International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 478-481 ISSN: 3048-6874
www.ijhssm.org

A Fuzzy Geometric Programming Approach for an EOQ model with carbon emissions by using trapezoidal fuzzy numbers

[1] ALDA.W. S, [2] REXLIN JEYAKUMARI. S
[1]Research Scholar, [2]Assistant Professor, Department of Mathematics,
Holy Cross College (Autonomous), Affiliated to Bharathidasan University, Trichy-620 002, India

Date of Submission: 20-05-2025 Date of Acceptance: 01-06-2025

Abstract:
Concentrating on the emission of carbon from industries to the environment is the notable criteria in the world focusing on sustainability. Economic Order Quantity(EOQ) models takes a special attention in this to speak about green features in the inventory supply chain system to develop a green inventory model with analyzation of carbon emission. In addition to green environment, tackling unpredictability and founding optimal solution in the inventory system among several parameters is the most needed fact since this situation make a stuck to take correct decision and to optimize the business. Fuzzy can play a major role to come out from this issue. Hence this model discusses a green inventory model with the incorporation of fuzzy methodology in a way by choosing three parameters as trapezoidal fuzzy numbers and solving the system by applying fuzzy geometric programming approach. A Numerical Analysis is provided to discuss the result.

Keywords: Fuzzy Geometric Programming, Trapezoidal fuzzy numbers and carbon emission.

I. Introduction:

TraditionalEconomic Order Quantity models with the consideration of emission of carbontake into account how inventory management choices affect the environment. When determining the ideal order amount to save overall expenses, these models take into account variables such as carbon emissions from production, storage, and transportation.This strategy aids companies in striking a balance between sustainability objectives and economic efficiency. The model's objective function is to reduce the overall cost, encompassing both environmental and economical expenses. Both cost and emissions of carbon can influence demand, and the mathematical framework can take into consideration how carbon dioxide emission effect demand. These approaches support sustainability initiatives and assist companies in lowering their carbon footprint. Businesses may have a competitive edge over their competitors if they use sustainable methods, such as inventory management that considers carbon emissions. Conceptualization and implementation of a sustainable EOQ model is developed by Battini et al in 2014. In their model, they studied that compared to more conventional methods, the optimization methodology is used to evaluate the influence of sustainability factors on purchases using representative information from manufacturing situations.Bazan et al in 2015 analysed the impact of energy and carbon emissions on inventory models for manufacturing and remanufacturing. A comparison of economic order quantity models incorporating emissions of carbon and just-in-time models is proposed by wang et al in 2018. Thus certain models specifically discussed about EOQ with carbon emissions.

In general uncertainty may happen in any cases of parameters in the green inventory system based on certain circumstances. The erratic character of client demand for an item or service, impacted by variables like as customer tastes, market movements, and prevailing economic situations, is known as demand uncertainty. It can affect profitability and customer happiness by causing outages or excessive stock and erroneous estimates. Profitability and supply chain resiliency depend on managing this volatility. Unpredictable changes in raw material supply, demand, quality, or price are referred to as raw material uncertainty. These changes can have an effect on a company's output, expenses, and revenue. As demand uncertainty and raw material uncertainty are needed to be rectified, fuzzy solution approaches can be implemented to get a clear outcome. Management of a green supply chain model with fuzzy demand and greenhouse gas emissions is developed by Noh et al in 2019. They considered uncertainty in demand and converted the demand as fuzzy parameter to solve the model. A carbon-emitting sustainable green supply chain model for faulty products being learned in a fuzzy setting is proposed by Alsaedi et al in 2023. An inventory model with effects of memory that incorporates greenhouse gas costs

International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 478-481 ISSN: 3048-6874
www.ijhssm.org

using fuzzy logic is analysed in 2024 by Pakhira et al where they have considered uncertainty in three parameters like for cost of ordering items, for demand and for deterioration rate and assumed them as triangular fuzzy numbers.

The inclusion of several green related costs speaks better in the process of initiating sustainability. Likewise, green devising cost is a cost which describes the price of developing or putting into action sustainable or eco-friendly projects or practices.The developed present model focuses on creating a fuzzy green EOQ model with carbon emissions and green devising cost using fuzzy geometric programming approach. Here three parameters are taken to be trapezoidal fuzzy numbers. And the solution is found using numerical data.

Definitions:

Fuzzy Set:
A fuzzy set $\tilde{A}$ defined on a Universe of discourse X may be written as a collection of ordered pairs,

$$\tilde{A} = \left\{(x,\mu_{\tilde{A}}(x)) : x \in X, \mu_{\tilde{A}} \in [0,1]\right\}$$

, where each pair $(x, \mu_{\tilde{A}}(x))$ is called a singleton and the element $\mu_{\tilde{A}}(x)$ belongs to the interval [0,1].The function $\mu_{\tilde{A}}(x)$ is called as membership function.

Trapezoidal Fuzzy Number:
The fuzzy number $\tilde{A} = (a_1, a_2, a_3, a_4)$,where $a_1 < a_2 < a_3 < a_4$ and defined on R is called the trapezoidal fuzzy number, if the membership function is given by,

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & : x < a_1 \text{ or } x > a_4 \\ \dfrac{(x-a_1)}{(a_2-a_1)} & : a_1 \le x \le a_2 \\ 1 & : a_2 \le x \le a_3 \\ \dfrac{(x-a_4)}{(a_3-a_4)} & : a_3 \le x \le a_4 \end{cases}$$

Assumptions:

- Green devising cost is included in the total cost of the green supply chain system.
- Uncertainties are found to be in the raw material cost for devising a product, in the demand and in the cost of holding items.
- Three parameters are considered using trapezoidal fuzzy numbers.

Notations:

Crisp Parameters:

D_i – demand.
C_h – cost of holding items.
S_c – cost of setting items.
a – first parameter related to carbon emissions.
b – second parameter related to carbon emissions.
c – third parameter related to carbon emissions.
G_D – green devising cost.
D_m – raw material cost for devising a product.
n – number of products.
Q_i – order quantity.
TC_{ci} – total cost.

Fuzzy Parameters:

$\tilde{D}_i$ – fuzzy demand.
$\tilde{C}_h$ – cost of holding items under fuzzy.
$\tilde{D}_m$ – raw material fuzzy cost for devising a product.
$\tilde{Q}_i^*$ – fuzzy optimum order quantity.
$\tilde{Q}_i^{*L}$ – fuzzy optimum order quantity in terms of left limit.
$\tilde{Q}_i^{*R}$ – fuzzy optimum order quantity in terms of right limit.

The Considered Green Inventory model:

The total cost of the considered green inventory model with the incorporation of green devising cost G_D is given by,

$$TC_{ci} = \frac{D_i}{Q_i} S_c + \frac{Q_i}{2} C_h + a\left(\frac{D_i}{Q_i} b + \frac{Q_i}{2} c\right) + G_D.$$

Here $G_D = D_m n$.

International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 478-481 ISSN: 3048-6874
www.ijhssm.org

Hence,

$$TC_{ci} = \frac{D_i}{Q_i} S_c + \frac{Q_i}{2} C_h + a\left(\frac{D_i}{Q_i} b + \frac{Q_i}{2} c\right) + D_m n.$$

-------------(1)

Differentiating eqn (1) with respect to Q_i and equating to zero gives an optimal order quantity and it is given by,

$$Q_i = \sqrt{\frac{2\left(D_i S_c + aD_i b\right)}{C_h + ac}}.$$

$$Q_i = \sqrt{\frac{2D_i\left(S_c + ab\right)}{C_h + ac}}$$

Solution procedure of the crisp green inventory model in Geometric programming technique:

The primal problem of TC_{ci} is given by,

$$\text{Min } TC_{ci}(Q_i) = \left(S_c + ab\right)\frac{D_i}{Q_i} + \frac{Q_i}{2}\left(C_h + ac\right) + D_m n.$$

And after applying the algorithm, we obtain

$$Q_i = \sqrt{\frac{2D_i\left(S_c + ab\right)}{C_h + ac}}.$$

Solution procedure of thefuzzy green inventory model by using Geometric programming technique:

Suppose $\tilde{D}_i$, $\tilde{C}_h$, $\tilde{D}_m$ are considered as trapezoidal fuzzy numbers, then the objective is to minimize the total cost, that is to find the optimum order quantity using geometric programming methodology.

Hence, we have to

$$\text{Min TC}_{ci}(Q_i) = \frac{\tilde{D}_i}{Q_i}\left(S_c + ab\right) + \frac{Q_i}{2}\left(\tilde{C}_h + ac\right) + \tilde{D}_m n.$$

After applying the fuzzy approach, we obtain the fuzzy optimum order quantities in the following forms,

$$\tilde{Q}_i^{*} = \sqrt{\frac{2\left(S_c + ab\right)\left(D_{i_L}, D_{i_R}\right)}{\left(\left(C_{h_L}, C_{h_R}\right) + ac\right)}},$$

$$\tilde{Q}_i^{*L} = \sqrt{\frac{2\left(S_c + ab\right)D_{i_L}}{\left(C_{h_R} + ac\right)}} \text{ and}$$

$$\tilde{Q}_i^{*R} = \sqrt{\frac{2\left(S_c + ab\right)D_{i_R}}{\left(C_{h_L} + ac\right)}}$$

Numerical Example:

Crisp Sense:

$D_i = 6000,\ C_h = 6,\ S_c = 2000,\ a = 40,$

$b = 0.5,\ c = 0.05,\ G_D = 180,\ D_m = 30,\ n = 6.$

Order Quantity, $Q_i = 1740.689519.$

Fuzzy sense:

$\tilde{D}_i = \left(5800, 5900, 6100, 6300\right),$

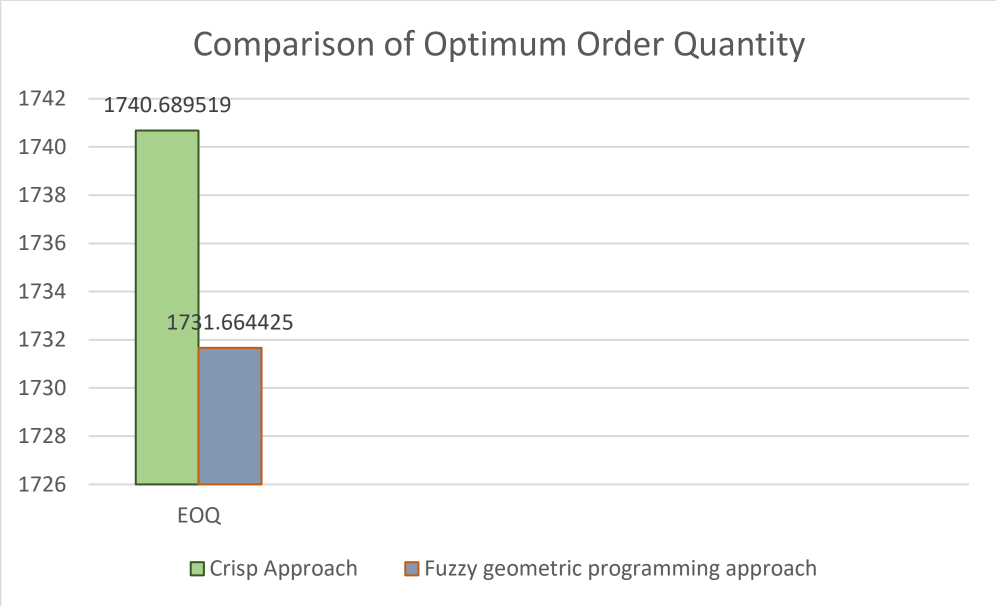
$\tilde{C}_h = \left(4, 5, 7, 10\right),\ \tilde{D}_m = \left(28, 29, 31, 32\right).$

Fuzzy optimum order quantity in terms of left limit, $\tilde{Q}_i^{*L} = 1500.285687.$

Fuzzy optimum order quantity in terms of right limit. $\tilde{Q}_i^{*R} = 1963.043163.$

Fuzzy optimum order quantity, $\tilde{Q}_i^{*} = 1731.664425.$

International Journal of Humanities Social Science and Management (IJHSSM)
Volume 5, Issue 3, May-June, 2025, pp: 478-481 ISSN: 3048-6874
www.ijhssm.org



II. Conclusion:

Business sectors focusing to create sustainable environment may incorporate certain ideas in their system of work for managing society and for optimizing their profit. Industries related to renewable energy, construction, food products preparation, automobiles, pharmaceuticals and health care in India mostly focuses on these environmental criteria based on the norms of government. While those industries are implementing such factors, they may face vagueness in many sort of parameters related to demand, raw materials, costs for carbon emissions and even in the expenses they spent in the supply chain process for each and every material they produce. So to find a solution for such cases, following the present model on carbon emissions, EOQ and fuzzy geometric programming approach helps them a lot. This model has solved a case of green EOQ in crisp and fuzzy senses and compared the results using diagrammatical representations. And on observing the results, solution obtained by fuzzy methodology has provided reduced and optimum outcome than compared to the result obtained by crisp way of solving the model.

References:

[1]. Battini, D., Persona, A., &Sgarbossa, F. (2014). A sustainable EOQ model: Theoretical formulation and applications. *International Journal of Production Economics*, *149*, 145-153.

[2]. Bazan, E., Jaber, M. Y., & El Saadany, A. M. (2015). Carbon emissions and energy effects on manufacturing–remanufacturing inventory models. *Computers & Industrial Engineering*, *88*, 307-316.

[3]. Wang, S., & Ye, B. (2018). A comparison between just-in-time and economic order quantity models with carbon emissions. *Journal of Cleaner Production*, *187*, 662-671.

[4]. Noh, J., & Kim, J. S. (2019). Cooperative green supply chain management with greenhouse gas emissions and fuzzy demand. *Journal of Cleaner Production*, *208*, 1421-1435.

[5]. Alsaedi, B. S., Alamri, O. A., Jayaswal, M. K., & Mittal, M. (2023). A sustainable green supply chain model with carbon emissions for defective items under learning in a fuzzy environment. *Mathematics*, *11*(2), 301.

[6]. Pakhira, R., Mondal, B., Thirthar, A. A., Alqudah, M. A., &Abdeljawad, T. (2024). Developing a fuzzy logic-based carbon emission cost-incorporated inventory model with memory effects. *Ain Shams Engineering Journal*, *15*(6), 102746.