# Improve of A Fuzzy Inventory Model Using Triangular Fuzzy Numbers and Fractal Interpolation

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**Abstract.** The Inventory models can be used to plan the optimal inventory of a product. Several factors that influence the inventory model include demand parameters, prices and costs related to inventory. In special cases, the values of these parameters are uncertain. The fuzzy numbers can be used to express inventory parameters with uncertainty. One of the approach techniques for determining fuzzy parameters is the interpolation technique. This research developed a fractal interpolation technique with an interpolation function constructed from the Sierspinski Carpet. The level of interpolation accuracy is determined by Mean Percentage Absolute Error (MAPE). Economic Order Quantity EOQ model is used to determine optimal inventory. Obtained a MAPE value of 7.15% in the very good category. The optimal inventory, safety stock and reorder points are 14197.49 tons, 2894.87 tons and 4654.669 tons, respectively.

**Keywords**: Inventory, Fuzzy Numbers, Carpet Sierspinski

## 1 Introduction

Inventory planning is a crucial in production, distribution, and trade activities. Planning is carried out to ensure the availability of products in fulfilling consumer demand. Inventory models can be applied to inventory planning activities. In inventory systems, operational policies related to product storage control are established, such as determining the maximum inventory level, the timing of ordering, and stock-out time, to minimize the total ordering cost. Inventory and resolution research methods has been extensively developed and applied in various fields. Inventory issues with payment system variations [1]. Algebraic methods for solving inventory models [2]. The application of inventory concepts in the inventory of food products [3], the application of inventory concepts in the field of aviation logistics inventory

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[4]. Optimization of the red chili inventory system using a probabilistic fuzzy inventory model [5].

One inventory model that can be utilized is the Economic Order Quantity (EOQ) model. Considering demand parameters, the EOQ inventory model can be applied to inventory optimization problems to obtain the optimal inventory quantity and reorder time. The following presents research on inventory issues using the EOQ model. Inventory problems are investigated using the EOQ model with nonlinear constraints [6]. Research related to inventory issues employs the EOQ model, considering factors such as the damage rate and inventory dependent on demand [7]. The application of the EOQ model with demand assumed as a nonlinear function [6]. One factor influencing inventory levels is demand. In some cases, demand for a product may not be constant in every inventory period. Therefore, a technique is needed to determine the demand level. Interpolation techniques can be used to obtain approximate values for demand parameters by considering specific value intervals. Interpolation techniques are developed in two ways, namely numerically and fractually.

Studies on numerical interpolation and its application in various fields have been widely conducted [8], [9], [10], [11], [12], [13]. In addition to the mentioned interpolation methods, interpolation using the fractal concept has been extensively developed and applied in various fields. Interpolation using the fractal concept is called fractal interpolation. The use of fractal interpolation in time series data was introduced by [14]. The application of fractal interpolation in Covid-19 data [15]. Fractal interpolation is also applied to seismic data by introducing a scaling factor [16]. In fractal interpolation, variations in vertical scaling factors and the choice of Fractal Interpolation Function (FIF) will affect the interpolation results [17], [18]. In the study [17], a fractal interpolation technique was developed with variations in vertical scaling factors and applied to rice inventory data. The interpolation results obtained were categorized as very good. In fractal interpolation, the choice of FIF also influences the interpolation results. This study developed a fractal interpolation technique with FIF constructed from the Sierpinski Carpet.

The interpolated data results are approximations; therefore, deterministic approaches are not precisely applicable. Fuzzy, probabilistic, and stochastic approaches can be employed for uncertainty parameters. One inventory model that can be used with uncertainty is the Economic Order Quantity (EOQ) model with fuzzy parameters, referred to as the Fuzzy EOQ (FEOQ) model. The following presents research related to the application of the FEOQ model. The FEOQ model was developed by [19], with demand parameters expressed in terms of cloudy fuzzy logic. The Fuzzy EOQ (FEOQ) inventory model with demand parameters expressed as fuzzy numbers and defuzzification technique using Graded Mean Integration is discussed by [20]. The FEOQ model, considering discount proportion factors, is presented in [21]. The solution procedure for the FEOQ model is provided by [22]. Trapezoidal [23], Pentagonal [24], and Hexagonal [25] fuzzy numbers can be used as fuzzy parameters in inventory models. This study develops a fuzzy inventory model using triangular fuzzy numbers (TFN).

## 2 Research Methodology

In this research, a fuzzy inventory model was developed and expressed by TFN. This article also introduces the application of fractal interpolation to determine the approximate value of rice demand parameters in the fuzzy inventory model. Below are the stages of solving inventory optimization problems using a fuzzy inventory model with the development of interpolation techniques.

### 2.1 Data

The data used in this research is rice inventory data from research [17], consists of data on prices, demand and costs related to rice inventory. Fuzzy demand parameters are determined using fractal interpolation techniques. The data is expressed in TFN by considering the highest, lowest and average data. The next stage is the defuzzification process using the mean integration technique. In the defuzzification stage, the TFN are transformed into crisp numbers and used as parameters in the inventory model.

### 2.2 Fractal Interpolation and Fuzzy Inventory Model

This paper introduces a fractal interpolation where the fractal interpolation function (FIF) is constructed from the Sierspinski Carpet. Below are Equation (1) to (8) of Sierspinski Carpet as FIF, $\{R^2; w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8\}$, $w_i, i = 1,2,\cdots,8$ are functions in two-dimensional space.

$$w_1\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}0\\0\end{bmatrix} \tag{1}$$

$$w_2\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}0\\\frac{1}{3}\end{bmatrix} \tag{2}$$

$$w_3\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}0\\\frac{2}{3}\end{bmatrix} \tag{3}$$

$$w_4\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}\frac{1}{3}\\\frac{2}{3}\end{bmatrix} \tag{4}$$

$$w_5\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}\frac{2}{3}\\\frac{2}{3}\end{bmatrix} \tag{5}$$

$$w_6\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}\frac{2}{3}\\\frac{1}{3}\end{bmatrix} \tag{6}$$

$$w_7\begin{bmatrix}x\\y\end{bmatrix} = \begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix} + \begin{bmatrix}\frac{2}{3}\\0\end{bmatrix} \tag{7}$$

$$w_8\begin{bmatrix}x\\y\end{bmatrix}=\begin{bmatrix}\frac{1}{3} & 0\\0 & \frac{1}{3}\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix}+\begin{bmatrix}\frac{1}{3}\\0\end{bmatrix} \tag{8}$$

Interpolation techniques are used to determine demand approximation values as part of the inventory planning process. Next, the interpolation results are expressed in the form of TFN and transformed into crisp numbers with the following Equation (9).

$$P(A)=\frac{\int_0^1 \frac{h}{2}\left(L^{-1}(h)+R^{-1}(h)\right)dh}{\int_0^1 h\,dh} \tag{9}$$

The results of the defuzzification process are used as parameter values in the inventory model. The model used is the inventory model [24].

## 3 Result and Discussion

There are two discussions in this paper. The first is the developing an interpolation technique using the Sierspinski Carpet and its application to rice supply data. The second is the development of a fuzzy inventory model with TFN. Then, interpolation techniques and fuzzy models are applied to the rice inventori planning problem.

### 3.1 Fractal Interpolation

Based on price and demand data for rice in research [17], consists of data on prices, demand and costs related to rice inventory. Fuzzy demand parameters, conditions were determined as the initial set. The initial condition considered by lowest price, highest price and average. Let the initial conditions $(10000{,}3138678.5)$, $(12000{,}362400)$, $(10400{,}1449570)$, and dummy $(11600{,}2051509)$. The aim of selecting a dummy is to make the initial shape formed is a symmetrical shape. Below is **Figure 1.** as the initial condition for fractal interpolation.

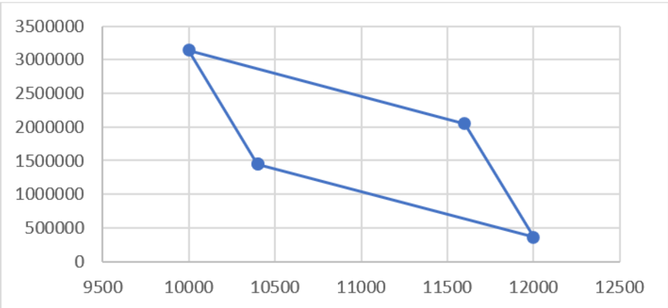


**Fig. 1.** Initial Condition Null Iteration

**Figure 1.** is a visualization based on the initial conditions given. Visualization of **Figure 1**. using Ms. Excel. The first iteration interpolation calculation, the horizontal $x$ axis is the price variable and the vertical $y$ axis is the demand variable. The next stage is to determine the distance from each pair of points.

$$d_1 = |x_2 - x_1| = |10000 - 10400| = 400$$
$$d_2 = |x_4 - x_1| = |12000 - 10400| = 1600$$
$$d_3 = |x_3 - x_2| = |11600 - 10000| = 1600$$
$$d_4 = |x_4 - x_3| = |12000 - 11600| = 400$$
$$d_5 = |x_3 - x_1| = |11600 - 10400| = 1200$$
$$d_6 = |x_4 - x_2| = |12000 - 10000| = 2000$$
$$d_7 = |y_2 - y_1| = |3138678.5 - 1449570| = 1689109$$
$$d_8 = |y_4 - y_1| = |362400 - 1449570| = 1087170$$
$$d_9 = |y_3 - y_2| = |2051509 - 3138678.5| = 1087170$$
$$d_{10} = |y_4 - y_3| = |362400 - 2051509| = 1689109$$
$$d_{11} = |y_3 - y_1| = |2051509 - 1449570| = 601939$$
$$d_{12} = |y_4 - y_2| = |362400 - 3138678.5| = 2776279$$

The calculation continues by determining the interpolation value using FIF (1) to (8) for each initial condition.

$$f_1(x_1, y_1) = (x_1, y_1) = (10400{,}1449570)$$
$$f_1(x_2, y_2) = \left(x_1 - \frac{1}{3}|x_2 - x_1|, y_1 + \frac{1}{3}|y_2 - y_1|\right) = (10267{,}2012606)$$
$$f_1(x_3, y_3) = \left(x_3 - \frac{2}{3}|x_3 - x_1|, y_3 - \frac{2}{3}|y_3 - y_1|\right) = (10800{,}1650216)$$
$$f_1(x_4, y_4) = \left(x_4 - \frac{2}{3}|x_4 - x_3|, y_4 + \frac{2}{3}|y_4 - y_3|\right) = (10933.3{,}1087180)$$
$$f_2(x_1, y_1) = f_1(x_2, y_2) = (10267{,}2012606)$$
$$f_2(x_2, y_2) = (10133{,}2575642)$$
$$f_2(x_3, y_3) = (10667{,}2213252)$$
$$f_2(x_4, y_4) = f_1(x_3, y_3) = (10800; 1650216)$$
$$f_3(x_1, y_1) = f_2(x_2, y_2) = (10133{,}2575642)$$
$$f_3(x_2, y_2) = (x_2, y_2) = (10000{,}3138678.5)$$
$$f_3(x_3, y_3) = (10533{,}2213252)$$
$$f_3(x_4, y_4) = f_2(x_3, y_3) = (10667{,}2213252)$$
$$f_4(x_1, y_1) = f_3(x_4, y_4) = (10667{,}2213252)$$
$$f_4(x_2, y_2) = f_3(x_3, y_3) = (10533{,}2213252)$$
$$f_4(x_3, y_3) = (11067{,}2413899)$$
$$f_4(x_4, y_4) = (11200{,}1850862)$$
$$f_5(x_1, y_1) = f_4(x_4, y_4) = (11200{,}1850862)$$
$$f_5(x_2, y_2) = f_4(x_3, y_3) = (11067{,}2413899)$$
$$f_5(x_3, y_3) = (x_3, y_3) = (11600{,}2051509)$$
$$f_5(x_4, y_4) = (11733{,}1488472)$$
$$f_6(x_1, y_1) = (11333{,}1287826)$$
$$f_6(x_2, y_2) = f_5(x_1, y_1) = (11200{,}1850862)$$
$$f_6(x_3, y_3) = f_5(x_4, y_4) = (11733{,}1488472)$$
$$f_6(x_4, y_4) = (11867{,}925436)$$
$$f_7(x_1, y_1) = (11467{,}724790)$$
$$f_7(x_2, y_2) = f_6(x_1, y_1) = (11333{,}1287826)$$
$$f_7(x_3, y_3) = f_6(x_4, y_4) = (1186{,}925436)$$
$$f_7(x_4, y_4) = (x_4, y_4) = (12000{,}362400)$$
$$f_8(x_1, y_1) = f_1(x_4, y_4) = (10933.3{,}1087180)$$
$$f_8(x_2, y_2) = f_1(x_3, y_3) = (10800{,}1650216)$$

$$f_8(x_3, y_3) = f_7(x_2, y_2) = 11333{,}1287826)$$
$$f_8(x_4, y_4) = f_7(x_1, y_1) = (11467{,}724790)$$

The visualization of the calculation results for 1st iteration given in **Figure 2** below.

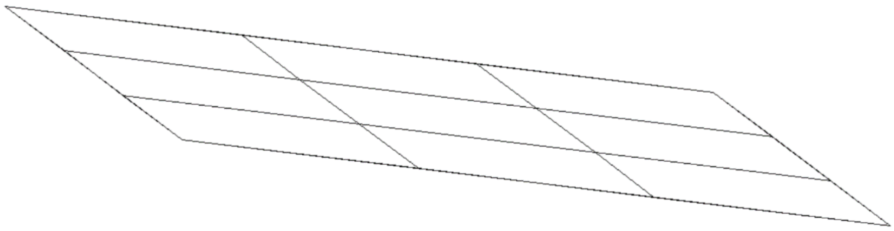

**Fig. 2.** The First Iteration

The iteration process is continued until the expected level of accuracy is obtained. In this research, calculations were carried out up to the $6^{th}$ iteration. In the $5^{th}$ and $6^{th}$ iterations, the MAPE values were obtained at 11.37% and 7.15% and included in the very good category. Below is **Figure 3**, which is a visualization of the 6th iteration. The interpolation results of the $5^{th}$ and $6^{th}$ iterations are given in Table 1.

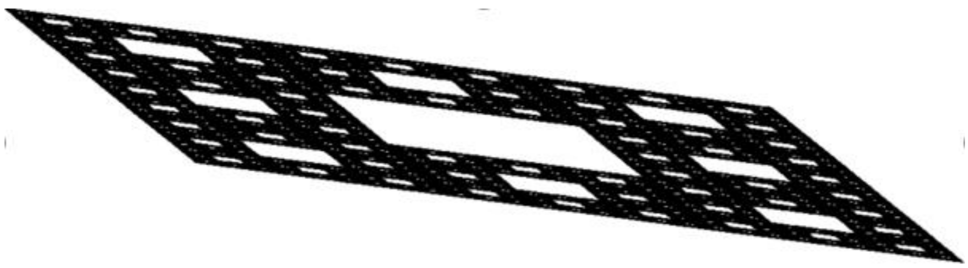

**Fig. 3.** The $6^{th}$ Iteration

**Table 1.** Fractal Interpolation $5^{th}$ and $6^{th}$ Iteration

| Data $n$ | demand ($y$) | Fractal Interpolation $5^{th}$ | Fractal Interpolation $6^{th}$ |
|---|---|---|---|
| 1 | 1877819 | 1865446.072 | 1878682.587 |
| 2 | 1512299 | | 2501497.653 |
| 3 | 1177733 | 1183610.076 | 1181293.055 |
| 4 | 1405435 | 1490140.364 | 1461350.313 |
| 5 | 2419069 | 2169347.778 | 2187218.335 |
| 6 | **362400** | **362400** | **362400** |
| 7 | 1966169 | 2082116.805 | 2079799.783 |
| 8 | 1848084 | 1842115.767 | 1842115.767 |
| 9 | **1449570** | **1449570** | **1449570** |
| 10 | 923049 | 923515.0638 | 923515.0638 |

| | | | |
|---|---|---|---|
| 11 | 2119598 | 2148038.309 | 2111471.489 |
| 12 | **3138678.5** | **3138678.5** | **3138678.5** |

In the 1st iteration, each initial condition will be mapped by the functions $f_1, f_2, f_3, f_4, f_5, f_6, f_7$, dan $f_8$ so that 8 new similar rectangles are obtained and 32 pairs of interpolation point. The 2nd iteration, 64 similar rectangles are obtained and 256 pairs of interpolated points were obtained. So, in the $n$ iteration we will get $8^n$ rectangles and $4.8^n$ pairs of interpolated point.

**3.2 Fuzzy Inventory Model**

In this section, a fuzzy inventory model is developed using TFN. Given TFN $\widetilde{A} = (a, b, c)$, where $a, b, c \in \mathbb{R}$, $L^{-1}(h) = a + (b - a)h$ and $R^{-1}(h) = c - (c - b)h$, using (9) is obtained.

$$P(A) = \frac{\frac{1}{2}\int_0^1 h(a + (b - a)h + c - (c - b)h\ )\ dh}{\int_0^1 h\ dh} = \frac{1}{6}(a + 4b + c)$$

Let TFN $\widetilde{D} = (d_1, d_2,\ d_3)$, $\widetilde{C_0} = (c_{01}, c_{02}, c_{03})$, $\widetilde{C_h} = (c_{h1}, c_{h2}, c_{h3})$. Developing the inventory model [24] with TFN, the optimal inventory formula is obtained in Equation (10) below.

$$TC = \frac{1}{6}\left(\frac{(c_{01}d_1 + 4c_{02}d_2 + c_{03}d_3)}{Q} + \frac{(c_{h1} + 4c_{h2} + c_{h3})Q}{2}\right) \quad (10)$$

$$Q^* = \sqrt{\frac{2(c_{01}d_1 + 4c_{02}d_2 + c_{03}d_3)}{c_{h1} + 4c_{h2} + c_{h3}}} \quad (11)$$

Where

$\widetilde{D}$ =fuzzy parameter for demand
$\widetilde{C_0}$ = fuzzy parameter for ordering cost
$\widetilde{C_h}$ = fuzzy parameter for holding cost
$TC$ = total cost (Rupiah)
$Q^*$ = optimal inventory (tons)

Based on the data in (18), the TFN of the fuzzy parameters is determined as follows.
$\widetilde{D} = (443458987.4, 443459729.4, 443460471.369), D = 443459729.4$
$\widetilde{C_0} = (6100000, 6500000, 6700000), C_0 = 6500000$
$\widetilde{C_h} = (27000000, 28680828, 29000000), C_h = 28680828$
Using Equation (11), the optimal annual demand is 14197.49 tons and safety stock 2894,87 tons. Total annual inventory is 17092.36.

## 4 Conclusion

Based on the results and discussion it can be concluded that The FIF constructed from the Sierspinski Carpet can be applied as a Fractal Interpolation Function in the fractal interpolation method. Based on data, the level of accuracy obtained is influenced by the number of iterations. The higher the iteration, the higher the level of accuracy. The specified fuzzy number greatly influences the Optimal Inventory Amount. The FIF influences fractal interpolation results. In this study, the FIF of Sierspinski Carpet is an affine function. A fractal interpolation technique can be developed with FIF non-affine function for further research.

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## References

[1] Sanni, S., Neill, B.O.: Inventory optimisation in a three-parameter Weibull model under a prepayment system. Computers & Industrial Engineering. Vol. 128, pp. 298–304 (2019)

[2] Luo, X., Chou, C.: Solving inventory models by algebraic method. International Journal of Production Economics Technical. pp.130–133 (2018)

[3] Aka, S., Akyüz, G.: An inventory and production model with fuzzy parameters for the food sector. Sustainable Production and Consumption, Vol. 26, pp. 627–637 (2021)

[4] Kenzhevayeva, Z., Katayeva, A., Kaikenova, K., Sarsembayeva, A., Babai, M.Z., Tsakalerou, M. et al.: Inventory control models for spare parts in aviation logistics. Procedia Manufacturing. Vol. 55, pp. 507–512 (2021)

[5] Susanti, E., Sitepu, R., Ondhiana, K., Wulandari, W.D.: Optimization of inventory level using fuzzy probabilistic exponential two parameters model. Jurnal Matematika MANTIK. Vol. 7, No. 2, pp.124–131 (2021)

[6] Cárdenas-barrón, L.E., Shaikh, A.A., Tiwari, S., Treviño-garza, G.: An EOQ inventory model with nonlinear stock dependent holding cost, nonlinear stock dependent demand and trade credit. Computers & Industrial Engineering. Vol. 139 (2020)

[7] Shaikh, A.A., Khan, M.A.A., Panda, G.C., Konstantaras, I.: Price discount facility in an EOQ model for deteriorating items with stock-dependent demand and partial backlogging. International Transactions in Operational Research, Vol. 26, No. 4, pp.1365–1395 (2019)

[8] Geng, F., Wu, X.: Reproducing kernel functions based univariate spline interpolation. Applied Mathematics Letters. Vol. 122, (2021)

[9] Hasanipanah, M., Meng, D., Keshtegar, B., Trung, N.T., Thai, D.K.: Nonlinear models based on enhanced kriging interpolation for prediction of rock joint shear strength. Neural Computing and Applications. Vol. 33, No. 9, pp. 4205–4215 (2021)

[10] Tayebi, S., Momani, S., Abu Arqub, O.: The cubic b-spline interpolation method for numerical point solutions of conformable boundary value problems. Alexandria

Engineering Journal. Vol. 61, No. 2, pp. 1519–1528 (2022)
[11] Lamberti, P., Saponaro, A.: Multilevel quadratic spline quasi-interpolation. Applied Mathematics and Computation. Vol. 373 (2020)
[12] Gandha, G.I., Nurcipto, D.: The newton's polynomials interpolation based-error correction method for low-cost dive altitude sensor in remotely operated underwater vehicle (ROV). Jurnal Infotel. Vol. 11, No. 1 (2019)
[13] Zou, L., Song, L., Wang, X., Weise, T., Chen, Y., Zhang, C.: A new approach to newton-type polynomial interpolation with parameters. Mathematical Problems in Engineering. Vol. 2020, pp. 1-15 (2020)
[14] Raubitzek, S., Neubauer, T.: A fractal interpolation approach to improve neural network predictions for difficult time series data. Expert Systems with Applications. Vol. 169 (2021)
[15] Păcurar, C.M., Necula, B.R.: An analysis of COVID-19 spread based on fractal interpolation and fractal dimension. Chaos, Solitons and Fractals. Vol. 139 (2020)
[16] Ochoa, H., Almanza, O., Montes, L.: Fractal-interpolation of seismic traces using vertical scale factor with residual behavior. Journal of Applied Geophysics. Vol. 182 (2020)
[17] Susanti, E., Puspita, F.M., Supadi, S.S., Yuliza, E., Ramadhan, A.F.: Improve fuzzy inventory model of fractal interpolation with vertical scaling factor. Science and Technology Indonesia. Vol. 8, No. 4, pp. 655–659 (2023)
[18] Ri, S: A new nonlinear fractal interpolation function. Fractals. Vol. 25, No. 6, pp. 1–12 (2017)
[19] Maity, S., De, S.K., Mondal, S.P.: A study of an EOQ model under lock fuzzy environment. Mathematics. Springer Singapore. pp. 149–163 (2019)
[20] Kalaiarasi, K., Gopinath, R.: Fuzzy Inventory EOQ Optimization Mathematical Model. International Journal of Electrical Engineering and Technology. Vol. 11. No. 8, pp. 169–174 (2020)
[21] Patro, R., Nayak, M.M., Acharya, M.: An EOQ model for fuzzy defective rate with allowable proportionate discount. Opsearch. Vol. 56, No. 1, pp. 191–215 (2019)
[22] De, S.K.: Solving an EOQ model under fuzzy reasoning. Applied Soft Computing. Vol. 99 (2021)
[23] Kalaiarasi, K., Sumathi, M., Henrietta, H.M., Raj, A.S.: Determining the efficiency of fuzzy logic EOQ inventory model with varying demand in comparison with lagrangian and kuhn-tucker method through sensitivity analysis. Computer Science and Engineering. Vol. 1, No. 1, pp. 1–12 (2020)
[24] Onyenike, K., Ojarikre, H.I.: A study on fuzzy inventory model with fuzzy demand with no shortages allowed using pentagonal fuzzy numbers. International Journal of Innovative Science and Research Technology, Vol. 7, No. 3, pp. 7–11 (2022)
[25] Chakraborty, A., Maity, S., Jain, S., Mondal, S.P., Alam, S.: Hexagonal fuzzy number and its distinctive representation, ranking, defuzzification technique and application in production inventory management problem. Granular Computing. Vol. 6, No. 3, pp. 507–521 (2021)