A Just-in-Time Inventory Model with Preventive Maintenance and Defect Rate

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ABSTRACT

In competitive market environments, businesses employ Just-In-Time (JIT) systems not only to reduce costs, but also to enhance their business partnerships. Although product quality level is essential for maintaining competitiveness, traditional inventory models do not consider defect rate, which is the main determinant of product quality. Also, in real working environments, machines break down after long operating times, which increases product defect rate. Therefore, an effective preventive maintenance policy is needed to ensure that machinery is reliable. Reworking defective items is another important inventory problem. To answer the above questions regarding varying defect rate, preventive maintenance and rework, this study developed an integrated two-echelon inventory model to determine the best production quantity, delivery frequency and preventive maintenance schedule under JIT production and delivery policy. The model results can be used to minimize total cost.

KEYWORDS

Defect Rate, Economic Production Quantity, Just-in-Time, Preventive Maintenance, Rework

INTRODUCTION

If there is no proper inventory level, the enterprise will not be able to meet the market demand or cope with the variation in the production process; on the other hand, too much inventory will result in an increase in the cost of the business. So how to set the right amount of order and safety stock is one of the most important tasks for business. Among many management tools, few models like EOQ can effectively answer the above question. However, the practicability of traditional Economic Order Quantity and Economic Production Quantity models are limited by their simplicity. Many researchers started to combine other functions to keep them up-to-date in the changing environments. Considering the impacts of machine operation time on product defect rate, this study explored the influences of varying product defect rate on the inventory model and then developed an integrated two-echelon inventory model of a single supplier and retailer that contains the growth function of defect rate in order to reflect the actual situation.

Inventory management is an important issue in many enterprises. Shin, Wood, and Jun (2016) stated that a lower inventory level has a positive relationship on industry profitability, but not all the inventories, classified by stage of production, equally contribute to improving industry profitability. Nag, Han, and Yao (2014) categorized incoming and outgoing supply chain strategies by using magnitudes of raw material and finished goods inventories. Moshrefi and Jokar (2012) proposed an integrated inventory model of two-stage supply chains with partial backordering, where the
backorder rate is a function of shortage period. Ramkumar, Subramanian, Narendran, and Ganesh (2013) proposed a two-stage methodology together with innovative strategic product classification to decide various elements of inventory standards and stocking quantity with regards to lead time and demand variability. Regarding inventory, many authors developed the optimal Economic Order Quantity (EOQ), which considers the tradeoff between ordering and holding costs to solve ordering quantity and reorder point while minimizing total cost.

Traditional EOQ and EPQ models consider minimal total cost of buyer or vender separately, so researchers in recent years have integrated buyer and vender in order to decrease total overall cost. Goyal and Srinivasan (1992) developed an integrated model in which the lot-size of suppliers are integer times as many as ordering lot-size of buyer, and allowed suppliers delivering their products in production processes. Battini, Persona, and Sgarbossa (2014) proposed a “sustainable EOQ model” by exploring the combination of factors that induce the environmental impact in the conventional EOQ model. In this competitive global market, companies must negotiate with others through partner relationships in order to maintain competitiveness. Therefore, JIT production systems have become critical in manufacturing industries.

Salameh and Jaber (1997) demonstrated a new manufacturing concepts, such as just-in-time (JIT) production and quality at source have tremendous impact on the productivity and quality in many manufacturing systems. JIT effectiveness is highly dependent on reducing variability and increasing visibility. Sugimori, Kusunoki, Cho, and Uchikawa (1977) addressed their viewpoints regarding variability and visibility. Reducing variability: In order to prevent problems such as different models with many variations and with large fluctuation in the demand of each variation in automotive industry, Toyota production system, also known as JIT system, recognized necessity of schemes adjustable to comply with changes because of problems and demand fluctuations. Increasing visibility: All processes are kept in the condition where they have no surplus so that if problem is left without care, the production line will instantly stop operating and will impact the whole factory in the just-in-time production. Therefore, JIT system is striving to make up a working place where not only the managers but also all workers can detect problem. This is called “visible control.”

Lau and Wang (2013) explores the latest state of lean thinking application, a concept originated from “just-in-time manufacturing”, in supply chain management by the manufacturers in China. Li (2011) established crucial guidelines for synchronizing the key JIT practices in the recent literature to enrich the functioning of constant work-in-process (CONWIP) in make-to-order environments. The implementation of JIT promises continuous improvement of the manufacturing system. Ideas such as in-process learning, reduction in setups, zero defects, preventive maintenance, etc. are adopted by JIT. Ansari and Modarress (1990) demonstrated that buyers exploit long-term contracts to purchase products from a few reliable suppliers, and suppliers prefer small lot-size and high frequency for just-in-time deliveries. Green, Inman, Birou, and Whitten (2014) defined Total JIT as an integrated supply chain system including a new element, JIT-information in normal JIT strategy, and examined the influence of Total JIT strategy in a supply chain setting. Many scholars have studied JIT purchase and manufacture policies. For example, Pan and Yang (2002) mentioned that lead time can be improved by investment, and setup time can be considered a variable in the integrated inventory model of JIT. They emphasized that the safety stock and shortages can be decreased by reducing lead time efficiently.

Wu, Shen, Xu, and Wu (2013) compared the inventory cost of purchasing via an economic order quantity (EOQ) model with price discount system and a just-in-time (JIT) order system.

Van der Duyn Schouten and Vanneste (1995) mentioned that highly automated production systems like JIT need highly reliable equipment. However, to maintain the production efficiency of JIT manufacturing, mechanical maintenance must be performed simultaneously to reduce the machine
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