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A cost/benefit model for investments in inventory and preventive maintenance in an imperfect production system

Hsu-Hua Lee

Department of Industrial Engineering and Management, Ching Yun University, No. 229, Jianshing Rd., Jungli City, Taoyuan, Taiwan, ROC

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Abstract

In this research, a cost/benefit model is developed for supporting investment strategies about inventory and preventive maintenance in an imperfect production system. The effect of such investments on the return is expressed as a function of measurable variables. Using this model, the decision maker can decide whether investments in inventory and preventive maintenance are necessary and how much to invest. This investment model is developed for an imperfect production system with imperfect product quality and supplied quantity. Investments in inventory and preventive maintenance increase service level for the customer and reduce the proportion of defective products, and hence affect stockout and backlog of supplied products and the delivery time to the customer. This model includes in its scope investment in inventory and preventive maintenance, manufacturing cost, inventory cost, backlog cost, stockout cost, and delay cost. This model can be used to evaluate the effects of investments on the financial cost/benefit and other relevant critical performance measures. This model can be solved by an iterative process using the Sequential Quadratic Programming Method. The optimal investment in inventory with respect to the service level and the optimal investment in preventive maintenance with respect to the proportion of defective items can be obtained first, and then other relevant costs can also be obtained.

Keywords: Inventory; Service level; Proportion of defective; Stockout; Delay cost

1. Introduction

Inventory can be used to protect the manufacturer against the randomness in production, respond to variable customer demand, and keep higher availability of goods to maintain high quality

E-mail address: hhlee@cyu.edu.tw

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customer service. The amount of inventory needed should depend on the safety stock as so to protect against the demand uncertainty, and to achieve a high service level for satisfying customers' demand. Thus, the proper inventory level should be set based on the relationship between the investment in inventory and the service level. On the other hand, the investment in preventive maintenance will reduce the process variance and the deviation of the process mean from the target value of the measured quality characteristic, and hence reduce the proportion of defective items.

However, few efforts reported in the literature aggregately link the investment in inventory to service level and link the investment in preventive maintenance to proportion of defective items. Most of the researchers focus on a perfect manufacturing system and a perfect service level, and do not present the effect of the service level and the proportion of defective items on relevant performance measures and costs. In this research, the investment model is developed for an imperfect production system with imperfect product quality and imperfect supplied quantity. The investment in inventory increases service level for the customer, and hence affects stockout and backlog situation of supplied products. The investment in preventive maintenance reduces the proportion of defective items, and also affects the delivery time to the customer. In this paper, the investment in preventive maintenance and the investment in inventory are jointly linked to relevant performance measures related to quality, delivery time, service, inventory, and costs in an imperfect production system. The development of cost/benefit models for supporting investment strategies in inventory and preventive maintenance is crucial because it can help manufacturers in evaluating the effectiveness of their investments and in selecting optimal investment opportunities. The impact of the investment on cost/benefit should be considered and related to management performance of a company, e.g. financial performance, so that the investor can select optimally from alternative projects, including quality improvement projects, productivity improvement projects, and customer satisfaction projects. Investments in inventory and preventive maintenance should be based on their impact on quantified measures of performance, e.g. service level and quality. Therefore, what is needed is a way of expressing the quantified performance measures as a function of investments in inventory and preventive maintenance.

2. Literature review

Mehrez (1998) presented that the quality level and lot size cannot be selected optimally without considering the effect of inventory. Cheung and Leung (2000) described the relationship between quality costs of sampling and inventory in supply chain management system. Chen (2000) developed the inventory model including quality level, replenishment rate of products and the price of sales. Zeng (2001) studied the effect of the strategy of backlog on inventory cost and the loss in sales. Hayek and Salameh (2001) presented an inventory model of shortage and backlog that considers rework of defective products. Hillier (1999) studied the relationship between service level and safety stock level. Zeng and Hayya (2002) researched the inventory model with two popular service levels. Souza and Ketzenberg (2002) discussed the effect of production rate and service level on lead time in production system with rework. Gunasekaran (1995); Porteus (1986) presented investment models for reducing setup cost and increasing the quality level. Lee, Chandra, and Deleveaux (1997) studied investment in quality improvement in order to reduce the proportion of defective items and affect the inventory cost, profit loss, and internal and external failure costs.