Applied Mathematical Modelling 35 (2011) 2087–2093

Contents lists available at ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

Note on minimax distribution free procedure for integrated inventory model with defective goods and stochastic lead time demand

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ARTICLE INFO

Article history:
Received 7 September 2009
Received in revised form 8 October 2010
Accepted 15 November 2010
Available online 21 November 2010

Keywords:
Minimax distribution free procedure
Analytical approach
Lean production
Partial backorder

ABSTRACT

This note is a response to a paper of Ho that was published in Information and Management Sciences, 20 (2009), 161–171. We find two reasonable criteria to insure the existence and uniqueness of the optimal solution. Based on the same numerical examples, if we directly compare our results with that by Ho, then the improvement is about 30%. Meanwhile, after revising the computation errors, then our analytical approach improves 4%.

1. Introduction

One of the distinguishing features of traditional inventory systems is that the purchasing side attempts to construct the inventory model, only for its own interest, with specific parameters or decision variables to fit the environment it faces and operates without considering the other parties or stakeholders, and based on which the inventory policy is knitted. However, a number of researchers and practitioners have queried: does this kind of policy really meet the best interest of a firm, in particular in the long run? That is why in recent years the notion of win–win strategy or supply chain management (SCM) is under the spotlight. For instance, without close and incessant coordination with its suppliers, TOYOTA on its own has no capability of achieving the highly-efficient objectives of just-in-time (JIT), zero inventory and lean production. By providing all-the-time and on-line examination of transparent manufacturing processes, scheduling, and production progress, Taiwan Semi-Conductor Manufacturing Company (TSMC), the world's largest wafer OEM (Original Equipment Manufacturing) and ODM (Original Design Manufacturing) firm, is able to closely interact with its customers and instantaneously correct and improve the quality of the products based on the requirements of the customers. In so doing, the long-term stable relationship with its primary partners, such as DELL, APPLE, HP, IBM, SONY, NOKIA, and so on, could be successfully established. Owing to this sort of vital trend, the cooperative vendor-buyer inventory systems become prevailing and grabbing manager's and academician's attention in which it would be no doubt that the defective goods delivered from vendors to buyers has been proved to be one of the major concerns of managers on both sides.

Lin [1] derived an integrated inventory-production model for a single product. With the existence of items deterioration and imperfect production process, the model unifies the decisions for raw materials and finished goods. Using computer coding, Rau et al. [2] developed a multi-echelon inventory model for a deteriorating item. The optimal solution of joint total cost

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doi:10.1016/j.apm.2010.11.034

Nomenclature

D	demand rate on the buyer (for non-defective goods)
P	production rate on the vendor
A_b	buyer's ordering cost per order
A_v	vendor's set-up cost per set-up
F	transportation cost per delivery
h_v	vendor's holding cost per item per unit time
h_{b1}	buyer's holding cost per non-defective item per unit time
h_{b2}	buyer's treatment cost (include holding cost) per defective item per unit time
w	vendor's unit treatment cost (include warranty cost) of defective goods q
s	buyer's unit inspection cost
π	buyer's unit shortage cost per unit short
π_0	buyer's marginal profit per unit
β	fraction of the demand during the stock-out period will be backordered, $DL\ \beta \in [0, 1]$
λ	defective rate in an order lot, $\lambda \in [0, 1)$, a random variable
$g(\lambda)$	the probability density function (p.d.f.) of λ with finite mean M_λ and variance V_λ, where $M_\lambda = E(\lambda) = \int_0^1 \lambda g(\lambda) d\lambda$ and $V_\lambda = E(\lambda^2) - (M_\lambda)^2$
L	length of lead time for the buyer
Q	order quantity (for non-defective goods) of the buyer (decision variable)
q	shipping quantity from vendor to buyer per shipment (decision variable)
r	reorder point of the buyer for non-defective goods (decision variable)
m	the number of deliveries from vendor to buyer in one production cycle, a positive integer (decision variable)
X	The lead time demand which has a p.d.f. f with finite mean and standard derivation $\sigma\sqrt{L}(> 0)$
x^+	maximum value of x and 0, i.e., $x^+ = \max\{x, 0\}$

was derived from the point-of-view of suppliers, producers, and buyers. Yang and Wee [3] derived an inventory model subject to multi-lot-size production and deteriorating items with constant production and demand rate in which the perspectives of both buyers and producers are considered. They found that the cost could be significantly reduced via integration and lot-splitting effects with JIT implementation. Under the single-vendor and single-buyer environment along with the assumption that there are imperfect items with identical quantities delivered from supplier to buyer, Huang [4] was able to develop a method to find an optimal solution for an integrated production-inventory model that minimizes the total joint annual cost for a just-in-time (JIT) manufacturing system. By taking the perspectives of both the manufacturer and the retailer, Lo et al. [5] built an integrated production and inventory model under the consideration of a varying rate of deterioration, partial backordering, inflation, imperfect production processes and multiple deliveries. The optimal solution was derived by means of the discounted cash flow method and classical optimization technique while a sensitivity analysis was carried out to validate the results of the production-inventory model.

Viewing the number of defective goods in a lot as a random variable, Paknejad et al. [6] built a modified economic order quantity (EOQ) model under the assumptions of stochastic demand and constant lead time. Wu and Ouyang [7] applied the minimax distribution-free procedure and developed an algorithm to obtain the optimal ordering strategy in which the order quantity, reorder point, and lead time are decision variables and the number of defective items is a random variable. For depicting the practical operations in the electronics industry, Salameh and Jaber [8] considered a production-inventory situation where items received or produced might not have perfect quality and the imperfect items might be used for another production-inventory situation. The optimal solution was found while achieving a balance among total revenues per unit time, procurement cost per unit time, inventory carrying cost per unit time and item screening cost per unit time. Goyal and Cárdenas-Barrón [9] derived an inventory system with imperfect items so that the economic production quantity (EPQ) could be determined. Their work featured an inventory system formed by a simple procedure with the existence of optimal solution found by a simple approach. By applying an algebraic approach, Wu and Ouyang [10] effectively determined the optimal replenishment policy for a single-vendor single-buyer inventory system in which shortage is allowed.

Eroglu and Ozdemir [11] developed an Economic Order Quantity (EOQ) model in which shortages are backordered and each order is screened for the separation of perfect and imperfect items. Wee et al. [12] presented a well-performed generalized inventory model with imperfect quality and total shortage backordering. Through the employment of the renewal theory, Maddah [13] built a simpler inventory system expression than that of Salameh and Jaber [8] with the effects caused by the variability of the fraction of imperfect quality items and the screening rate on the order size.

By taking the considerations of production-inventory and imperfect-item environment as described above, Ho [14] developed an algorithm to derive an integrated inventory model with defective goods and stochastic lead time demand. The conditions of partial backorder and unknown probability distribution for demand during the period of lead time were assumed. He claimed that the optimal solution could be effectively found through the iterative approach. However, upon close examination of his approach and problem-solving mechanism, the purpose of this study is to point out two deficiencies of Ho's