

Fuzzy Inventory Model with Eco Friendly Package, Carbon Emission, Cap Policy and Life Cycle Assessment Technology

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ABSTRACT:

Environmental sustainability has turn out to be more famous in recent years. It is to observe about environmental interactions to count on environmental declination. In addition, global warming is one of the major threats in our day to day lifestyles. Because of this global warming greenhouse gases takes place .GHG occurs particularly through human activities like combustion of fossil fuels in factories ,power plants etc. Also, it increases carbon emissions that absorb heat energy which is emitted from earth surface. Supply chain sustainability is affecting an employer deliver chain or logistics community and its far often related to an incorporating economic, social and environmental components .This paper investigates that the environmental pollutants to achieve sustainability , Green inventory model is used to achieve a minimum carbon emission using fuzzy logic. Fuzzy logic has been majorly used nowadays. It is applied to many fields, from control theory to artificial intelligence .Fuzzy logic is useful for minimizing the total cost, that is to reduce (GHG) emission through logistics activities.

INTRODUCTION:

Inventory is a stock of goods which cannot be provided to the market place on the market. Goyal in 1988 was setup a joint overall applicable costs for a single dealer overall applicable costs for a single dealer manufactured device in which he expected that the vendor's advent rate is endless. Goyal model depends on supposition that the seller could supply to the consumer truly within the wake of finishing the entire optical order length and the model changed into appeared to provide a lower or equal joint overall relevant costs. In order to maximize their advantage seller and purchase need to be in common comprehension and they are cooperating to perform the goal of the model.

Herman Hollerith is an American inventor, who invented the electromechanical tabulator for punch playing cards in 1880's. These cards are used for making very small holes in pieces of cardboard and it lets in the humans to list a number of the capabilities which includes stocks. After that, inventory management become generated by universal product code (UPC) in the year 1960, when current stock control systems began for use at the cease of 1990 as we got higher pc technology. Such high quality technologies used in recent times for the identification of ration frequencies which radiate the particulars containing the commercial enterprise associated with customers and the proprietor. It's by no means been less complicated to control your inventory in the twenty first century with a telephone stock app, while the prevailing and future stock management are each interesting to announce the extraordinary deal about the history of the inventory.

Inventory is to save a raw materials for later we use whenever it is far required. Inventory has its very own beginning within the historical Greek and Roman societies by way of the development of stock management gadget. Inventory management is a look at of assets and inventory gadgets. It is the glide of Merchandise from manufactures to warehouses and then to the point of sale. It is a critical device to small groups in which it makes the method easies then trying to do them all manually.

Over a century stock management has been studied with the aid of researchers. The major inventory until date is the Economic order quantity. It turned into first delivered by way of Ford W. Harris of constant amount extensions. Further R.H. Wilson generalized this EOQ version via analysis deeply. Wilson system offers on how to order the

products and how frequently?. R.H. Wilson carried out and used this formula to inventory optimization. The fundamental faulty of this system is that it considers all of the parameters as constant. Limitations of the Wilson system/EOQ are volatile demand, the buy rate, inconsistent fee, inconsistent or unpredictable lead time and no protection stocks.

Inventory has been applied in exclusive fields particularly in commercial enterprise areas. In nowadays business fields inventory management machine is an important elements. Those who in no way served inside the commercial enterprise may not be understood about significance of successfully dealing with inventories. Despite the reality that conveying stock can bring about vast costs it is probably increase the price of the enterprise. The maximum not unusual makes use of inventories which includes to offer versatility in assembly patron necessities as an instance, in mass customization and to offer the potential to realize savings via economic order production.

Fuzzy set theory has been confirmed to be beneficial apparatus to painting instances in which the statistics are uncertainty or ambiguous. Fuzzy sets take care of such situations through crediting a degree to which a specific article has an area with a fixed. In actual existence in this kind of case, an man or woman may additionally take delivery of that a piece of writing in a particular manner, but it's miles plausible that isn't so relaxed with it. As it had been, there is probably a faltering or vulnerability approximately the club stages. In fuzzy set speculation there is no way to fuse that hesitation inside the membership ranges. A capability association is to make use of inter valued fuzzy sets characterized by Sambue in 1975 (or) intuitionistic fuzzy units which was characterized with the aid of Atanassov in 1983.

In 1984, there had been 4000 publications and in 2000 there have been greater than 30,000. Applications of fuzzy set idea is useful in the fields of operation researches, selection theory, PC science, medicine drug, control engineering, artificial intelligence, control technological know-how, professional structures, logic and robotics. After the discovery of fuzzy set idea once more in 1970. Zadeh Beliman constructed a mathematical version on choice making in fuzzy surroundings. In 1991, Kaufmann and Gupta supplied an advent to fuzzy arithmetical operation and Zimmerman mentioned the concept of the bushy set idea and its programs.

To address sick described gadgets like lovely, smart, toll, brief, more or much less approximately, spherical approximately, etc., can't be solved through mathematical tools. The answers for such type of troubles became coined through Lofti A.Zadeh in 1965 with the period of "Fuzzy sets", designed to deal with all described items. Fuzzy set is any crisp set precise with the membership feature in $[0,1]$ it's miles a collection of associated gadgets which belong to that set of different degrees. The club grade is an element given inside the fuzzy set as a degree of reality or diploma of certainty.

LITERATURE REVIEW:

In 1915 Harris implemented the first inventory version which took very few parameters such as demand, maintaining fee, manufacturing fee, deterioration rate, set up cost etc., which might be unknown. Goyal (1985) evolved a single inventory model for products below allowable fee delay. Liu and Shi has divided perishability and decaying stock fashions into two principal corporations, specifically fashions of degradation and finite lifetime models. Duan et al. published inventory coordination of customer-supplier with amount discount incentive for fixed lifetime commodity. P.Muniappan, R. Uthaya Kumar and S. Ganesh has listed a production stock version for organizing supplier-customer co-ordination with quantity discount, backordering and rework for fixed time items.

The impact of fuel rate and carbon emissions on stock policies is addressed via Amulya Gurtu and Mohammed Y.Jaber of their paper. W.Ritha and I.Francina Nishanthi carried out emission minimisation guidelines which includes Cap and Trade machine in the degree supply chain version. Hua and T.C.E Cheng and Wang addresses the reduction of carbon footprint within inventory control. Xi Chen uses the EOQ model and presents a conditions in which the relative emission reduction is more than quantities.

Uncertainties, however, are because of fuzziness in certain scenario, and such cases are diluted in the fuzzy set idea which was developed by way of Zadeh in 1965. Following the development of fuzzy set idea once more than in 1970, Zadeh and Bellman developed a mathematical version on decision making in a few operation on fuzzy

numbers. Kaufmann and Gupta applied fuzzy mathematics on operations, and Zimmerman discussed the standards of fuzzy set idea and its program.

Some researchers have commenced making use of fuzzy set principle in Kacprzyk and Staniewski stock control by presenting a version for lengthy-term stock policy-making through fuzzy decision making version. Yao and Lee proposed a fuzzy stock version with backorder for fuzzy order amount. Vujosevic et.al evolved an EOQ components when fuzzy invention cost. Gen et al. Gift a fuzzy stock mange model. Chang implemented fuzzy triangular quantity in production inventory model. Syed and Aziz implemented a signed distance method to defuzzify the stock version with out scarcity.

Analysis of stock systems beneath carbon emission regulation rules in an emerging field of inventory management. Recently, a few researchers have accomplished great research in this discipline. Bonney and Jaber analysed the impact of environmentally responsible inventory models on most useful decisions of traditional inventory fashions. Hua .et.al proposed a managerial technique to manipulate carbon footprint in stock management system underneath carbon emission buying and selling mechanism. El Saadany .et.al investigated a echelon supply chain version with price and products environmental pleasant dependent call for Wahab et.al advanced a lot size inventory version with environmental considerations. Their principle cognizance become on reducing carbon dioxide emission in stock transportation.

Bouchery .et.al reformulated the classical financial order quantity model as a multi objective problem taking sustainability worries into account. Glock et. Al evolved an inventory model.

Fuzzy logic was introduced by means of Lofti Zadeh in 1965. Fuzzy logic changed into carried out to solve stock issues uncertainty and ambiguity are traits of all deliver chain. Therefore, fuzzy logic is an appropriate method for dealing this form of troubles. Some researchers used fuzzy logic (arithmetic principles) in studying stock problems. Appadoo.et.al developed a fuzzy logic based EOQ model using possibilistic method in case of the carrying cost and order value are unsure. Jaggic .et.al advanced afuza good judgement primarily based EOQ model for deteriorating items with charge established call for and time various preserving value. Zhang and Xu used abi-fuzzy nonlinear a couple of objective decision making (0400M) version for dealing the supply chain management (SCM) with amount cut price policy. Dinagar and kannan used hexagonal fuzzy numbers and simple calculus techniques to discover the bushy premier ordinary cost and most useful order quantity with allowable shortage.

Other researchers applied fuzzy expert system (rule based) to handle inventory problems. Zarandi and saghiri developed a fu24 expert system (FES) based on the knowledge and knowledge and information of the experts in an automotive supply chain. Then the results were compared with the same of the fuzzy linear programming models. Ramezani and Montazer developed a fuzzy expert decision support system to solve the vendor selection problem with multiple objectives where some parameters are fuzzy in nature. Price, quality and delivery time are the factors consider for supplier selection. Z Xandi et.al developed fuzzy crisp and fuzzy linear programming models for supply chain of an automatic manufacturing system and compare this models with a developed ruled based fuzzy expert system model showed better results than the other models. Tanthatamee et.al developed a rule based fuzzy inventory model for uncertain demand and supply.

The model aimed to extract the fuzzy order quantity and the fuzzy reorder point. Chede et. Al built a fu24 model (rule based) of shares and substances control thinking about demand and inventory quantity. Rezaei developed an intelligent inventory manipulate version to find the safety stock based on fuzzy logic machine and weighted association rule. Omar et.al carried out fuzzy logic (rule primarily based) inside the qualitative overall performance size of supply chain management. Mira used fu24 expert machine to model uncertainty in call for and lead time. Hosseininasab and Dehghanbaghi proposed a fuzzy expert gadget for copying with returned products troubled. Lee et.al used lot to inventory con

NOTATIONS:

F – Annual demand

Q – Order quantity period

S – Order cost per period

C – Carbon emission price

S_c – Carbon emission quantity from order per period

K – Setup cost

K_c – Carbon emission from setup

n – Number of times the order is placed

W – Manufacturing cost

W_c – Carbon emission from Manufacturing

A – Screening cost

LCA (T) – Life cycle assessment technology cost.

H – Inventory holding cost per unit time

H_c – Carbon emission quantity from inventory holding

P – Production rate

h_m – Inventory holding cost per unit time and per unit quantity for manufacturer

h_{mc} – Carbon emission quantity from inventory holding for manufacturer

L – Labour cost for packing per parcel

M – Material cost used for packing per parcel

N – Number of parcels

α - Fixed cost per transport

b – Variable cost per unit transported per distance travelled

u – Distance travelled

y – Proportion of demand returned

g – Social cost from vehicle emission

v – Average velocity

μ' – Fixed cost per waste disposal activity

μ – Cost to dispose waste to the environment

Z – Proportion of waste produced per demand

α – Cap of carbon emission for the retailer

β – Cap of carbon emission for the manufacturing industry

R_N – Revenue earned due to LCA

ASSUMPTIONS:

- ❖ Life cycle assessment (LCA) technique is used for assessing products environmental impacts
- ❖ The units transported are finally packed in parcels
- ❖ Waste Management makes a speciality of supply discount, pollution prevention and disposal
- ❖ The substances transformed the use of LCA technology are used as raw substances in production
- ❖ For retailer and manufacturer, the carbon emission quantities obey EOQ and EPQ assumptions, respectively.
- ❖ Eco-friendly materials are used for packaging.

MATHEMATICAL FORMULATION:

Under the cap and trade mechanism for vendor buyer system with green inventory model consists of green procurement cost, green setup cost, green manufacturing cost, holding cost, screening cost, green distribution cost, green logistics cost, cap and trade, waste produced by the inventory system, life cycle assessment technology cost.

$$TC = \frac{F}{Q} \left[(S + CS_c) + \left(\frac{K + CK_c}{n} \right) + (W + CW_c) + A + LCA(T) + 2\alpha + \frac{2gu}{v} + \mu' + (L + M)N \right] + \frac{Q}{2} \left[(H + CH_c) + \left(n \left(1 + \frac{F}{P} \right) - 1 \right) (h_m + Ch_{mc}) \right] + \frac{bu(1+y) + \mu(z+y)}{F}$$

$$-C(\gamma + \beta) - R_N$$

In order to find the economic order quantity the above equation is differentiated with respect Q and equated to zero. The economic order quantity is derived as Q^* .

$$Q^* = \sqrt{\frac{2F \left[(S + CS_c) + \left(\frac{K + CK_c}{n} \right) + (W + CW_c) + A + LCA(T) + 2\alpha + \frac{2gu}{v} + \mu' + (L + M)N \right]}{\left[(H + CH_c) + \left(n \left(1 + \frac{F}{P} \right) - 1 \right) (h_m + Ch_{mc}) \right]}}$$

Using fuzzy logics, the fuzzified total cost is obtained as,

$$TC = \frac{F}{Q} \left[(\tilde{S} + CS_c) + \left(\frac{\tilde{K} + CK_c}{n} \right) + (\tilde{W} + CW_c) + A + L\tilde{C}A(\tilde{T}) + 2\alpha + \frac{2gu}{v} + \tilde{\mu}' + (\tilde{L} + \tilde{M})N \right] + \frac{Q}{2} \left[(\tilde{H} + CH_c) + \left(n \left(1 + \frac{F}{P} \right) - 1 \right) (h_m + Ch_{mc}) \right] + \frac{bu(1+y) + \tilde{\mu}(z+y)}{F} - C(\gamma + \beta) - R_N \quad \text{----- (1)}$$

The fuzzified economic order quantity is,

$$Q^* = \sqrt{\frac{2F \left[(\tilde{S} + CS_c) + \left(\frac{\tilde{K} + CK_c}{n} \right) + (\tilde{W} + CW_c) + A + L\tilde{C}A(\tilde{T}) + 2\alpha + \frac{2gu}{v} + \tilde{\mu}' + (\tilde{L} + \tilde{M})N \right]}{\left[(\tilde{H} + CH_c) + \left(n \left(1 + \frac{F}{P} \right) - 1 \right) (h_m + Ch_{mc}) \right]}} \quad \text{----- (2)}$$

NUMERICAL EXAMPLES:

$$S = (25, 50, 100, 100, 150, 175, 200)$$

$$A = (18, 20, 24, 28, 32, 38, 40)$$

$$M = (25, 30, 35, 45, 50, 55, 60)$$

$$h_r = (0.01, 0.02, 0.03, 0.04, 0.1, 0.2, 0.4)$$

$$\Psi_0 = (0.04, 0.05, 0.1, 0.15, 0.2, 0.21, 0.25)$$

$$L = (0.05, 0.1, 0.2, 0.3, 0.4, 0.45, 0.5)$$

$$p = (0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.09)$$

$$LCA = (0.01, 0.02, 0.03, 0.04, 0.04, 0.05, 0.06)$$

$$\Psi = (0.01, 0.02, 0.03, 0.1, 0.14, 0.2, 0.3)$$

Defuzzifying we get $S = 229.167, A = 57, M = 85.833, h_r = 0.198, \Psi_0 = 0.285$

$$L = 0.575, p = 0.083, LCA = 0.072, \Psi = 0.215$$

Substituting the above parameters in equation (2).

We get,

$$Q^* = \sqrt{\frac{2(60000) \left[\frac{(57 + (0.2)(400)) + \left(\frac{229.167 + (0.2)(400)}{1} \right) + (85.833 + (0.2)(400)) + 0.2}{+ 0.072 + 2(50) + \left(\frac{2(250)(0.5)}{180} \right)} + 0.285 + (0.083 + 0.575)600 \right]}{(0.198 + (0.2)(2)) + \left(1 + \frac{60000}{80000} - 1 \right) (0.4 + 0.2(1))}}$$

$$Q^* = 11267 \text{ units.}$$

Substituting the above values in equation (1).

We get,

$$TC = \frac{60000}{11267} \left[\frac{(57 + (0.2)(400)) + \left(\frac{229.167 + (0.2)(400)}{1} \right) + (85.833 + (0.2)(400)) + 0.2}{+ 0.072 + 2(50) + \left(\frac{2(250)(0.5)}{180} \right)} + 0.285 + (0.083 + 0.575)600 \right] +$$

$$\frac{11267}{2} \left[(0.198 + (0.2)(2)) + \left(1 + \frac{60000}{80000} - 1 \right) (0.4 + 0.2(1)) \right] +$$

$$\frac{5(250)[1 + 0.2] + 0.215(0.5 + 0.2)}{60000} - 0.2(8000 + 60000) - 200$$

$$TC = \text{Rs. } 8807.806$$

CONCLUSION:

Considering environmental affects of commercial decisions performs an imperative function in retaining our surroundings. At the present time, environmental issues are one of the maximum essential troubles regarding human

beings' lifestyles. In order to preserve our environment and resources for destiny generations, we need to change the manner we are managing and running our supply chains. In this paper a inexperienced inventory version with cap and trade mechanism is provided. The company and society are benefited by using this inexperienced inventory model. Some of them to mention are the reduction of raw fabric and energy charges used, insurance expenses are reduced as this version reduces changes; control waste bills and pollutants fines. This model facilitates the firm to improve productiveness because it makes use of natural light and air flow. The company can boom the assets value by using decreasing operating expenses. Enhancing, the public picture via green inventory version ends in elevated sales, better public belief and network aid. This model allows in developing healthier environments which leads to much less toxins and purifier air with much less unsafe production methods.

References

- [1] Baruah, M., Madan, K. C. and Eldabi, T, "A Batch Arrival Single Server Queue with Server Providing General Service in Two Fluctuating Modes and Reneging during Vacation and Breakdowns", Journal of Probability and Statistics, 2014.
- [2] C.H. Cheng, "A New Approach for Ranking fuzzy numbers by distance method", Fuzzy Sets and Systems, 1998, Vol. 95, pp. 307-317.
- [3] C. S. Dinesh Bisht, Pankaj Kumar Srivastava, "Trisectional Fuzzy Trapezoidal Approach to Optimize Interval data based Transportation Problem", Journal of King Saud University-Science, 32, 2020, pp. 195-199.
- [4] D. Dubois and H. Prade, "Fuzzy Sets and Systems", Theory and Applications, Academic Press, New York, (1980).
- [5] D. Wu and H. Tagaki, "M/G/1 Queue with Multiple Working Vacation", Performance Evaluation, 63, 2006, pp. 654-681.
- [6] L.D. Servi and S.G. Finn, "M/M/1 Queues with Working Vacations (M/M/1/WV)", Performance Evaluation, 50, 2002, 50, pp. 41-52.
- [7] R. F. Khalaf, K.C. Madan and C.A. Lukas, "An $M^{[X]}/G/1$ Queue with Bernoulli Schedule Vacation Times, Random Breakdowns, General Delay Times and General Repair Times", Applied Mathematical Sciences, 2011, 5, pp. 35-51.
- [8] S. Richa, "Mathematical Analysis of Queue with Phase Service: An Overview", Advances in Operation Research, (2014).
- [9] Samuel Ugochukwu Enogwe, Happiness Onyebuchi Obiora-Ilouno, "Effects of Reneging, Server Breakdowns and Vacation on a Batch Arrival Single Server Queuing System with Three Fluctuating Modes of Service", Open Journal of Optimization, 2020, 9, pp. 105-128.
- [10] W. J. Gray, P. P. Wang and M. Scott, "A Queuing Model with Multiple Types of Server Breakdowns", Quality Technology and Quantitative Management, 2004, 1, pp. 245-255.
- [11] Y. J. Wang, and H. S. Lee, "The Revised Method of Ranking Fuzzy Numbers with an Area between the Centroid and Original Points". Computers and Mathematics with Applications, Vol. 55, No: 9 (2008), pp. 2033-2042.
- [12] Y. Tang, "Single Server M/G/1 Queuing system Subject to Breakdowns-Some Reliability and Queuing Problems", Microelectronics Reliability, 2003, 149, pp. 588-613.