



# Optimal length of lease period and maintenance policy for leased equipment with a control-limit on age

Ruey Huei Yeh<sup>a</sup>, Wen Liang Chang<sup>b,\*</sup>, Hui-Chiung Lo<sup>c</sup>

<sup>a</sup> Department of Industrial Management, National Taiwan University of Science and Technology, Taipei, Taiwan

<sup>b</sup> Department of Information Management, Cardinal Tien College of Healthcare & Management, Taipei, Taiwan

<sup>c</sup> Department of Business Administration, Tamkang University, Tamsui, Taipei, Taiwan

## ARTICLE INFO

### Article history:

Received 18 December 2009

Received in revised form 5 May 2011

Accepted 5 May 2011

### Keywords:

Preventive maintenance

Length of lease period

Discount

Control-limit

Residual value

## ABSTRACT

This paper investigates the optimal length of lease period and maintenance policy for leased equipment. In order to have steady revenue, the lessor (owner) of equipment may provide a discount to encourage the lessee (user) to sign a contract with a longer lease period. However, as the lease period increases, the maintenance cost also increases due to the deterioration or usage of the equipment. Therefore, there is a need to determine an appropriate length of lease period and a corresponding maintenance policy for the leased equipment from the viewpoint of the lessor such that the expected total profit is maximized. In this paper, the following maintenance scheme is considered. When the leased equipment fails, a minimal repair is conducted to bring the equipment back to an operating condition. Furthermore, when the age of the equipment reaches a specified level (called as a control-limit), an imperfect preventive maintenance (PM) is carried out to avoid possible failures. Under this maintenance scheme, the mathematical model of the expected total profit is developed and the optimal length of lease period and the corresponding optimal maintenance policy are derived. Finally, some numerical examples are given to illustrate the effects of the length of lease period and the maintenance policy on the expected total profit.

© 2011 Elsevier Ltd. All rights reserved.

## 1. Introduction

Due to consumers' various requirements on the functionality of a product and the rising price of some production equipment, it may not be economical for a manufacturer to purchase expensive production equipment to produce the multi-functional products requested by consumers. Instead, manufacturers may lease these production equipments rather than purchasing them [1]. In general, the content of a lease contract usually includes the lease period, rent, new/old equipment, preventive maintenance (PM) schedule, tolerable time of repair, and penalty. Especially, the length of lease period and the maintenance and service of production equipment usually play a critical role in the contract.

For repairable leased equipment, the maintenance actions can be classified into two major categories, (i) Corrective Maintenance (CM) and (ii) Preventive Maintenance (PM). CM actions are used to rectify failed equipment back to its operational state, and PM actions are performed to improve the operational state of the equipment to avoid failures. For CM action, minimal repair is often adopted to restore failed equipment [2]. After minimal repair, the equipment is in normal operation but the failure rate function remains unchanged. As to preventive maintenance, it can be further classified into perfect PM actions and imperfect PM actions. Perfect PM restores the equipment to its original (new) condition and imperfect

\* Corresponding author.

E-mail address: [D9101402@mail.ntust.edu.tw](mailto:D9101402@mail.ntust.edu.tw) (W.L. Chang).