An Optimization Model for Inventory System and the Algorithm for the Optimal Inventory Costs Based on Supply-Demand Balance

Abstract

In order to investigate the inventory optimization of circulation enterprises, demand analysis was carried out firstly considering supply-demand balance. Then, it was assumed that the demand process complied with mutually independent compound Poisson process. Based on this assumption, an optimization model for inventory control of circulation enterprises was established with the goal of minimizing the average total costs in unit time of inventory system. In addition, the optimal computing algorithm for inventory costs was presented. Meanwhile, taking the agricultural enterprises in Aksu, Xinjiang, China, for example, the researchers conducted numerical simulation and sensitivity analysis. Through constantly adjusting and modifying the parameters values in model, the optimal stock and the optimal inventory costs were obtained. Therein, the numerical results showed that the uncertainty of lead time greatly influenced the optimal inventory strategy. Besides, it was demonstrated that the research results provided a valuable reference for the agricultural enterprises in terms of optimal management for inventory system.

1. Introduction

Warehousing is an important part of logistics system. Inventory control of warehousing has been widely focused on by circulation enterprises and relevant scholars all the time. If the stock is high, smooth business process can be fully guaranteed to improve service level and customer satisfaction, while if the stock is low, capital backlog of enterprises and the corresponding management costs are able to be reduced (as in [[1](https://www.hindawi.com/journals/mpe/2015/508074/#B1)]), to optimize and control stock matters to the service quality and economic benefits of circulation enterprises. In addition, the sustainable development of circulation enterprises is crucial.

Owing to the significance of inventory optimization and control in circulation enterprises, there are many relevant scholars that begin to pay attention to this. In the last two decades, the issue has attracted much attention from many researchers. Among these researches, economic order quantity (EOQ) model based on stock-dependent demand was established (as in [[2](https://www.hindawi.com/journals/mpe/2015/508074/#B2)]). Besides, the production-inventory model for perishable items with definite productivity and with demand linearly depending on inventory level was considered (as in [[3](https://www.hindawi.com/journals/mpe/2015/508074/#B3)]). Some scholars explored the inventory issue with allowable shortages under inventory-level-dependent demand; at the same time, they also took monetary value as well as the expansion rate caused by external and internal costs into consideration (as in [[4](https://www.hindawi.com/journals/mpe/2015/508074/#B4)]). In addition, EOQ model for perishable items was established, where the perishable items were under the following conditions: the demand rate was related to inventory level and some stock-outs could be supplemented later (as in [[5](https://www.hindawi.com/journals/mpe/2015/508074/#B5)]). Cárdenas-Barrón et al. (as in [[6](https://www.hindawi.com/journals/mpe/2015/508074/#B6)]) studied the optimal solution of multiproduct EOQ model. Moreover, the optimal replenishment strategy for perishable items was investigated aiming at maximizing profits (as in [[7](https://www.hindawi.com/journals/mpe/2015/508074/#B7)]), while the inventory optimization for perishable items under stock-dependent demand was studied as well (as in [[8](https://www.hindawi.com/journals/mpe/2015/508074/#B8)]). Wang et al. (as in [[9](https://www.hindawi.com/journals/mpe/2015/508074/#B9)]) discussed the inventory control model for fresh agricultural products on Weibull distribution under the assumption that the inflation rate is higher than the natural decay rate. Paul and Rajendran (as in [[10](https://www.hindawi.com/journals/mpe/2015/508074/#B10)]) studied the problem of rationing mechanisms and inventory control-policy parameters for a divergent supply chain operating with lost sales and costs of review. Krishnamoorthy and Narayanan (as in [[11](https://www.hindawi.com/journals/mpe/2015/508074/#B11)]) considered the stability and performance analysis of a production-inventory system. Yadavalli et al. (as in [[12](https://www.hindawi.com/journals/mpe/2015/508074/#B12)]) studied the problem of updating service facilities for inventory system to achieve production and service synchronization. From the inventory cost and the cost of order to determine the optimal order point and quantity, Doğru et al. (as in [[13](https://www.hindawi.com/journals/mpe/2015/508074/#B13)]) pointed out enterprises adjust inventory quantity through a large number of buffer stocks and there is a serious bullwhip effect. Hua et al. (as in [[14](https://www.hindawi.com/journals/mpe/2015/508074/#B14)]) studied the carbon emissions in inventory management. The corresponding model is established by the joint of replenishment strategy, and through genetic algorithm, Zhou et al. (as in [[15](https://www.hindawi.com/journals/mpe/2015/508074/#B15)]) gave the solution and simulation of the model. Murray et al. (as in [[16](https://www.hindawi.com/journals/mpe/2015/508074/#B16)]) studied the multiproduct pricing and inventory issues. Choi and Ruszczyński (as in [[17](https://www.hindawi.com/journals/mpe/2015/508074/#B17)]) established a multiproduct risk-averse newsvendor, and they pointed out that the increase of risk aversion does not necessarily lead to the reduction of the order quantity. Schrijver et al. (as in [[18](https://www.hindawi.com/journals/mpe/2015/508074/#B18)]) studied the optimization model and algorithm of multiproduct demand inventory network design for stochastic demand and inventory decision. Based on the theory of nonlinear integer programming, Yang et al. (as in [[19](https://www.hindawi.com/journals/mpe/2015/508074/#B19)]) studied the integrated multiproduct optimization model. Liu et al. (as in [[20](https://www.hindawi.com/journals/mpe/2015/508074/#B20)]) studied the flexible service policies for a Markov inventory system with two demand classes. Zhao and Lian (as in [[21](https://www.hindawi.com/journals/mpe/2015/508074/#B21)]) studied the priority service rule of a queueing-inventory system with two classes of customers. Karimi-Nasab and Konstantaras (as in [[22](https://www.hindawi.com/journals/mpe/2015/508074/#B22)]) studied an inventory control model with stochastic review interval and special sale offer. By determining the level of customer’s anchoring effect, Liu and Shum (as in [[23](https://www.hindawi.com/journals/mpe/2015/508074/#B23)]) studied the joint control of pricing and inventory allocation in two periods of retailers based on constructing the customer’s disappointment aversion utility function. Mo et al. (as in [[24](https://www.hindawi.com/journals/mpe/2015/508074/#B24)]) researched the inventory issue for the perishable multi-items with just-in-time (JIT) inventory-level-dependent demand. Ji and Jin (as in [[25](https://www.hindawi.com/journals/mpe/2015/508074/#B25)]) established an inventory optimization model meeting the restrained conditions of being controllable in lead time and service level. Li (as in [[26](https://www.hindawi.com/journals/mpe/2015/508074/#B26)]) studied the control and optimization model for multiechelon inventory in supply chain, while the optimization method for two-echelon inventory system based on stochastic lead time was researched by Dai et al. (as in [[27](https://www.hindawi.com/journals/mpe/2015/508074/#B27)]). Zhao (as in [[28](https://www.hindawi.com/journals/mpe/2015/508074/#B28)]) presented an optimization study on multiechelon inventory in supply chain on the basis of time competition, while Wang (as in [[29](https://www.hindawi.com/journals/mpe/2015/508074/#B29)]) studied the optimization model for production-inventory under uncertain environments. Fu and Pan (as in [[30](https://www.hindawi.com/journals/mpe/2015/508074/#B30)]) mainly explored disposing the inventory management problem by using fuzzy theory under uncertainty to derive the fuzzy mathematical model for single inventory management with multiple fuzzy parameters in the case of allowing moderate shortages. Besides, supply chain inventory optimization with controllable lead time under fuzzy environment was investigated by Li and Xu (as in [[31](https://www.hindawi.com/journals/mpe/2015/508074/#B31)]). Wang and Guo (as in [[32](https://www.hindawi.com/journals/mpe/2015/508074/#B32)]) analyzed the inventory risk loss led by the EOQ and order cycles of classical inventory models under fuzzy demand to deduce the economic risk function in fuzzy situation. Kong and Jirimutu (as in [[33](https://www.hindawi.com/journals/mpe/2015/508074/#B33)]) researched the inventory optimization under stochastic demand based on Monte Carlo simulation. Xu et al. (as in [[34](https://www.hindawi.com/journals/mpe/2015/508074/#B34)]) explored the inventory control model during random replenishment interval with inventory-level-dependent demand.

Most of the above researches were conducted on the basis of continuous normal population, which made the researches convenient and operable to some extent. However, on the premise of uncertain supply and demand, there were a lot of uncertain factors for inventory optimization. In fact, most of the demand and supply in reality cannot distribute continually but present in the form of discrete random variables usually. As a result, on the assumption that the demand process of each subwarehouse submitted to the mutually independent compound Poisson process, the authors carried out the researches on some aspects, including the optimization and control of inventory system based on supply-demand balance as well as the algorithm design for the optimal inventory costs. In addition, the related researches have a certain value on theoretical research.

Although there have been quite a few researches on inventory control, it is still necessary to take many factors and variables into account due to its systematicness and complexity of inventory problem. Besides, it is difficult to quantify and define the optimal inventory because the correlation degrees between each factor are fuzzy. In view of the above facts, the optimization and control of inventory can be summarized as a complex dynamic system containing multifactors, while the quantitative model about the optimization and control of inventory is considered as a complex system with multiple variables and multiple parameters. It is very difficult to solve the problem once and for all by using a single model and a unified algorithm for the research work of the optimization and control of inventory. Most of the existing researches were focused on some specific fields of a particular region to only work out the specific issues under a certain environment. In addition, it is inevitable that the research process is influenced by the subjectivity of the researchers themselves, which suggests that the optimization and control of inventory under various situations cannot be solved. Hence, this issue will undoubtedly attract the persistent attention from the relevant experts and scholars. Actually, it still plays a very realistic role in carrying out pertinent researches on optimization and control model for inventory and algorithm with respect to some specific fields in different areas.

2. Inventory System Model

From a practical point of view of research object, a necessary simplification for the research object was conducted during the research combining the actual conditions of regional circulation enterprises. For the underdeveloped regions, the two-echelon inventory system is more common. In order to improve the practical significance of research results and enhance the operability, a typical two-echelon inventory system composed of a central warehouse and several subwarehouses was emphatically studied