimization of the EOQ model for Perishable products

Taking 'p' and 'λ' are fuzzy parameter

$$T = \sqrt{\frac{\begin{matrix} 2(O + C(a-bp_1+k\lambda_1)\mu_1) + 4(O + C(a-bp_2+k\lambda_2)\mu_2) \\ +4(O + C(a-bp_3+k\lambda_3)\mu_3) + \\ +4(O + C(a-bp_4+k\lambda_4)\mu_4) + 2(O + C(a-bp_5+k\lambda_5)\mu_5) \end{matrix}}{\begin{matrix} p_1(a-bp_5+k\lambda_5)I_e + 2p_2(a-bp_4+k\lambda_4)I_e \\ +2p_3(a-bp_3+k\lambda_3)I_e + 2p_4(a-bp_2+k\lambda_2)I_e + p_5(a-bp_1+k\lambda_1)I_e \end{matrix}}}$$

By differentiating these equation with respect to T

$$TP(T) = \frac{1}{8}\begin{pmatrix} \frac{Tp_1\mu_1(a-bp_1+k\lambda_1)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_1+k\lambda_1) \\ +2\left(\frac{Tp_2\mu_2(a-bp_2+k\lambda_2)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_2+k\lambda_2)\right) \\ +2\left(\frac{Tp_3\mu_3(a-bp_3+k\lambda_3)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_3+k\lambda_3)\right) \\ +2\frac{Tp_4\mu_4(a-bp_4+k\lambda_4)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_4+k\lambda_4) \\ +\frac{Tp_5\mu_5(a-bp_5+k\lambda_5)I_e}{2} + \frac{O}{T} + \frac{C}{T}(a-bp_5+k\lambda_5) \end{pmatrix}$$

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$$T* = \sqrt{\frac{2(O + C(a - bp_5 + k\lambda_5)\mu_1) + 4(O + C(a - bp_4 + k\lambda_4)\mu_2) + 4(O + C(a - bp_3 + k\lambda_3)\mu_3) + 4(O + C(a - bp_2 + k\lambda_2)\mu_4) + 2(O + C(a - bp_1 + k\lambda_1)\mu_5)}{p_1(a - bp_1 + k\lambda_1)I_e + 2p_2(a - bp_2 + k\lambda_2)I_e + 2p_3(a - bp_3 + k\lambda_3)I_e + 2p_4(a - bp_4 + k\lambda_4)I_e + p_5(a - bp_5 + k\lambda_5)I_e}}$$

The mathematical calculations and tables of Neutrosophic Inventory Model are as follows:

Table 1 Optimal order quantity for Inventory Model -Using Lagrangian method

Demand	Optimal order quantity	Deficient items
6	1.0065	38
7	1.0063	39
8	1.0062	40
9	1.0061	41
10	1.0059	50
11	1.0056	55
12	1.0045	67
13	1.0036	79
14	1.0021	89
15	0.0098	92
16	0.0078	105

Table 2 Optimal order quantity for Inventory Model -Using Kuhn- Tucker method

Demand	Optimal order quantity	Deficient items
6	1.00651	38
7	1.00632	39
8	1.00621	40
9	1.00612	41
10	1.00593	50
11	1.00565	55
12	1.00456	67
13	1.00362	79
14	1.00212	89
15	0.00982	92
16	0.00786	105

This part analyses the best order amount for the following sets: The findings are compared graphically.

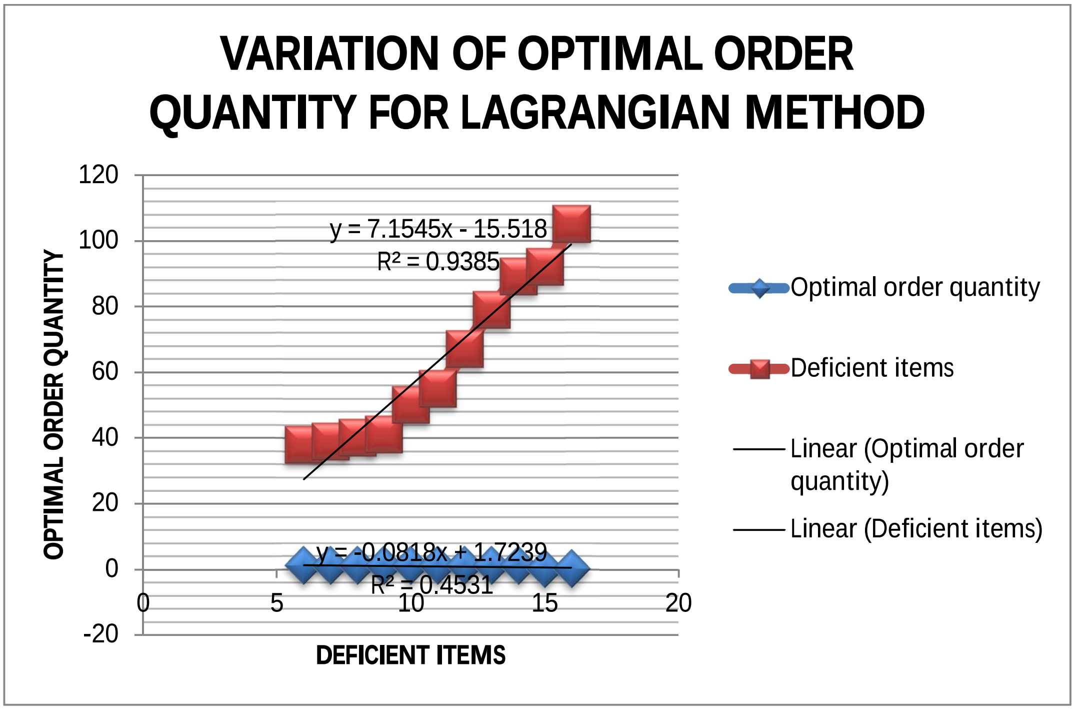
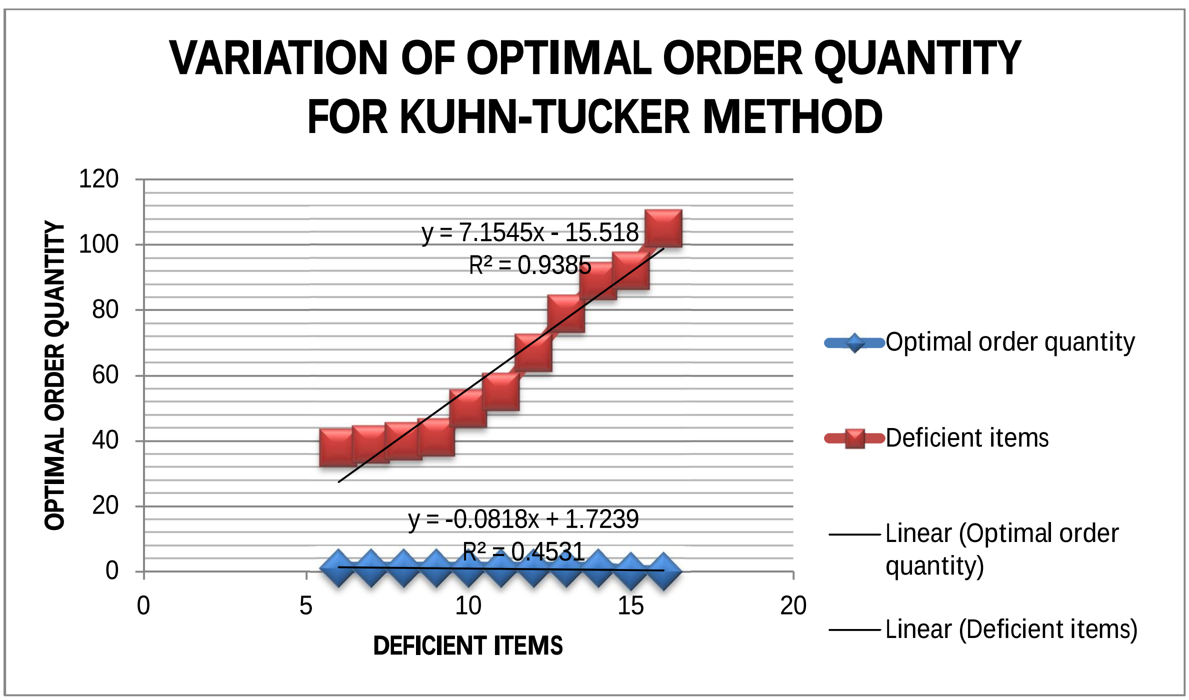


Figure1. Sensitivity Analysis by Lagrangian method.



According to the above-mentioned research, a fuzzy solution offers the better answer for the ideal order amount when compared to a crisp one for both the Lagrangian and Kuhn-Tucker methods. The ideal order amount is better addressed by the trapezoidal method than by the alternative approach, and both methods also produce results that are similar. Figures 1 and 2 show the minimal order amount as the ideal order quantity.

V. MATLAB PROGRAMMING

A three-dimensional surface plot, or three-dimensional surface with solid edge and solid face colours, is produced by the function surf(X,Y,Z). In the x-y plane defined by X and Y, the function depicts the values in matrix Z as heights above a grid. Depending on the Z-specified heights, the surface's colour changes.

```
[X,Y] = meshgrid(6:0.10:10,30:50);
Z = sin(X) + cos(Y);
surfc(X,Y,Z)
```

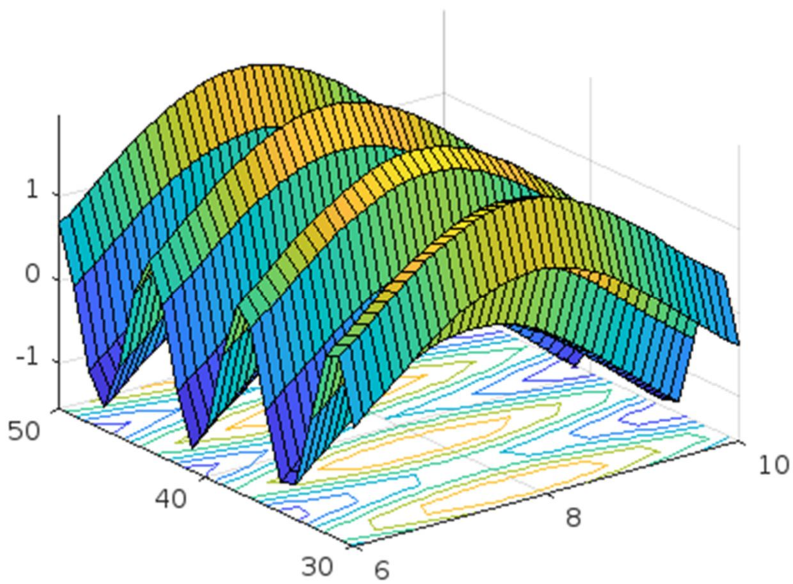


Figure 3: Surface 3D plot of both Lagrangian & Kuhn-Tucker method to the optimization of the EOQ model for Perishable products

VI. CONCLUSION

The Kuhn-Tucker and Lagrange methods are both taken into account in this work. When the ordering amount, reorder point, and quantity of shipments are all maximized, the supply chain's overall expected cost is decreased. Production and inventory including defectives have both been considered. According to carbon policies, it has been found that both the cost and defectives can be under control with a few operational adjustments. This model could help businesses choose the appropriate order quantity, reorder point, and number of shipments. The similarities and numerical results have both been examined. From an economic and environmental perspective, the study has shown that the right Matlab contour plot between surface plots of this strategy is valid. According to the mentioned earlier research, a fuzzy solution offers the more accurate answer for the perfect order amount compared to a crisp one for both the Lagrangian as well as Kuhn-Tucker methods. The suitable order amount is more effectively addressed by a trapezoidal method compared with the alternatives approach, and both procedures also produce similar results. The Matlab program graph shows the minimal order quantity as the ideal order quantity.

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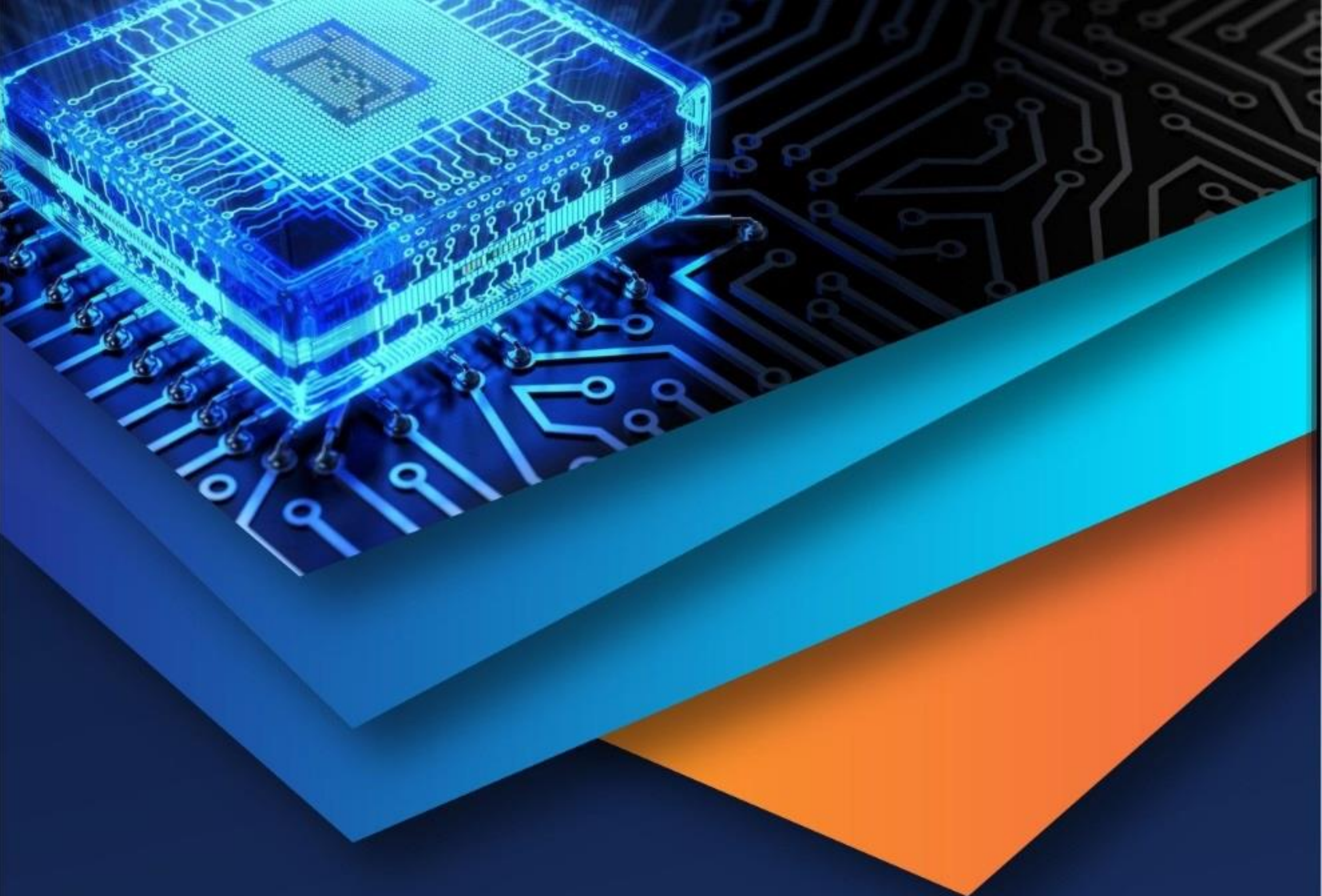

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