Safety Stock Identification in Beverage Soft Drink Industries by Using Dynamic Fuzzy Logic

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Abstract:

The optimization of Safety stock considered an important element in the supply chain of beverage industries. In this paper, dynamic fuzzy logic was used as an advanced approach to identify the safety stock level in the beverage industries with the objective of minimizing total cost and meet with customer requirements. The problem of shortage occurred in these organizations due to poor inventory strategies which considered negative storage driver, so provide advanced safety stock identification strategy will lead to overcome this problem especially for organizations work under make to stock policy.

Three main steps are included here to identify safety stock level firstly, building of fuzzy sets for each variable, secondly, identifying max values to represent universe of discourse of variables and identify monthly input values of the variables, finally, execution of the proposed model in fuzzy logic tool embedded in Matlab software. In order to demonstrate the validity of proposed model, real data soft drink supply chain problem was presented. Reduction in stock-out of drinks about 99.9% was obtained by applying this model where the shortage was decreased from (53,423 package) to only (154 package). The obtained results of the research demonstrated the need to adopt advanced methodologies such as soft computing to identify safety stock level.

Key words: Dynamic safety stock optimization, Inventory optimization, Dynamic fuzzy logic, Beverage industries.

1. Introduction

The organizations work always to meet with customer demand by improving their service level, so optimization of safety stock level (SSL) is required, on the other hand, the increasing of the (SSL) leads to surplus capital commitment which influences on the economic efficiency. The competing logistic objectives i.e. high capability to delivery and low inventory level describe that is called "dilemma of inventory management"[1].

However, the (SSL) is used in the supply chain to compensate shortage quantities when the actual demand is more than expected demand, during lead time or when actual lead time longer than expected lead time[2]. Therefore, proper safety stock management as one of the most significant drivers of inventory is considered critical objective in order to have leanness philosophy and toward efficient inventory control[3].

Indeed, proper management of inventory requires suitable safety stock in order to protect against the increasing of stretch in breaking points of the supply chain, which is lead to a possible reduction of inventory[4].

The organizations and supply chains work under pressure of providing high customer service level while operating effectively with low level inventory. At the same time the supply chains generally are exposed to different risks types, such as demand uncertain, supply uncertain, process uncertain, lead times uncertain and natural and disasters. Different strategies were used to mitigate these risks impact, such as safety stocks, safety time or a combination of these two types[5]. Through this area of inconsistency and conflict, different methods were proposed in order to determine the inventory.

Pull strategy was used instead of traditional inventory approach this is because, it described as a customer driven strategy[6].

2. Literature Review

Chandra and Grabis (2005) argue that it is possible for an organization to reduce its safety inventory and optimize customer service through accurate inventory planning, predication and decreasing replenishment lead-time[7]. Placement of safety stock in multiple stages supply chain was presented by [11], demand uncertainty and backorder of unmet demand are two assumptions of the model. The simulation technique was used and the mathematical models solved by rolling horizon. Implementation of proposed model in real number case study, the researcher was concluded that the large part of the safety stock should be in downstream to meet the requirements of the customers, and concluded results show that the safety stock can only be moved to upstream zone when the lead time is relatively low, also less uncertainty in customer demand [5].

Emphasis on the management of the inventory through the use of modern methods, especially in small and medium enterprises discussed by Rajeev in (2010), the researcher provided two dimensions for inventory evaluation; these are inventory cost per sales and inventory turnover. SME can obtain strong competitive position by controlling these two factors i.e. decreasing of inventory cost per sales and increasing of inventory turnover[8].

The study of the modern inventory system and its impact on the performance of the organizations, especially in the beverage industries was presented by Lingxin Chen&Jiahong Xuin 2015. The study aimed to identify the importance of optimal inventory management in order to achieve the strategic objectives of the organization which are fulfillment of customer requests, reduction of total cost, and maintain the competitive position in the market. The researcher concluded that there are a group of factors that would develop inventory system, these factors are information sharing, Technical Fra structure, Top management support:, and employee involvement[7].

Demand uncertainty and backorder of unmet demand are the two assumption of model. The simulation technique was used and the mathematical models solved by rolling horizon. Implementation of proposed model in real number case study, the researcher concluded that the large part of the safety stock should be in downstream to meet the requirements of the customers, and concluded results shows that the safety stock can only be moved to upstream zone when the lead time is relatively low, also less uncertainty in customer demand[5].

The relationship between demand uncertainty and inventory level in fast moving consumer goods were studied by Ndivhuwo Nemtajela & Charles Mbohwa (2017). A survey questionnaire used and distributed to five organizations and just 255 respondent questionnaires were analyzed, the results show that about 72.2 % of answers is to agree with the statement (there are a strong positive impact between demand uncertainty and suitable inventory management, hence higher uncertainty demand considered more difficult and great challenging for holding inventory in an organization). They also concluded that the organizations should implement effective forecasting techniques[9].

According to the presented survey about safety stock, it is clear to notice the scarcity of research that deals with safety stock by using fuzzy logic. Table (1) below shows the approaches used in different researches to calculate safety stock level;

Table (1): Summary of safety stock research approaches.

No	Researcher	Year	Reference	Approach used		Developed points occurred in presented research
				Statistical	Fuzzy	
1	Simchi-Levi& Zhao	2005	[10]	✓		One of the major limitation of this research was the safety stock calculated for one product, while the presented research examined the calculation of the safety stock of a set of products (6 products) and the other drawback is the external demand treated as independent Poisson processes while the proposed model used (n) dynamic factor to control the behavior of external demand
2	Vanteddu.	2007	[11]	✓		The proposed model was solve the problem mentioned in this research, this problem is identification of SSL for strategic policy
3	Jung	2008	[12]	✓		The addition of the dynamic factor is an important step in the proposed model because the researcher relied on natural distribution, which is generally dependent on applications that require constant demands.
4	Patel	2010	[13]	✓		A model was developed using the simulation to calculate the amount of safety stock. The model was applied to data from the steel plant and the SSL was calculated for a period of 30 months to overcome the problems of fluctuations in demand, but the limitation is the high quantity of safe stock.
5	**H. R. Rezaei**	2012	[14]	✓		Building of dynamic model to identify SSL instead of normal fuzzy logic model
6	Youssef Boulaksil	2016	[5]	✓		The researcher assumed that the amount of safe storage should be increased taking into account the change in demand, but we found that the three factors have a very strong impact on the quantities of safe storage and these factors are change in demand, change in the level of crude feed, and the current level of storage
7	**Ndivhuwo Nemtajela**	2017	[9]	✓		The proposed model was employed upstream uncertainty (raw material) which is not taken here by Ndivhuwo Nemtajela

3. Proposed model of safety stock calculation:

The general structure of proposed model is presented. This model consists of three steps: Identifying of demand uncertainty conditions, identifying of inventory on hand conditions, and identifying of raw material conditions to develop dynamic fuzzy logic safety stock, as shown in Figure 1.

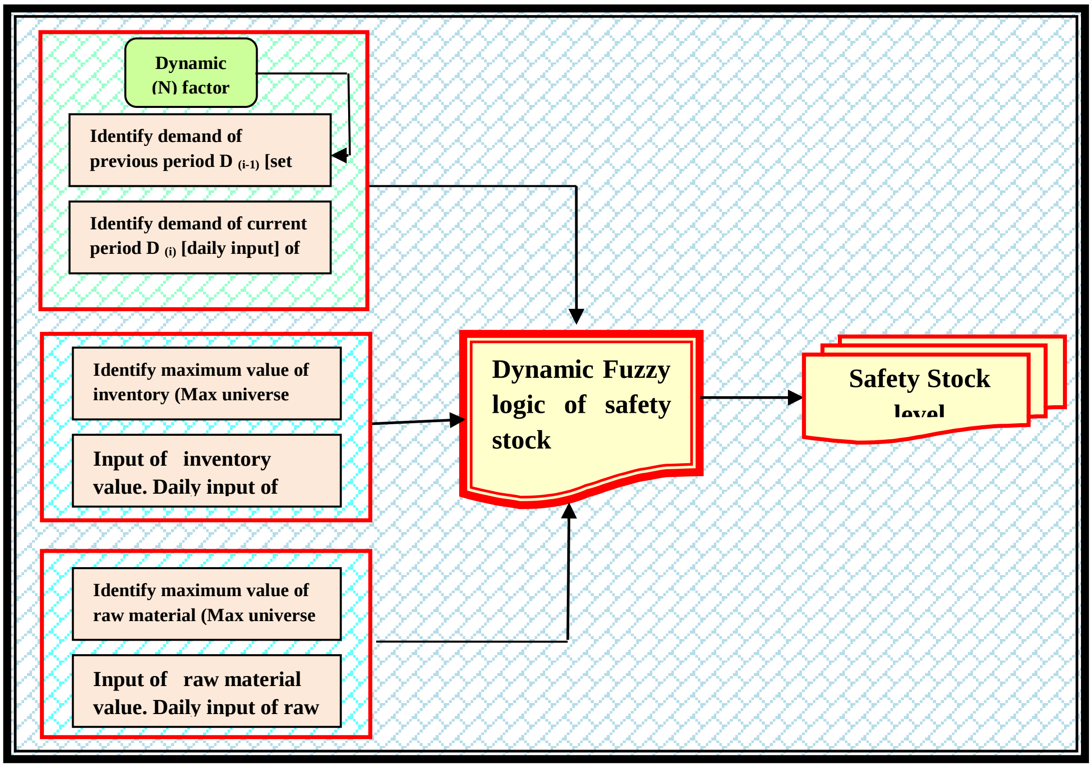

Figure (1); general structure of Proposed Model

3.1 steps of proposed model

The algorithm called Fuzzy Safety Stock Level (FSSL) is used to identify the level of safety stock based on dynamic fuzzy logic; the steps below will explain this algorithm.

Step (1): Identification Demand Stability Level

Demand stability level plays an important role in identifying (SSL), dynamic fuzzy safety stock model was presented to cope with dynamic behavior of global market. The uncertainty of demand was embedded in this approach by following the steps;

- Identifying of dynamic factor concept (N factor) which represent the max rate of increasing in the demand for a specific a period (monthly).
- Building of membership function sets to describe the status of demand stability level as shown in Figure (2).
- Identify max value of universe of discourse of current month ($D_{(i)}$) by multiplying (N factor) by demand of previous day ($D_{(i-1)}$).
- Input of value of demand of current month ($D_{(i)}$).

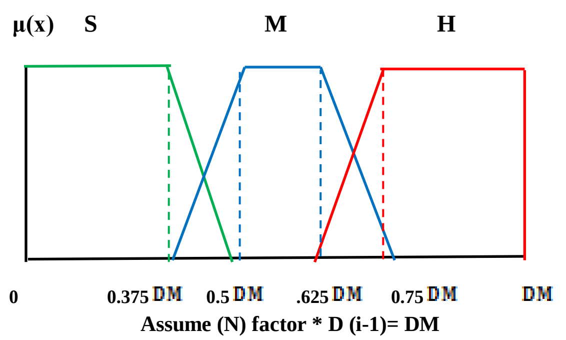

Figure (2) fuzzy set of demand stability level

Step (2): Identification the raw material availability level by using fuzzy set.

Raw material availability is necessary in identifying safety stock level because unavailability of raw material leads to unmet customer requirement and reflect bad reputation of the organization. The raw material is embedded by following steps below;

- Building set of membership function to describe the statues of raw material availability. These sets are Unavailability (UAV), Rare Availability (RAV), and Availability (AV) as shown in Figure (3).
- Identifying of max value and min values of raw material availability to represent universe of discourse of the variable for specific month.
- Input of monthly value of raw material availability for current month ($D_{(i)}$).

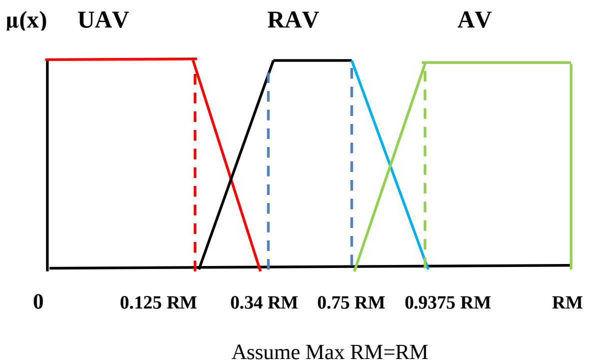

Figure (3) fuzzy set of availability of raw material;

Step (3): Identification the inventory on hand level by using fuzzy set.

The quantity of on hand inventory product must be taken into account to identify the (SSL) in order to optimize inventory levels by appropriate identification of (SSL). The procedure of identifying on hand inventory is embedded in this approach by following steps below;

- Building of set of membership function to describe the statues of on hand inventory which are low, medium, and high as shown in Figure (4).
- Identifying of max value and min values of on hand inventory to represent universe discourse of the variable for specific month.
- Input of daily value of on hand inventory of current day ($D_{(i)}$).

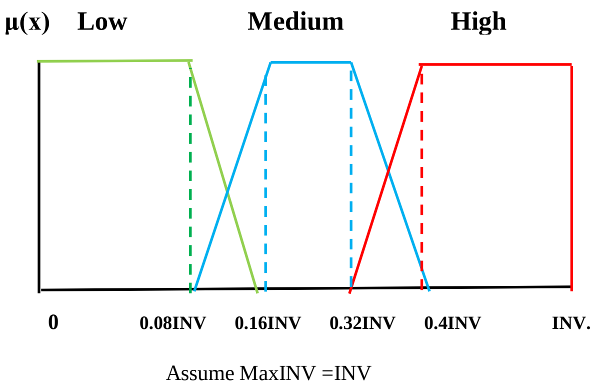

Figure (4) fuzzy sets of inventory level

3.2 Safety Stock Level

Safety stock level is the only output of this model. The reasoning rules are applied to the system after the entering of all parameters of inputs. Maximum universe of discourse of safety stock variable was calculated as an average demand of two days. Where the level of SS is assumed to have the required quantity of two days as an average and these values changed monthly for each product, as shown in Table (2) for Pepsi 250 ml as a sample.

Table (2); maximum value of SS level of Pepsi 250ml

Month	Max SS level for P1	Month	Max SS level for P1
T1	41112	T7	79081
T 2	42540	T 8	77165
T 3	48916	T 9	74838
T 4	47776	T 10	72550
T 5	63356	T 11	40604
T 6	51380	T 12	21299

4. Mechanism of safety stock identification

The safety stock is determined by applying dynamic fuzzy logic for the three identified variables where the max value of universe discourse for the first variable (demand stability level) is changed monthly. This is because this study was worked in a dynamic and complex environment, the mechanism of change this value is shown by following the procedure described in step (1). While in the max universe discourse of safety stock the procedures included in the article (4) it is sufficient to identify those values. By calling the procedures of step (20 and step (3) the max values universe discourse of raw material and inventory on hand are identified respectively.

5. Case Study

The validity of the proposed model is demonstrated by applying numerical example. Private soft drink industry selected as a field to test the model. High competitive environment and make to stock policy will force to optimize inventory level and reduce the problem of stock-out which occurred at different month for different products. Six products were chosen (P1, P2, P3, P4, P5, & P6). Table (3) shows the shortage occurred, where the red cells represents this shortage, while table (4) shows the parameter of this case study

Table (3) shows the shortage occurred in product for year 2016

	P1	P2	P3	P4	P5	P6
T1	0	0	0	0	0	0
T2	0	0	0	0	0	0
T3	0	0	0	0	0	0
T4	0	4106	3958	0	4417	0
T5	0	0	0	0	1417	0
T6	0	0	0	0	0	0
T7	0	0	0	0	0	0
T8	0	0	0	507	2617	0
T9	53423	0	996	7596	103	0
T10	0	0	0	0	262	0
T11	0	0	0	0	0	0
T12	0	0	0	0	0	0

By calling (FSSL) algorithm, the steps of solution for this case study are;

Table (4); parameters related to (P1) from case study above

Product	**month**	**Factor (n)**	**d(i)**	**Max.RM**	**daily.RM**	**Max.INV.**	**INV.**	**SS**
P1	T1	2	489606	6500	6500	284505	124582	41112

Step (1): Identification demand stability level

In order to control this variable (demand stability level), it is important to take the following steps;

a) Identifying of dynamic factor concept (N factor) which represent max rate of increasing in demand for a specific period (monthly). After comparing the demand for each month of the specific product with the next month, Table (5) was obtained that represents (N factor) values for each product

Table (5) ;(N) Factor values for all selected products.

Product	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
N factor	**2**	**2**	**3**	**3**	**3**	**3**

- Building of membership function set to describe the statues of demand stability level as shown in Figure (2).
- Identify max value of universe discourse of current month ($D_{(i)}$) by multiplying (N factor) by demand of previous day ($D_{(i-1)}$). For example, P1 quantity of ($D_{(i-1)}$) is (489606) and (N factor) is (2), universe discourse is (979212). The other details shown in table (6)
- Input of value of demand of current month ($D_{(i)}$).

Table (6); universe discourse values of demand stability variable

System variables	Linguistic variable	Linguistic values	Numerical ranges
Demand uncertainty condition	**Low**	**L**	**(0-0.5) *979212**
	Medium	**M**	**(0.375-0.75) *979212**
	High	**H**	**(0.625-1) *979212**

Step (2): Identification raw material availability level.

Universe discourse of raw material is identified for all year and then entered to the model in order to identify the impact of this variable on SS level. Table (7) shows the universe discourse of this variable which has quantity equal to (6500 package)

Table (7); universe discourse of raw material variable

Raw material availability	**Unavailable**	**UAV**	**(0-0.34) *6500**
	Rare available	**RAV**	**(0.125-0.9375) *6500**
	Available	**AV**	**(0.75-1) *6500**

Step (3): Identification the inventory on hand level by using fuzzy set.

Inventory on hand universe discourse and fuzzy sets were identified in this step, Table (8) shows the universe discourse of this variable in January month, where max level of raw material is (248505 packages).

Table (8); universe discourse of inventory on hand variable

On hand inventory	Low	L	(0-0.16)*248505
	Medium	M	(0.08-0.4) *248505
	High	H	(0.32-1) *248505

Step (4); Safety Stock Level (Output)

The only one output i.e. safety stock level was determined by this model, seven sets are used to identify grip the SS level. Maximum universe discourse of safety stock variable is calculated as an average demand of two days. The level of SS is assumed to have the required quantity of two days as an average and these values changed monthly for each product. For P1 max SS universe, discourse equal to (41112 package). Table (9) presents the values of SS level.

Table (9); the values of SS level for all fuzzy sets

Safety stock level	Low	L	(0.-0.08)*41112
	Little	LI	(0.05-0.2)* 41112
	Medium	M	(0.17-0.32)* 41112
	High	H	(0.3-0.42)* 41112
	Very high	VH	(0.4-0.54)* 41112
	Extreme	E	(0.51-0.65)* 41112
	Very extreme	VE	(0.62-1)* 41112

For the first product (***pepsi 250 ml***). The SS level for first month equal to (5270 package), this came via entering the data shown in Table (4) in to proposed model.

The inferred rule is (12), and because of using (AND) logic operator, then min values are selected for implication process as shown in Figure (5)

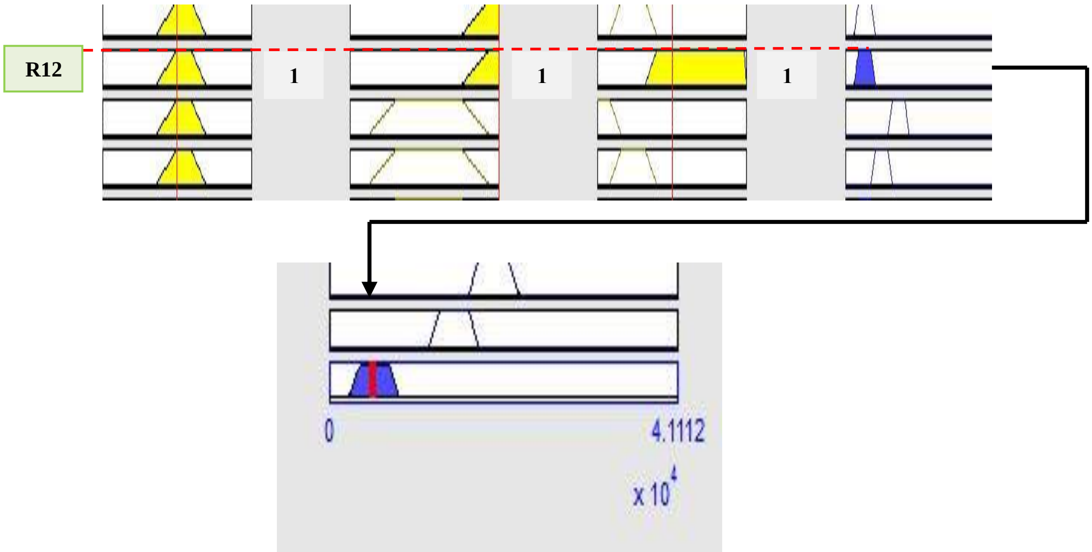

Figure (5); implication process used to calculate crisp output (safety stock)

Table (10) shows the demand of products and safety stock level monthly for 2016 year for P1 (Pepsi 250 ml) for organization before and after applying of the proposed model;

Table (10): The results of applied proposed model for first product (P1).

			Developed model		Current level
Month	Demand	Sales	Inventory	SS	Inventory on
T1	489606	534460	124285	5270	79431
T2	559670	510480	84941	8050	128621
T3	684737	635913	141941	8450	177445
T4	523251	621084	199215	9670	79612
T5	907680	823630	108352	22600	163662
T6	752818	667944	215002	6590	248536
T7	803598	1028050	306466	39500	24084
T8	1004808	1003143	121514	15600	25749
T9	893721	972893	138779	14600	53423
T10	961232	943149	74207	25000	18083
T11	540098	527855	117990	5140	30326
T12	380466	276888	135373	2700	133904

It is easy to notice that the organization suffering from shortage as shown in September month equal to (-53423 package) due to following low efficiency inventory system and it ignores the impact of SS level. While in the proposed approach, there is a great mitigation in stock-out level as shown in table (10) after application of the proposed model. It was completely different through a significant decrease in shortage occurrence for all products and in all year. This is because, the level of safety stocks in general lead to more stable organization.

Table (11) below provided with shortage quantities for all products which are appeared great reduction in the amount of the stock-out;

Table (11); stock-out quantities after implementation of proposed model.

	P1	P2	P3	P4	P5	P6
T1	0	0	0	0	0	0
T2	0	0	0	0	0	0
T3	0	0	0	0	0	0
T4	0	0	0	0	0	0
T5	0	0	0	0	0	0
T6	0	0	0	0	154	0
T7	0	0	0	0	0	0
T8	0	0	0	0	0	0
T9	0	0	0	0	0	0
T10	0	0	0	0	0	0
T11	0	0	0	0	0	0
T12	0	0	0	0	0	0

By comparing the two tables (3&11) and after implementation of the proposed model for six products for 2016 year, it is clear to notice that the results of this approach will reduce the shortage in demand fulfillment. It was dropped almost entirely, leaving only 154 in (P5 for T6) out of total shortage (79402). This is estimated at about 0.1%. The application of the proposed approach has led to the final elimination of the deficit in the provision of products with a significant increase in the level of inventory.

6. Conclusion

Based on the obtained results of applying the proposed model in beverage industries; the following conclusions can be drawn;

- The rest of stock-out after applying the proposed model is not more 0.1%, which meaning that the use of dynamic fuzzy logic is an indispensable technique to solve this type of problems.

- High ratio of stock-out mean that the organization must to use advanced forecasting methods and applying new approaches to help them in reduction stock-out level.
- The finding of the research demonstrated the urgent need to adopt advanced methodologies and ideas such as soft computing to control the inventory, especially when it working in such a competitive and dynamic environment.
- Based on reduction in stock-out, the relationship with upstream zone of supply chain (suppliers) must be enhanced.
- Based on current SSL of organization, there is clear evidence that the application of common statistical safety stock equations represents a clear weakness in identification of SSL.
- The inclusion of the proposed model for the three variables i.e. (demand stability level, raw material availability, and inventory on hand) made it possible to apply it in other industries with easy manner.

There is a clear limitations of this research can be treated. Embedded of some variables and take into account in identifying SSL is important. These variables are electricity shut down, internal country crisis, and climate conditions. There are some research areas that can be developed by using this model, such as the check the possibility of applying this model in services field.

Table (12); the abbreviation used in the research.

Symbol	*Definition*
SSL	*Safety stock level*
MTS	*Make to stock*
FSSL	*Fuzzy safety stock level*
AV	*Available*
UAV	*Unavailable*
RAV	*Rare available*

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

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تحديد مستوى خزين الامان في صناعة المشروبات الغازية وذلك باستخدام المنطق الضبابي الديناميكي

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الخلاصة:

يعتبر تحديد المستوى الأمثل لمخزون الامان عنصرا هاما في سلسلة توريد صناعات المشروبات الغازية. في هذه البحث، تم استخدام المنطق الضبابي الديناميكي كنهج متقدم لتحديد مستوى مخزون الامان في صناعات المشروبات الغازية بهدف تقليل الكلفة الإجمالية وتلبية متطلبات العملاء .ان حدوث مشكلة النقص وعدم تلبية طلبات المستهلكين في هذه الشركات بسبب ضعف استراتيجيات الخزين المتبعة تعتبر امرا سلبيا للغاية، لذا فإن توفير استراتيجية خزين الامان المتقدمة سيؤدي إلى التغلب على هذه المشكلة خاصة بالنسبة إلى الشركات التي تعمل ضمن سياسة التصنيع لاجل التخزين. في هذا البحث تم تضمين ثلاث خطوات رئيسية هنا لتحديد مستوى الخزين الامن SS وهي أولاً، بناء مجموعة ضبابية لكل متغير، وثانيًا تحديد القيم القصوى لتمثيل مستوى الاحداثي السيني للمتغير الضبابي وكذلك تحديد قيم المدخلات الشهرية للمتغيرات، وأخيراً، تنفيذ النموذج المقترح في أداة المنطق الضبابي وذلك من خلال تطبيق برنامج .Matlabوالذي يوفر الحل الموصى به ومن اجل اثبات صلاحية النموذج المقترح، تم تطبيقه لحل مشكلة في احدى شركات صناعة المشروبات الغازية وكذلك يثبت صلاحية النموذج المقترح والمناسب لهذه الصناعات. بعد تطبيق النموذج المقترح حدث تخفيض في العجز في تلبية طلبات المستهلكين بنسبة تصل الى 99.9% حيث انخفض مستوى العجز من (53,423 علبة) الى (154 علبة) فقط. أظهرت النتائج التي تم الحصول عليها من البحث الحاجة إلى اعتماد منهجيات متقدمة مثل الحوسبة الناعمة لتحديد مستوى مخزون السلامة.

الكلمات المفتاحية: الامثلية لمستوى مخزون الامان بشكل دينامي، امثلية الخزين، المنطق الضبابي الديناميي، صناعات المشروبات الغازية.