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Analysis of safety stock determination methodology-quantity vs. time buffers

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Abstract

In supply chain management, the safety stock approach is a viable solution to counter supply and demand uncertainty. Safety stock ensures safety against forecast errors and buffers against events that could not be predicted during the supply and demand forecast. Forecasting is an art, and safety stock calculation is science. Today various methods exist to determine safety stock, like static quantity based on historical data, Dynamic determination of minimum and maximum safety stock quantity through coverage profiles for each material, service level-based quantities, and maintaining safety stock based on time buffer instead of quantity buffer. The primary goal of this research is to analyze which method among quantity buffer /time buffer makes sense to different types of organizations based on various factors. Based on the systematic review of the recent studies, this paper suggests the appropriate approach for the unit of measure (UOM) for the safety stock for the products of the stable and low volume, regular and high volume, intermittent and low volume demand patterns, High seasonal, and high volume but has higher fluctuation categories. As a result, the conclusions of this study will help future researchers accurately anticipate the unit of measurement of safety stock based on their business conditions.

Keywords: High volume, Low volume, Safety stock, Seasonality, Unit of measurement, Variance in customer, Variance in lead time

1. Introduction

Inventory and safety stock management are two critical components of supply chain management. Supply chain management contributors strive to maximize the utilization of safety stock. Safety stock not only guards against unexpected increases in demand but also aids in market forecasting, particularly during peak seasons. Safety stock is one of the well-known tactics for managing inventory supply and demand, which is why most businesses utilize it to improve the performance of their supply chain process. [1]. Determination of the appropriate approach for the unit of measure (UOM) in the safety stock is considered one of the most challenging and vital tasks handled by the operation managers in an organization [2]. The quantity of inventory that an organization chooses to hold can have dramatic consequences on the overall business operations [1]. An inappropriate UOM strategy in the safety stock can lead to higher inventory holding costs. Similarly, sometimes due to improper quantity estimation or UOM, the organization faces inventory shortages, which leads to sales loss. That is why identifying the appropriate strategy for the unit of the measure is crucial for any organization [2].

Several techniques are used to measure the demand for products for the condition. Economic order quantity is the strategy used for units of measurement for safety stock. This method is also familiar with the name of the Wilson formula [3].

$$Q = \sqrt{\frac{2 \times K \times D}{G}} \tag{1}$$

where Q is the optimum quantity of every order, D is the annual demand for the raw material, Q is the cost of the order, K is cost of placing the order, and G is storage cost for each order for the appropriate unit of measurement for safety stock through the Economic Order Quantity (EOQ)

The main aim of this unit of measurement (UOM) is to keep the little stock according to the possibilities by fulfilling the service demand [2]. In this way, EOQ supports the measurement unit concerning the quantities [3]. There are several other approaches for determining the unit of measurement, but their applications are highly dependent on the circumstances [2].

Companies confront issues regarding safety stock, such as effective inventory management, stock placement, and stock dimensions. As a result, there are several disruptions or problems related to supply chain management. Furthermore, it has been found that there are a few issues associated with this approach of the unit of measurement of safety stock. The EOQ approach of measuring safety stock is best if there is no issue in the supply chain. For the appropriate UOM, it is crucial to revisit this EOQ formula as supply chain disruptions arise over time. The primary goal of the research project is to determine and select the best approach for the unit of measurement for safety stock. As a result, the technique and critical analysis continue as follows.

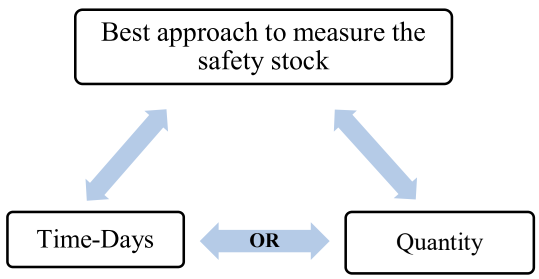

Figure 1 Conceptual (systematic review).

It has been seen that most organizations face challenges when it comes to the measurement and estimation of the safety stock. The main objective of the present paper is to investigate and find the suitable unit of measure for the safety stock with the help of a systematic review (Figure 1). The research question is presented: How Should the Safety Stock determination approach be Time- or Quantity-based buffer?

2. Materials and methods

2.1 Research approach and design

Research approach and design assists in achieving the desired results [4]. Appropriate research design can be attained with the cooperation of well-planned strategies. That is why research design is considered an integral part of the research [4]. Hence, the study's main findings are according to secondary sources (past research), and more emphasis is given to qualitative analysis. The framework of this research is designed so that the inventories are divided into different categories based on the volume demand pattern, seasonality, trends fluctuation, and turnover. Then the unit of measurement (UOM) is analyzed based on these categories. It is not justifiable to create a single unit of measure for all types. However, the emphasis of the research revolves around subjective and statistical information [5].

2.2 Sources of data

This study is based on secondary data collection as per the nature of the research and its fundamental objectives. Secondary data assists in the systematic investigation and analysis. The data is gathered from the existing articles related to this research [5]. The main issues arise in the unit of measurement when all of the safety is measured similarly. However, this research uses secondary data to attain consistency in the safety stock by focusing on critical issues such as supplier delays and demand patterns.

2.3 Data analysis

Data analysis of this research is highly dependent on secondary data, and appropriate data collection leads to the analysis part [6]. Therefore, the study is based on both statistical and past research. The inventory is distributed into several groups based on their volume demand pattern, seasonality, fluctuations, and turnover. Concerning this, data of each group of safety stock is analyzed individually. In this way, each safety stock reflects a separate unit of measure (UOM).

2.4 Research assumption

The z-score is one of the most traditional and widely used methods for measuring and identifying safety stocks [7]. Hence, different cases are based on the equations presented for the analysis. Unit of measurement is essential for safety stock. Similarly, safety stock is crucial for accurately handling supply chain operations [8]. This study assessed the usage of several methodologies for the unit of measurement of safety stock, as well as some insight into how and why the individual formulae are employed; it also provides an example. Uncertain demand, on the other hand, can result in stakeouts. [9]. The goal of this study is to justify the optimal techniques for the safety stock's unit of measure (UOM) as days (Time) or amounts (quantity). Fill rates and cycle service levels, variation in consumer demand, and variation in lead time are some techniques businesses employ to assess the safety stock level. As a result, it is thought that both approaches to measuring safety stock depend on the circumstances. Furthermore, this research focuses on finding the best methods of UOM in terms of quantity or days.

2.4.1 Basics of safety stock calculations

2.4.1.1 Variance in demand of the consumers

Below is a statistical study of a business that has acquired an excess of stock, similar to 1.65 standard deviations of the demand of the consumers needed to supply the stock to the consumers at a ninety-five percent confidence level. The scenario discussed is the case that the Z score amounts to 1.65. The following graph show the relationship between the desired cycle service levels to the Z-score (Figure 2).

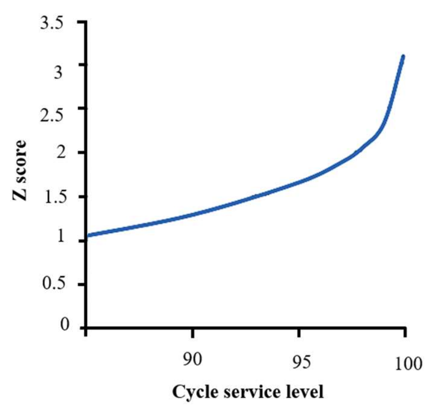

Figure 2 Cycle service level [15].

From this graph above, it can be noticed that a larger volume of cycle service levels will create a larger Z-stock, making the business ultimately carry a larger volume of safety stocks. Suppose the aforementioned standard deviation of demand is determined using weekly demand data and the entire lead time, including the review period, is twenty-one days. In that case, the standard deviation of demand is equal to the weekly standard deviation multiplied by the square root of the time unit ratio, or 31/2. The following basic safety stock equation can be used [17-19]:

$$\text{Safety stock} = Z \times \left(\frac{PC}{T^1}\right)^{\frac{1}{2}} x\, \sigma_D \tag{2}$$

where: T1 = Time increment, Z = Z-score, σ_D = standard deviation of demand and PC= Performance cycle, or entire lead time.

e performance cycle encompasses the time spent on tasks like determining what to purchase or manufacture, transmitting orders to suppliers, manufacturing and handling, and distribution and warehousing [19].

2.4.1.2 Variance in lead time

Safety stock is utilized to offset demand fluctuation in the prior calculation. When lead time unpredictability seems to be the significant issue, the following safety stock calculation can be used:

$$\text{Safety stock} = Z \times \sigma_{LT} \times D_{avg} \quad (3)$$

where: D_{avg} = average demand, and σ_{LT}= standard deviation of lead time. The following formulae is used when there is a high fluctuation and no relation between demand and the lead time.

$$\text{Safety stock} = Z \times \left(\frac{PC}{T^1} \times \sigma_D{}^2\right) + \left(\sigma_{LT} \times D_{avg}\right)^{2\,\frac{1}{2}} \quad (4)$$

This given equation can only be used when the demand and the lead time are not directly proportional. For example, the following formulae can be used if the case is otherwise:

$$\text{Safety stock} = \left(\frac{PC}{T^1}\right)^{\frac{1}{2}} \xrightarrow{} {}^{\frac{1}{2}} \times \sigma_{D \times Z)} + \left(Z \times \sigma_{LT} \times D_{avg}\right) \quad (5)$$

2.4.1.3 Fill rate and cycle service level

The previous passage has discussed two formulas that may be used by business to estimate the amount of safety stock. Sometimes a company may want to manage the proportion of quantity bought that is accessible to meet consumer demand, a metric called fill rate.

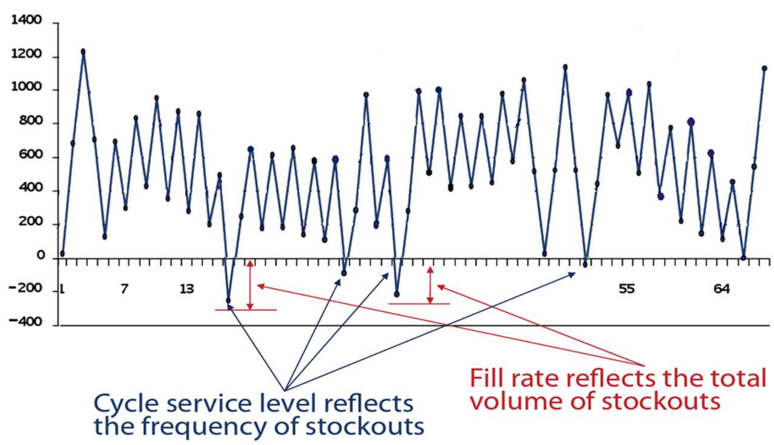

Figure 3 Finished product inventory [15].

When demand standard deviations and lead times acquire, a lesser fill rate will generally have a more extensive cycle service level. The fill rate is slower in the lead time and the demand has a high number of fluctuations (Figure 3) [20,21].

3. Results and discussion

3.1 Safety stock unit for intermittent and low volume demand pattern

In this section, we will discuss how an irregular and low-volume demand pattern can cause many complications when calculating safety stock and determining a perfect unit of measurement due to the high amount of financial resources required to acquire the stock as well as the significant amount of time it takes for the stock to be produced; thus, a simulation is one of the preferred methods for determining the right amount of safety stock levels that can be maintained. Theoretical methods often tend to implicate matters as they cannot cater to many factors influencing the demand for the stock. This paper will demonstrate how a simulation can compensate for the shortcomings of intermittent demand that has had its safety calculated by theoretical methods [25]; this report will analyze the results of the simulation set for safety stock in a fixed quantity to analyze how the irregular and low volume demand pattern; safety stock expressed in days causes the safety stock to fluctuate wildly while the demand does not fluctuate (other than being intermittent). Such parameters can upset the stock level when an unnatural rise in demand arises for the kept stock; one of the most important factors included in this set of parameters is UOM.

While determining whichever UOM to utilize, a corporation must consider the demand for the product as well as the stock lead time; it'll become easier to focus development efforts if a company realizes which elements dominate an equation as well as its safety supply [22]. If a high level of client interaction is not required, the safety supply can indeed be lowered to a more tolerable level [23]. Nevertheless, before making any changes, a company should employ the root cause technique to determine if any specific causes are to blame for the deviations from expected outcomes [24]. If the UOM uses the Quantity technique, it should be aware of the quantity of stock it needs to keep rather than the days it needs to refill because its stock might be sold in small or large quantities. It is probable that the UOM will have stock that is difficult to sell, such as pricey technological equipment, vehicles, or merchandise. The days it takes to refill such a commodity must be measured. Any firm that sells items sporadically and in low volume must recognize that holding a specified amount of product inventory at all times is critical to staying in business [10]. If a warehouse kept much merchandise at any given moment, it would jeopardize its business by tying up much money in its working capital. [11]. This evaluation introduces the notion of safety stock; safety stock is stock retained by a corporation more than projected demand due to a fluctuating demand rate or variable lead time [12]. In summary, the benefit of employing the right UOM is that it saves the firm time when selecting how to replace its inventory.

3.2 Safety stock unit for stable and low volume

This portion of the article will go through the items sold in a steady and low volume. The unit of measurement to be employed relies on market circumstances, the kind of stock, and the equations used to determine the safety stock. In any case, using the word kg or any equivalent unit is the best approach to determine how much of a particular commodity remains. If the product is a device, a car, then the best way to determine how much quantity a specific product remains is through "units" since there is no other measurement. Either way, the use of units depends on the type of safety stock calculation method used and does not affect much the kind of safety stock measurement that fits best according to the UOM in question. Nonetheless, while choosing the sort of safety stock calculation technique to adopt, it is wise to grasp the significance of the unit utilized. For example, if the stock has a shallow volume flow (as in the case of vehicles, three or four units), the calculating technique employed would be different because the value of days while supplying a commodity such as toilet paper is more diminutive. These circumstances necessitate a distinct safety stock calculation approach, and both would result in a further analysis based on that calculation. The following section of the passage will examine how the safety stock for sold items is steady and how volume should be maintained.

When the amount of stock is important, the economic order quantity formula is the best since it takes into account the keeping cost of the materials. For example, if autos are included, the cost of keeping and maintaining the car will be added. Let us assume that a Company ABC deals in the buying and selling of cars; if the company sells 100 cars per year, with a fixed cost to hold a single car in stock of $1200 per year and a fixed cost to place an order of $480, the Economic Order Quantity would be, using the formulae = 8.94, indicating that the ideal order size for the company is nine cars.

3.3 Safety stock unit for products sold year-round but exhibiting high seasonality

This section of the article will discuss one of the best products that can serve as the basis for year-round products but exhibits high seasonality in the sale of cakes; cakes are sold all year to be used for birthdays, celebrations, and other types of events, but their demand increases, especially during the wedding season (from June to September). Cakes are in more demand during the wedding season. As a result, the company should design the stock cycle to adjust for demand constantly. If the business cannot cater to this, there is a high chance that it will end up with a high volume of stock at the time when the season has ended [26]. A suitable method to sell a product that is sold all year round and has high seasonality is to use time-varying days to express safety stock. Usually, for such a circumstance, the is to set 0 days just after the season; this means that the use of the basic stock formulae is renewed with the coming and going of the season [26]. A business must be able to cater to these changes in the season and have a well-thought-out plan to effectively cater to the rise and fall of the demands of the product. The UOM for the products depends on the type of products and the volume of order, which are discussed in the previous passages.

3.4 Safety stock unit for products sold in high volume but fluctuating, volatile or cyclical

This section of the report will discuss that to maintain a safety stock that can cater to a high volume of supply while also dealing with the implications of fluctuation, volatile, or cyclical demand, it is best to account for the lead time that is required between the time a customer places an order for the product and the time it takes for the product to be sold to the customer [26]; this is because different businesses have different ways to replenish t It is essential to create a model that can cater to the current season's need. Usually, a company can figure out when the stock is in high demand or when it will be in high demand; similarly, the business can also find out when the order will be low and when the demand for the product will start to reduce. If not, the company must analyze when the product is expected to increase in demand [26]. The UOM for the products depends on the type of products and the volume of order, which are discussed in the previous passages.

3.5 Safety stock unit for stable and high volume

This part of the report will address the considerations that come into play when a UOM has to decide on the type of safety stock applications it must employ to maintain a continuous flow of sales and purchases of its products to ascertain the fact that a product is sold stable and in high volume. It is determined by the influx and outflow of stock, market supply, and demand figures, the cost of acquiring or manufacturing the items, and supplier lead times. Considering that the inventory is perishable, it is prudent to maintain stock concerning the selling volume. In this given case, it would be prudent for the UOM to maintain safety regarding the days it takes for the stock to remain in the warehouse and then to be sold from the warehouse to the retailer or consumer [27]. Usually, such products are not seasonal, as seasonal products have a high demand and are sold in large quantities. The next part of the passage will analyze how the safety stock for products sold is stable and how volume should be maintained.

The main stock calculation takes no account of market variables (seasonal occurrences, for example) or other expenses. However, it is still helpful in determining the principal quantity of the safety stock that a firm must hold if it sells them in large quantities. For the sake of this article, let us imagine that EFG is a company that buys and sells water. The firm sells 80 barrels daily and wants three days' worth of safety stock. Using the Basic Safety Stock Formulae, it is determined that the corporation must have a safety stock of 240. This firm now has no maintenance costs because its product is highly sought after and is bought and sold regularly. Moreover, the company does not have to see the market conditions, as the demand for water remains stable throughout the year. Therefore, there is no need for the company to go through extra calculations and research other than to ensure that it has three days' worth of stock at all times.

3.6 Stock outs and their influence on the appropriate unit of measurement

This section of the report will address the purpose of safety stock, which is to mitigate the effects of stock out; stock-outs occur due to a variety of factors, including variations in consumer demand for the product, inaccurate forecasting of the demand for the product set by the business, variations in the lead time of the production and the product, and changes in the use of raw materials [13]. Stock-outs usually occur when operation managers decide the amount of stock kept in warehouses based on self-estimates, without any statistics or study of the market or ongoing trends [14]. This evaluation will go over a reliable mathematical strategy, describing how a corporation can keep the number of goods on hand [15,16]. The safety stock will be used in more than 45 percent of the cycles, but the firm should expect a safety stock for the remaining 5%. If market circumstances change, the company should utilize a new form of UOM, considering the volume and timeliness of when the company needs to replenish [16]. Overall, if a company strives for a higher service level, such as 98 percent, it may result in fewer stock-outs; nevertheless, it will also demand a considerable increase in safety stock.

3.7 Safety stock in industry 4.0

Industry 4.0 seeks to alter the manufacturing and engineering sectors by establishing factories where cyber-processing systems connect via Artificial Intelligence based technologies, big data, Internet of Things, allowing people and machinery to complete their work as quickly as possible with the implementation of advanced techniques. However, support of the top management, internal resources, and instructional staff expertise and capabilities are critical for Industry 4.0 implementation as there is a need to understand the advanced concepts [28]. Inventory management must understand its consumers and suppliers thoroughly. Industry 4.0 opens all possibilities for inventory management to maximize income as machine learning, Artificial Intelligence technologies, and other advanced technologies can improve working efficiency, specifically in inventory management or safety stock measuring. However, they work on the algorithmic scale, which automatically operates based on the provided data. Due to this, it is crucial for the firms to at least decide the appropriate method based on the circumstances and companies' operations. These practices are being applied on a very small scale worldwide due to people-related constraints, such as change aversion, a digital skills gap, increasing socioeconomic inequalities, organizational culture challenges, and a lack of industry-wide collaboration and leadership [29]. The use of AI and big data can help organizations to make decisions on the possible approach of choosing Time buffer vs. Quantity buffer based on the regular analysis of stock outs – safety stock maintained with changes in demand patterns.

Another key safety stock solution used by the popular ERP system SAP is the coverage profile. The coverage profile is used for calculating the dynamic safety stock. The safety calculation here is based on the average daily requirement of the material. The dynamic safety stock calculation depends on the requirements within the specified period and the range of coverage. The dynamic safety stock method takes demand fluctuations into account.

$$\text{Dynamic safety stock} = \text{Average daily requirement of the material} \times \text{Range of coverage} \quad (6)$$

$$\text{Average daily requirements} = \frac{\text{Sum of Requirements in the no.of periods}}{\text{No.of days in the number of periods}} \quad (7)$$

$$\text{Range of coverage} = \frac{\text{Current Stock}}{\text{Average usage per day}} \quad (8)$$

Modern-day answers to lean safety stock can also be achieved by exposing the forecast of raw material requirements with your preferred vendors across the globe and viewing the inventory situation of those raw materials in vendor premises. Instead of buying the material and keeping it in the inventory for a long, you can always buy the raw material just in time by making decisions through AI/ML based on various parameters like the vendor's inventory, his ability to transport at the least cost, and the best possible price.

4. Conclusion

Several factors influence the selection of the right Time vs. Quantity methodology for safety stock determination in businesses, either directly or indirectly. Storing safety stock is a widely used approach, particularly in the logistics sector. [23]. Therefore, having too much safety stock might be problematic because it limits the available resources and indicates that organizations' forecasting is inefficient. Typically, this occurs due to an incorrect storage projection without considering the demand forecast. [24]. The above analysis regarding UOM indicates that for analyzing the irregular and low-volume demand pattern, it would be best to determine the safety stock in a fixed quantity. If the product belongs to the stable and low volume category, in that case, the best way to determine how much quantity a specific product remains is through "units" since there is no other measurement. On the other hand, using time-varying days to represent safety stock is a viable strategy for selling a product that is sold all year round and has strong seasonality. It is recommended to handle safety stock for solely seasonal products using time-varying days (Time buffer). Hence, it is best to cater to a high volume but variation to keep a safety stock that can cater to the lead time. Finally, for steady and high-volume items, measuring and maintaining safety stock in days is preferable (Time Buffer). As a result, the findings may alleviate future researchers' concerns about the safety stock's UOM.

5. References

[1] Gonçalves JN, Carvalho MS, Cortez P. Operations research models and methods for safety stock determination: a review. Oper Res Perspect. 2020;7:100164.

[2] Paul B, Tondihal S, Das BB. Safety stock in inventory management and wastage analysis at construction sites. In: Das BB, Nanukuttan SV, Patnaik AK, Panandikar NS, editors. Recent trends in civil engineering. 1st ed. Singapore: Springer; 2021. p. 509-517.

[3] Zenkova ZN, Musoni W. The economic order quantity taking into account additional information about the known quantile of the cumulative distribution function of the product's sales volume. Bus Inform. 2020;3(eng):24-34.

[4] Omair A. Selecting the appropriate study design for your research: Descriptive study designs. J Health Special.2015;3(3):153.

[5] Kothari CR. Research methodology methods and techniques. 1st ed. New Delhi: New Age International (P) Ltd; 2004.

[6] Visser M, editor. Recognition and (de) humanization in the neoliberal workplace: Prospects and possibilities.36th EGOS Colloquium. 2020 Jul 2-4; Colloquium, Hamburg. Hamburg: Radboud University; 2020.

[7] Curtis AE, Smith TA, Ziganshin BA, Elefteriades JA. The mystery of the Z-score. Aorta. 2016;4(04):124-130.
[8] Barros J, Cortez P, Carvalho MS. A systematic literature review about dimensioning safety stock under uncertainties and risks in the procurement process. Oper Res Perspect. 2021;8:100192.
[9] Brunaud B, Laínez-Aguirre JM, Pinto JM, Grossmann IE. Inventory policies and safety stock optimization for supply chain planning. AIChE J. 2019;65(1):99-112.
[10] Lee CJ, Rim SC. A mathematical safety stock model for DDMRP inventory replenishment. Math Probl Eng. 2019;2019:6496309.
[11] Ranjith AM, Pillai VM. Determination of Safety Stock in Divergent Supply Chains with Non-stationary Demand Process. In: Pandey PM, Kumar P, Sharma V, editors. Advances in Production and Industrial Engineering. Singapore: Springer; 2021. p. 63-73.
[12] Sarkar M, Sarkar B. Optimization of safety stock under controllable production rate and energy consumption in an automated smart production management. Energies. 2019;12(11):2059.
[13] Bruzda J. Demand forecasting under fill rate constraints-The case of re-order points. Int J Forecasting.2020;36(4):1342-1361.
[14] Rodrigues LR, Yoneyama T. A spare parts inventory control model based on Prognostics and Health monitoring data under a fill rate constraint. Comput Indust Eng. 2020;148:106724.
[15] Trapero JR, Cardos M, Kourentzes N. Empirical safety stock estimation based on kernel and GARCH models.Omega. 2019;84:199-211.
[16] Gonçalves JN, Carvalho MS, Cortez P. Operations research models and methods for safety stock determination: a review. Operations Research Perspectives. 2020;7:100164.
[17] Persson F, Axelsson M, Edlund F, Lanshed C, Lindström A, Persson F, editors. Using simulation to determine the safety stock level for intermittent demand. 2017 Winter Simulation Conference (WSC). 2017 Dec 3-6; Las Vegas, NV, USA. USA :IEEE; 2017.
[18] Gonçalves JN, Carvalho MS, Cortez P. Operations research models and methods for safety stock determination: a review. Operations Research Perspectives. 2020;7:100164.
[19] Fillie S, Arvitrida NI, Pujawan, NI, editors. Simulation study of collaborative inventory management for seasonal products by incorporating newsvendor and buyback contract. The 21st International Conference on Engineering and Management in Industrial System (ICOEMIS 2019). 2019 Aug 8-9; Malang, Indonesia. Dordrecht: Atlantis Press; 2019.
[20] Pham TN, Tan A, Ang A. Determining safety stock for an omni-channel environment. Int J Inform Syst Suppl Chain Manag. 2020;13(2):59-76.
[21] Cai X, Du DL. On the effects of risk pooling in supply chain management: Review and extensions. Acta Mathem Appl Sinica, English Ser. 2009;25(4):709-722.
[22] Deiranlou M, Dehghanian F, Pirayesh MA. The simultaneous effect of holding safety stock and purchasing policies on the economic production quantity model subject to random machine breakdown. Int J Eng. 2019;32(11):1643-1655.
[23] Beutel AL, Minner S. Safety stock planning under causal demand forecasting. Int J Produc Econ.2012;140(2):637-645.
[24] Jonsson P, Mattsson SA. An inherent differentiation and system level assessment approach to inventory management: a safety stock method comparison. Int J Logist Manag. 2019;30(1):663-680.
[25] Kania A, Sipilä J, Afsar B, Miettinen K. Interactive multiobjective optimization in lot sizing with safety stock and safety lead time. In: Mes M, Ruiz-Lalla E, VoB S, editors. Computational Logistics Cham: Springer; 2021.p. 208-221.
[26] King PL. Crack the code: Understanding safety stock and mastering its equations. APICS magazine.2011;21(2011):33-36.
[27] Kumar K, Aouam T. Extending the strategic safety stock placement model to consider tactical production smoothing. Eur J Oper Res. 2019;279(2):429-448.
[28] Srivastava DK, Kumar V, Ekren BY, Upadhyay A, Tyagi M, Kumari A. Adopting Industry 4.0 by leveraging organisational factors. Technol Forecasting Soc Change. 2022;176:121439.
[29] Mukhuty S, Upadhyay A, Rothwell H. Strategic sustainable development of Industry 4.0 through the lens of social responsibility: The role of human resource practices. Bus Strategy Environ. 2022;31(5):2068-2081.