The Neutrosophic Treatment of the Static Model for the Inventory Management with Safety Reserve

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Abstract:

Institutions must store materials to ensure the continuity of their activity and to avoid incurring big losses as a result of the storage process, various models have been studied that cover all scenarios in which stock insurance is required to allow institutions to continue operating while avoiding losses. The static model with safety reserve is one of these models, and it is used in emergency and ambulance circumstances to transport medicines, food, and fuel, etc.

Those in charge of any project must estimate the quantities that will need to be stored in order to ensure that the necessary materials are available and that storage costs are minimized. As a result, a mathematical model has been developed that expresses the circumstance in which a safety reserve is necessary to meet market material demand, and the optimal answer for this model is the required solution. This model is treated in classical logic by adding the amount of the safety reserve to the ideal quantity determined through the static model without a deficit, and this quantity is a fixed amount during each storage cycle over time, which does not correspond to reality and ignores cases of fluctuations demand in the rate of demand for inventory .In this study, three scenarios were used to construct a study for the static stock model with safety reserves and for one substance utilizing neutrosophic theory through three different cases.

The First Case: Using the optimal amount of stock that determined by studying the static model with a deficit using neutrosophic logic , while assuming the safety reserve S_N as a vague value, either $S_N = \{S_1, S_2\}$ or $S_N = [S_1, S_2]$.

DOI: https://doi.org/10.54216/IJNS.180209

Received: November 6, 2021 Accepted: March 24, 2022

The Second Case: Taking the ideal value of stock that was previously determined by studying the static model with deficient using neutrosophic logic , wherein regard the safety reserve S_N as constant value.
The third Case: Taking the optimal value of stock that determined by studying the static model with deficient using classical logic, and assuming the safety reserve S_N as a vague value, either $S_N = \{S_1, S_2\}$ or $S_N = [S_1, S_2]$.

In other words, we approached the problem using neutrosophic tools, which accounts for all possible scenarios that may arise throughout the course of the job, yields more accurate results, and so ensures a safe working environment for the facilities at the lowest possible cost.

Keywords.

Inventory Management, Static Inventory Management Model, Neutrosophic Logic, Inventory Management with Safety Reserve using Neutrosophic Logic.

1- Introduction

The inventory is considered one of the assets of the facility and it can change the financial state of the facility and achieve great profits or inflict huge losses on it. The size of the stock is affected by the conditions of the facility's work, and therefore basic hypotheses are developed for the issue describing the workflow in this facility. Through these assumptions, the appropriate model is built and its solution gives the ideal size. There are several things that affect the ideal size and are related to the type of model, such as the rate of demand for inventory, the size or the available space, the amount of the deficit, the amount of the safety reserve ...etc., and the more accurately they are determined, the more we can determine the ideal size that needs to be stored during the period of the storage cycle according to the conditions of the facility's work and at the lowest cost, the classic logic consider these situations with specific values, which does not correspond to reality because the rate of demand for stock, the size or available space, the amount of the deficit, the amount of the safety reserve and others change simultaneously and unpredictably.

In this study, we will rely on the research that we had previously published [4]. Neutrosophic Logic is a logic that is a new vision of modeling designed to effectively address the uncertainties inherent in the real world, as it came to replace the binary logic that admits right and wrong only, by introducing a third, neutral state that can be interpreted as undetermined or uncertain. Neutrosophic theory is founded by the American mathematical philosopher Florentin Smarandache [8-12], who introduced it in 1995 as a generalization of fuzzy logic as an extension of the theory of fuzzy categories presented by Lotfi Zadeh [5] in 1965, as well as, Ahmed A. Salama presented the theory of neutrosophical classical categories as a generalization of the theory of classical categories [11,13,14]. Also, there were developments, introducing and formulation for new concepts in the fields of mathematics, statistics, computer science and others through neutrosophic vision [15,18,19].

The notion of neutrosophic theory has developed in popularity in recent years as a result of its use in measurement theory, set theory, graph theory, statistics, and a variety of other scientific and practical domains [6,7,19,20-23].

DOI: https://doi.org/10.54216/IJNS.180209
Received: November 6, 2021 Accepted: March 24, 2022

Recently, there were dozens of articles dedicated to reformulate most mathematical branches, especially in operating research and optimization to reconstruct either its fuzzy or classical problems in the light of neutrosophic theory [1,2,3,16,17,24-26].

In this study, we will investigate the static model with the safety reserve and for one substance using neutrosophic logic, which will allow us to determine the required amount of stock as a safety reserve during the storage cycle, more precisely, by studying the issue in three cases, in other words, we will address the issue using neutrosophic logic, which takes into account all of the possible scenarios that we may encounter during the work and provides more accurate results, ensuring secure workflow and storage at the lowest costs for facilities that rely on such models in their job, and we will provide practical examples that exemplify each of the preceding cases.

2- Discussion

It is the responsibility of the facility managers to determine the optimal policy for the work of the facility by collecting the necessary data for the work and then employing this data in managing the work of the facility. One of the most important things that must be worked on is the inventory, because inventory management is one of the most important functions of management in terms of determining the mechanism used in the process storage in terms of allowing or not allowing a deficit or securing a safety reserve ...etc., by comparing the costs in each case, large profits or huge losses, so there was an urgent requirement to procedure a study to help us determine the ideal size of the stock at the lowest possible cost. In this research, we will study the static model with a safety reserve and for one material, which is used to store materials that require a safety reserve for emergencies situations such as medicines, food, and fuel...etc.

Here it should be noted that the treatment of this model is resulting from the study prepared for the static model without deficit by adding the quantity of the safety reserve to the ideal quantity that we reached when studying the static model without deficit and also we add to the costs, the cost of storing the quantity of the safety reserve.

We will study this model according to the neutrosophic logic in the following three cases:

3- The first case: (assuming that the rate of demand for inventory is determined and the amount of the safety reserve is also not specified)

3.1- The Fundamental Assumptions:

1- The Size of demand Q.

2- The rate of demand for inventory in time unit is λ_N which is indeterminate value, i.e. $\lambda_N = [\lambda_1, \lambda_2]$, where λ_1 is the lower bound of the rate of demand for inventory, λ_2 is the upper bound of the rate of demand for inventory.

3- Fixed cost of demand preparation $C_1 = K$.

4- Cost of purchase, delivery and pickup $C_2 = C.Q$.

DOI: https://doi.org/10.54216/IJNS.180209
Received: November 6, 2021 Accepted: March 24, 2022

5- The cost of storage h is a fixed amount for each unit in the warehouse during time unit, and it includes the cost of frozen liquidity, the cost of occupied space, the cost of protection, security, insurance, taxes and various fees, then Then the storage cost during time unit is for the quantity remaining in warehouse C_3.

6- The amount of the safety reserve in each storage cycle and over time is equal to S_N and it is indeterminate , i.e. $S_N = [S_1, S_2]$, so that the lower bound of the safety reserve is S_1, while the upper bound of the safety reserve is S_2, and the cost of storing one unit of it during time unit is h, then the cost of that reserve is equal to $C_4 = hS_N$.

7-The period of running out of the stored quantity is $\frac{Q}{\lambda_N}$ (or the duration of the storage cycle).

Using the previous hypotheses and benefiting from the results we reached from the study of the static model without deficits according to the neutrosophic logic [5], we find that the neutrosophic ideal size of the first demand is given by the following relationship:

$$Q_N^{**} = Q_N^* + S_N$$

where Q_N^* represents the formula of the neutrosophic optimal size for the demand ,and it has been derived by previous article [5]. It is given by the following relationship:

$$Q_N^* = \sqrt{\frac{2\lambda_N K}{h}}$$

Consequently, the neutrosophic optimal size for the first demand is:

$$Q_N^{**} = \sqrt{\frac{2\lambda_N K}{h}} + S_N$$

After determining the amount of the first demand, the movement of inventory proceeds until it reaches to the level $S_N = [S_1, S_2]$, then it is renewed with a new demand Q_N^*. The purchase price of the safety reserve quantity is CS_N and it is one-time calculation.

The total cost of inventory during each cycle of successive cycles is:

$$TC(Q_N^*) = K + C.Q_N^* + \frac{h.Q_N^*}{2\lambda_N} + h.S_N.T^*$$

While the total cost of inventory during the time unit from successive cycles is:

$$C(Q_N^*) = \frac{K.\lambda_N}{Q_N^*} + C.\lambda_N + \frac{h}{2}Q_N^* + h.S_N$$

Finally, the amount of re demand is calculated by the relation:

$$Q_N = d.\lambda_N + S_N$$

3.2- Practical Example:

A productivity company stores flour in its warehouses, according to the following conditions and data: The safety reserve to ensure the continuity of work is absolutely indeterminate and ranges between [0,100] tons per month, and the rate of demand for flour is absolutely indeterminate, but ranges between [10,20] tons per month, depending on the company's conditions of work pressure, operating pressure, weather conditions, etc. The cost of one-ton storage equals 40 monetary units per month. The cost of

DOI: https://doi.org/10.54216/IJNS.180209
Received: November 6, 2021 Accepted: March 24, 2022

preparing one demand is 150 monetary units, the purchase price of one ton is equal to 1200 monetary units, and the period required to receive the demand is 6 days. Calculate the following:

1- calculate the optimal size of the first demand and successive demands.

2-determine the amount of re demand.

3- Calculate the total cost of inventory during a month time unit.

4-Calculating the investment cost of storage during a year.

Keep in mind that we have, $d = 6,\ C = 1200,\ K = 150,\ h = 40,\ \lambda_N = [10,20],\ S_N = [0,100]$.

1- The optimal size of the first demand is:

$$Q_N^{**} = Q_N^* + S_N$$

$$Q_N^{**} = \sqrt{\frac{2\lambda_N K}{h}} + S_N = \sqrt{\frac{2[10,20].150}{40}} + [0,100] = [8.66,12.25] + [0,100] = [8.66,112.25]$$

The optimal size for successive demand is $Q_N^* = [8.66,12.25]$.

2- The amount of re demand is given by the following relations:

$$Q_N = d.\lambda_N + S_N = 6.[10,20] + [0,100] = [60,220].$$

3- The total cost of inventory during a month time unit is:

$$C(Q_N^*) = \frac{K.\lambda_N}{Q_N^*} + C.\lambda_N + \frac{h}{2}Q_N^* + h.S_N$$

$$= \frac{150.[10,20]}{[8.66,12.25]} + 1200.[10,20] + \frac{40}{2}.[8.66,12.25] + 40.[0,100]$$

$$= \frac{[1500,3000]}{[8.66,12.25]} + [12000,24000] + [173.2,245] + [0,4000]$$

$$= [173.210162, 244.897959] + [12173.2, 6645] = [12346.4102,6889.89796]$$

4-The investment cost of storage during a year is:

$$CI_N = C(Q_N^*).12 + CS_N = [12346.4102,6889.89796].12 + 1200.[0,100] =$$

$[148156.922, 82678.7755] + [0,120000]$= [148156.922,202678.776].

4- The second case: (in which the rate of demand for inventory is indeterminate and the value of the safety reserve is fixed value *S*)

4.1- The Fundamental Assumptions:

1- The Size of demand Q.

2- The rate of demand for inventory in time unit is λ_N which is indeterminate value, i.e. $\lambda_N = [\lambda_1, \lambda_2]$, where λ_1 is the lower bound of the rate of demand for inventory, λ_2 is the upper bound of the rate of demand for inventory.

3- Fixed cost of demand preparation $C_1 = K$.

4- Cost of purchase, delivery and pickup $C_2 = C.Q$.

5- The cost of storage h is a fixed amount for each unit in the warehouse during time unit, and it includes the cost of frozen liquidity, the cost of occupied space, the cost of protection, security, insurance, taxes and various fees, then Then the storage cost during time unit is for the quantity remaining in warehouse C_3.

DOI: https://doi.org/10.54216/IJNS.180209
Received: November 6, 2021 Accepted: March 24, 2022

6- The amount of the safety reserve in each storage cycle and over time is equal to S, and the cost of storing one unit of it during time unit is h, then the cost of that reserve is equal to $C_4 = hS$.

7-The period of running out of the stored quantity is $\frac{Q}{\lambda_N}$ (i.e. the duration of the storage cycle).

Using the previous hypotheses and benefiting from the results we reached from the study of the static model without deficits according to the neutrosophic logic [5], we find that the neutrosophic ideal size of the first demand is given by the following relationship:

$$Q_N^{**} = Q_N^* + S$$

where Q_N^* represents the formula of the neutrosophic optimal size for the demand ,and it has been derived by previous article [5]. It is given by the following relationship:

$$Q_N^* = \sqrt{\frac{2\lambda_N K}{h}}$$

Consequently, the neutrosophic optimal size for the first demand is:

$$Q_N^{**} = \sqrt{\frac{2\lambda_N K}{h}} + S$$

After determining the amount of the first demand, the movement of inventory proceeds until it reaches to the level S , then it is renewed with a new demand Q_N^*. The purchase price of the safety reserve quantity is CS and it is one-time calculation.

The total cost of inventory during each cycle of successive cycles is:

$$TC(Q_N^*) = K + C.Q_N^* + \frac{h.Q_N^*}{2\lambda_N} + h.S.T^*$$

While the total cost of inventory during the time unit from successive cycles is:

$$C(Q_N^*) = \frac{K.\lambda_N}{Q_N^*} + C.\lambda_N + \frac{h}{2}Q_N^* + h.S$$

Finally, the amount of re demand is calculated by the relation:

$$Q_N = d.\lambda_N + S$$

4.2- Practical Example:

depending upon the previous example and adapting the data according to the hypothesis of this case:

A productivity company stores flour in its warehouses, according to the following conditions and data:

The safety reserve to ensure the continuity of work is 100 tons per month and the rate of demand for flour is absolutely indeterminate, but ranges between [10,20] tons per month, according to the company's conditions of work pressure, operating pressure, weather conditions, etc., and that the cost of storing one ton is equal to 40 monetary units in month. And the cost of preparing one demand equals 150 monetary units, and the purchase price of one ton is equal to 1200 monetary units, and the period required to receive the order is 6 days. Calculate the following:

1- calculate the optimal size of the first demand and successive demands.

2-determine the amount of re demand.

3- Calculate the total cost of inventory during a month time unit.

4-Calculating the investment cost of storage during a year.

DOI: https://doi.org/10.54216/IJNS.180209

Received: November 6, 2021 Accepted: March 24, 2022

It is obvious from the problem's information that $d = 6,\ C = 1200,\ K = 150,\ h = 40,\ \lambda_N = [10,20]$, $S = 100$.

1- $Q_N^{**} = \sqrt{\frac{2\lambda_N K}{h}} + S = \sqrt{\frac{2[10,20].150}{40}} + 100 = [8.66,12.25] + 100 = [108.66,112.25]$

While the optimal size for successive demand is $Q_N^* = [8.66,12.25]$.

2- The amount of re demand is given by the following relations:

$Q_N = d.\lambda_N + S = 6.[10,20] + 100 = [160,220]$.

3- The total cost of inventory during a month time unit is:

$$C(Q_N^*) = \frac{K.\lambda_N}{Q_N^*} + C.\lambda_N + \frac{h}{2}Q_N^* + h.S$$

$$= \frac{150.[10,20]}{[8.66,12.25]} + 1200.[10,20] + \frac{40}{2}.[8.66,12.25] + 40.(100)$$

$$= \frac{[1500,3000]}{[8.66,12.25]} + [12000,24000] + [173.2,245] + 4000$$

$$= [173.210162, 244.897959] + [16173.2, 28245] = [16346.4102, 28489.898]$$

4- The investment cost of storage during a year is:

$$CI_N = C(Q_N^*).12 + CS = [16346.4102, 28489.898].12 + 1200.(100)$$

$$= [\ 196156.922\ ,341878.776] + 120000 = [316156.922, 461878.776]$$

5- The third case: (where the rate of demand for inventory is fixed value and the amount of the safety reserve is indeterminate)

5.1- The Fundamental Assumptions:

1- The Size of demand Q.

2- The rate of demand for inventory in time unit is λ.

3- Fixed cost of demand preparation $C_1 = K$.

4- Cost of purchase, delivery and pickup $C_2 = C.Q$.

5- The cost of storage h is a fixed amount for each unit in the warehouse during time unit, and it includes the cost of frozen liquidity, the cost of occupied space, the cost of protection, security, insurance, taxes and various fees, then Then the storage cost during time unit is for the quantity remaining in warehouse C_3.

6- The amount of the safety reserve in each storage cycle and over time is equal to S_N and it is indeterminate , i.e. $S_N = [S_1, S_2]$, so that the lower bound of the safety reserve is S_1, while the upper bound of the safety reserve is S_2, and the cost of storing one unit of it during time unit is h, then the cost of that reserve is equal to $C_4 = hS_N$.

7-The period of running out of the stored quantity is $\frac{Q}{\lambda}$ (i.e. the duration of the storage cycle).

Using the previous hypotheses and benefiting from the results we reached from the study of the static model without deficits according to the neutrosophic logic [5], we find that the neutrosophic ideal size of the first demand is given by the following relationship:

$$Q_N^{**} = Q^* + S_N$$

where Q^* represents the formula of the neutrosophic optimal size for the demand ,and it has been derived by previous article using classical logic [5]. It is given by the following relationship:

DOI: https://doi.org/10.54216/IJNS.180209

Received: November 6, 2021 Accepted: March 24, 2022

$$Q^* = \sqrt{\frac{2\lambda K}{h}}$$

Consequently, the neutrosophic optimal size for the first demand is:

$$Q_N^{**} = \sqrt{\frac{2\lambda K}{h}} + S_N$$

After determining the amount of the first demand, the movement of inventory proceeds until it reaches to the level $S_N = [S_1, S_2]$, then it is renewed with a new demand Q^*. The purchase price of the safety reserve quantity is $C.S_N$ and it is one-time calculation.

The total cost of inventory during each cycle of successive cycles is:

$$TC(Q^*) = K + C.Q^* + \frac{h.Q^*}{2\lambda} + h.S_N.T^*$$

While the total cost of inventory during the time unit from successive cycles is:

$$C(Q) = \frac{K.\lambda}{Q} + C.\lambda + \frac{h}{2}Q + h.S_N$$

Finally, the amount of re demand is calculated by the relation:

$$Q_N = d.\lambda + S_N$$

5.2- Practical Example:

depending upon the previous example and adapting the data according to the hypothesis of this case:

A productivity company stores flour in its warehouses, according to the following conditions and data: The safety reserve to ensure the continuity of work is absolutely indeterminate, and ranges between [0,100] tons per month, and the rate of demand for flour is a specific amount equal to 20 tons per month, according to the company's conditions of working pressure, operating pressure, weather conditions, etc., and the cost of storing one ton is equal to 40 monetary units in the month. The cost of preparing one demand equals 150 monetary units, the purchase price of one ton is equal to 1200 monetary units, and the period required to receive the order is 6 days. Calculate the following:

1- Calculate the optimal size of the first demand and successive demands.

2- Determine the amount of re demand.

3- Calculate the total cost of inventory during a month time unit.

4- Calculating the investment cost of storage during a year.

It is obvious from the problem's information that $d = 6,\ C = 1200,\ K = 150,\ h = 40,\ \lambda = 20,\ S_N = [0,100]$.

1- $Q_N^{**} = Q^* + S_N$

$$Q_N^{**} = \sqrt{\frac{2\lambda K}{h}} + S_N = \sqrt{\frac{6000}{40}} + [0,100] = 12.25 + [0,100] = [12.25,112.25]$$

While the optimal size for successive demand is $Q_N^* = 12.25$.

2- The amount of re demand is given by the following relations:

$Q_N = d.\lambda + S_N = 6.(20) + [0,100] = [120,220]$.

3- The total cost of inventory during a month time unit is:

DOI: https://doi.org/10.54216/IJNS.180209
Received: November 6, 2021 Accepted: March 24, 2022

$$C_N(Q^*) = \frac{K.\lambda}{Q^*} + C.\lambda + \frac{h}{2}Q^* + h.S_N = \frac{150.[10,20]}{[8.66,12.25]} + 1200.[10,20] + \frac{40}{2}.[8.66,12.25] + 40.(100)$$

$$= \frac{150.(20)}{12.25} + 1200.(20) + \frac{40}{2}.(12.25) + 40.[0,100]$$

$$= 244.9 + 24000 + 245 + [0,4000] = [24489.9,28489.9]$$

4- The investment cost of storage during a year is:

$$CI_N = C_N(Q).12 + C.S_N = [24489.9,28489.9].(12) + 1200.[0,100] = [295078.8,461878.8]$$

6- Conclusion

From this research, we conclude that dealing with inventory management models with the perspective of the neutrosophic logic provides us with a more general and comprehensive study than the well-known classical study so that it does not neglect any data just because it is explicitly indeterminate, especially when we deal with the static model with the safety reserve. The demand for inventory, or the undetermined quantity of the safety reserve, or both of them together have affected on the optimal size of the demand, and it was expressed in an approximate form that is absolutely indeterminate ranging between two values. Therefore, we find that the presence of uncertainty actually affects the results and these unspecified values cannot be ignored or removed from the framework of the study with the aim of obtaining more accurate results, and thus obtaining the ideal volume of inventory that meets the needs of the facility during the period of the storage cycle at the lowest cost. We find that working within the classical logic in particular in the framework of inventory management is no longer sufficient at the present time, as the development of science has set in front of us a large number of new problems that need more general and accurate results than the obtained results using classical logic or fuzzy logic , and here the role of the neutrosophic logic comes in, which provides us with more comprehensiveness in interpreting the study data and obtaining the required accurate results, and enables us to deal with all forms of data that we may encounter in our practical and scientific lives.

Funding: "This research received no external funding"

Conflicts of Interest: "The authors declare no conflict of interest."

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DOI: https://doi.org/10.54216/IJNS.180209

Received: November 6, 2021 Accepted: March 24, 2022