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Mathematics

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SURVEY OF TWO WAREHOUSE INVENTORY MODELS

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ABSTRACT

In this paper, we presented literature review of two warehouse inventory models. This study provides an up-to-date review of inventory models with two warehouses.

INTRODUCTION

We know that inventory management and control system deals with demand and supply chain related problems. The business is basically based on demand and supply of goods/commodity either finished or raw materials. It is necessary to put the items demanded at any instant to fulfill the requirement of the consumer or retailer and for this purpose the sufficient space is required to stock the goods. This space which is used to stock the goods is known as ware-house. In inventory models, generally it is assumed that the demand and holding cost are constant and goods are supplied instantly under infinite replenishment policy, when demanded. After that many researchers assumed that demand may vary with time, due to price and on the basis of other factors and holding cost also may vary with time and depending on other factors. Considering various time dependent demands with shortages and without shortage, many models were developed. Inventory models considering demand variation assume that the holding cost is constant for the entire inventory cycle. Generally unlimited warehouse capacity is often assumed in inventory studies. But as we know, in marketplaces like super markets, corporation markets etc. the storage space for goods may be limited. Another case, of inadequate storage area, can occur when a procurement of a large amount of items is decided. Because of the price break for bulk purchase which is available or, when the cost of procuring goods is higher than the other inventory related costs or, when items demand very high or, when the seasonal items are under consideration like the yield of a harvest or, when in frequent procurement there are some problems. In these cases it is not possible to accommodate the goods in the present store space i.e. own ware house. So for stock of the excess items, another warehouse is needed i.e. rented warehouse. It may be located nearby own ware-house. An inventory model with two storage system was first explained by Hartely1. It is essential to consume the goods of the Rented Warehouse at the earliest due to more holding cost so that inventory cost can be reduced.

ANALYSIS

Sarma (1983) proposed a two warehouse inventory model by assuming the cost of transporting K-unit from RW to OW as constant and called it as K-release rule (KRR). The rate of replenishment was assumed as infinite. Murdeshwar and Sathe (1985) formulated some aspects of lot size models with two level of storage and derived complete solution for optimum lot size under finite production rates. The authors assumed while deriving the K-release rule that K units were transferred n-times from OW to RW during production stage with constant transportation cost.
Sarma (1987) developed a deterministic inventory model for a single deteriorating item which was stored in two different warehouses of non deteriorating product. The preserving facilities were better in rented warehouse than own warehouse resulting in a lower rate of deterioration. Goswami and Chaudhuri (1992) developed an economic order quantity model for items with two levels of storage for a linear trend in demand. In the first phase of the paper, a deterministic model without shortage was developed with numerical examples and in the second phase deterministic model with shortage was considered with numerical example and sensitivity analysis. In this model, the time interval between two successive shipments was constant while the numbers of units transported in a shipment was different and increased with the number of shipment. However, the above assumption is doubtful in many cases like consumer goods type, where the customers are attracted with the easy availability or abundance supply of the items.

An inventory model for deteriorating items with two warehouses was formulated by Pakkala and Achary (1992). Pakkala and Achary (1994) proposed an inventory model for deteriorating products when two separate warehouses were used. In developing the model, the demand was assumed as uniform with finite replenishment rate and shortages were allowed in the model. An analytical study of the model was presented and the model for the case of non-deteriorating items was deduced. A two warehouse inventory model for a linear trend in demand was proposed by Bhunia and Maiti (1994) for single item with infinite rate of replenishment and linear increasing trend in demand. Shortage was fully backlogged. The transportation cost was assumed to be dependent on the quantity transported from RW to OW. The optimal values of the number of shipment made, quantity transported in each shipment from RW to OW and highest storage level with cost minimization criteria were obtained, sensitivity analysis was shown with graphs at the end of the paper together with concluding remarks.

A deterministic order level inventory model for deteriorating items with two storage facilities was discussed by Benkherouf (1997).
Bhunia and Maiti (1998) developed a deterministic inventory model with two warehouses for deteriorating items taking linearly increasing demand with time, shortages were allowed and excess demand was backlogged as well. Stock was transferred from RW to OW under a continuous release pattern taking transportation cost into account. The deterioration rate was different in both the warehouses and scheduling period was taken as variable.

Optimal inventory policy for deteriorating items with two warehouse and time dependent demand was produced by Lee and Ma (2000).

Deterministic inventory model with two levels of storage, a linear trend in demand and a fixed time horizon was developed by Kar,S., Bhunia, A. K., Maiti, M. (2001).

A deteriorating inventory model with stock-dependent demand and partial backlogging under conditions of permissible delay in payment was developed by Dye, C. Y. (2002).

Papachristos, S. and Skouri, K. developed an inventory model with deteriorating items, quamtity discount and time-dependent partial backlogging (2003).

Yang (2004) developed the two-warehouse inventory models for deteriorating items with constant demand rate under inflation. Optimal replenishment policies for EOQ inventory model with limited storage capacity under permissible delay in payments was

developed by Chung, K. J. and Huang, Y. F. (2004).

Two-warehouse inventory model with partial backordering and weibull distribution deterioration under inflation was developed by Wee, H. M., Yu, J. C. P., & Law, S. T. (2005). An inventory model with two warehouses and stock-dependent demand rate was proposed by Zhou and Yang (2005). Shortages were not allowed in the model and the transportation cost for transferring items from RW to OW was taken to be dependent on the transported amount. A computational procedure was proposed to obtain the optimal replenishment quantity, the optimal replenishment cycle and the optimal shipment schedule so that the average total profit of the system should be minimum.

Two warehouse inventory models with LIFO and FIFO dispatching policies were developed by Lee (2006). In this study, Pakkala and Achary's (1992) model was first modified and then a FIFO dispatching two-warehouse model with deterioration was propped. It has been observed by the comparison of these two models that the FIFO model is less expensive to operate than LIFO, if the mixed effects of deterioration and holding cost in RW were less than that of OW. Two-warehouse inventory model for deteriorating items under inflation was developed by Yang, H. L. (2006). H. L. Yang developed two-warehouse partial backlogging inventory models for deteriorating items under inflation (2006).

A two ware-house supply chain model under possibility/necessity/creditability measures was developed by Das, B., Mainty, K. and Maiti, M. (2007). Alfares, H. K. developed inventory model with stock–level dependent demand rate and variable holding cost (2007). Chung, K. J. and Huang, T. S. developed the optimal retailer's ordering policies for deteriorating items with limited storage capacity under trade credit financing (2007). A two-warehouse supply chain model under possibility/ necessity/ credibility measures was developed by Das, B., Maity, K. and Maity, M. (2007). Deterministic inventory model for deteriorating items with capacity constraint and time-proportional backlogging rate was developed by Dye, C. Y., Ouyang, L. Y. and Hsieh, T. P. (2007).

Niu and Xie (2008) presented a note on Lee's (2006) model. This note points out that the conclusion of Lee's model was incorrect and misleading. Authors have provided a new sufficient condition such that the modified LIFO model always has lower cost than Pakkala and Achary's (1992) model. Besides, authors have compared Pakkala and Achary's original LIFO model with Lee's FIFO model for the special case where the two warehouses have the same deterioration rates. Hsieh et al. (2008) suggested a deterministic inventory model for deteriorating items with two warehouses by minimizing the net present value of the total cost. Deterioration rates in both warehouses were taken as different. Shortage in inventory was allowed and fully backlogged. A two warehouse inventory model with shortages for a deteriorating item has been formulated by Rong et al. (2008) and an inventory policy was proposed for maximum profit. J. K. Dey, S. K. Mondal, and M. Maiti developed two storage inventory problem with dynamic demand and interval valued lead-time over finite time horizon under inflation and time value of money (2008). Two-warehouse inventory model for deteriorating items with partial backlogging under the conditions of permissible delay in payments was developed by Singh, S. R., Kumar, N., & Kumari, R. (2008). Rong, M., Mahapatra, N. K. and Maiti, M. developed a two-warehouse inventory model for a deteriorating item with partially/fully backlogged shortage and fuzzy lead time (2008).

An order-level inventory model under two level storage system with timed dependent demand was developed by S. Ghosh and T. Chakrabarty (2009). Singh, S. R., Kumar, N., & Kumari, R. developed two warehouse inventory model for deteriorating items with shortages under inflation and time-value of money (2009). Goyal, S. K. and Chang, C. T. developed an optimal ordering and transfer policy for an inventory with stock-dependent demand (2009).

C. K. Jaggi and P. Verma developed two warehouse inventory model for deteriorating items with linear trend in demand and shortages under inflationary conditions (2010). Two-warehouse inventory models for single vendor multiple retailers with price and stock dependent demand was developed by Panda, D., Maiti, M. K., & Maiti, M. (2010). Singh, S. R., Kumar, N., & Kumari, R. developed an inventory model for deteriorating items with shortages and stock-dependent demand under inflation for two-shops under one management (2010). An inventory model under inflation for deteriorating items with stock-dependent consumption rate and partial backlogging shortages was developed by Yang, H. L., Teng, J. T. and Chern, M. S. (2010).

Two-warehouse inventory model for deteriorating items: a study with shortages under inflation and time value of money was developed by S. K. Patra (2011). S. R. Singh, R. Kumari, and N. Kumar developed a deterministic two warehouse inventory model for deteriorating items with stock-dependent demand and shortages under the conditions of permissible delay (2011). A fuzzy inventory model with two-warehouse under the conditions of permissible delay in payments was developed by Singh, S. R., Kumar, N., & Kumari, R. (2011-a).

Two-warehouse partial backlogging inventory model with three-parameter Weibull distribution deterioration under inflation was developed by H. L. Yang (2012). Das, D., Kar, M. Roy, A. & Kar, S. developed two-warehouse production model for deteriorating inventory items with stock-dependent demand under inflation over a random planning horizon (2012). Kumar Sett, B., Sarkar, Biswajit, Goswami developed a two-warehouse inventorymodel with increasing demand and time varying deterioration (2012). Liao, Jui-Jung, Huang, Kuo-Nan, Chung and Kun-Jen described Lot-sizing decisions for de-teriorating items with two warehouses under an order-size-dependent tradecredit (2012).

Inventory model of deteriorating items with two-warehouse and stock dependent demand using genetic algorithm in fuzzy environment was developed by Yadav, Dharmendra, Singh, S.R., Kumari, Rachna (2012). Yang, Hui-Ling developed two-warehouse partial backlogging inventory models with three-parameter weibull distribution deterioration under inflation (2012b).

Two storage inventory model of a deteriorating item with variable demand rate was developed by Guchhait, P., Maiti, M. K., & Maiti, M. (2013). Valliathal, M., Uthayakumar, R. studies a comparative study on two-warehouse inventory model for deteriorating items with shortages (2013a). Ghiami, Yousef, Williams, Terry, Wu, Yue developed a two-echelon inventory model for a deteriorating item with stock-dependent demand, partial backlogging and capacity constraints (2013). Liao, Jui-Jung, Chung, Kun-jen, Huang, Kuo-Nan developed a deterministic inventory model for deteriorating items with two warehouses and trade credit in a supply chain system (2013). Supply chain inventory model with price-de-pendent consumption rate with ameliorating and deteriorating items and two levels of storage was developed by Singh, S.R., Vishnoi, Monika, (2013). Yang, Hui-Ling, Chang, Chun-Tao described a two-warehouse partial backlogging in-ventory model for deteriorating items with permissible delay in payment under inflation (2013).

Chen, Sheng-Chih, Chang, Chun-Tao, Teng, Jinn-Tsair developed a comprehensive note on "Lot-sizing decisions for deteriorating items with two warehouses under an order-size-dependent trade credit" (2014a). A two-warehouse inventory model for deteriorating items with linear demand under conditionally permissible delay in payment was presented by Singh, Trailokyanath, Pattnayak, Hadibandhu (2014). Yu, Jonas C. P., Wang, Kung-Jeng, Lin, Yu-Siang studied to manage dual warehouses with an incentive policy for deteriorating items (2014).

Ghiami, Yousef, Williams, Terry developed A two-echelon production-inventory model for deteriorating items with multiple buyers (2015). Jaggi, Chandra K., Tiwari, Sunil, Shafi, Ali Akbar developed an effect of deterioration on two-warehouse inventory

model with imperfect quality (2015). Kumar, Neeraj, Singh, S.R. developed an effect of salvage value on a two-warehouse inventory model for deteriorating items with stock-dependent demand rate and partial backlogging (2015). Palanivel, M., Uthayakumar, R. They also discussed two-warehouse inventory model for non-instantaneous deteriorating items with optimal credit period and partial backlogging under inflation (2015b).

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