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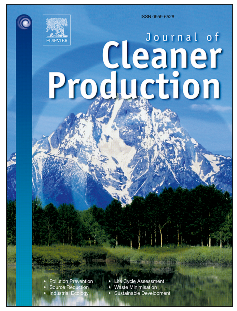

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Haolan Liao, Qianwang Deng, Neng Shen

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Optimal remanufacture-up-to strategy with uncertainties in acquisition quality, quantity, and market demand

Haolan Liao[a,b], Qianwang Deng[a], Neng Shen[b,*]

[a] State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, Hunan University, Changsha, Hunan, 410082, China
[b] College of Public Administration, Huazhong University of Science and Technology, Wuhan, Hubei, 430074, China

Abstract

Remanufacturing promotes the limiting of waste and increasing the reuse of recoverable components from obsolete products. However, in most relevant studies, the condition of returned end of life (EOL) items is taken as a constant, which causes deviation in the cost of remanufacturing. Some researchers assume it as a discrete series, which also isolates the uncertainty analysis of quality from other uncertainty factors in the remanufacturing systems. This study considers the uncertainties in acquisition quantity, quality, and market demand, then establishes the relationships among production indices and remanufacture-up-to ratio to derive the optimum production strategies. Using the Lagrange multiplier method, we proved the existence of these optimum solutions and deduced the close-form expressions for minimum cost and maximum profit. Validated by numerical examples, our results indicated that the assumption of a condition distribution type had little influence on the optimal strategies or the optimum remanufacture-up-to ratio increases, as the expected supply and demand gap becomes wider. The method employed by this model provides an innovative approach in uncertainty analysis and helps remanufacturers adopt preemptive policies for acquisition and production.

Keywords: EOL; Remanufacture; Uncertainty; Fitting; Lagrange multiplier.

1. Introduction

With the shortage of resources and environmental degradation becoming an increasingly more pressing problem, industrial development has embraced the concept of sustainable development. Remanufacture as a solution to the shortage of resource and energy is increasingly gaining attention because of its value-added potential and environment-friendly features (Guide & Wassenhove, 2009; Deng et al., 2017; Ji et al., 2017). Increasingly, world-leading enterprises have begun to integrate reverse logistics (RL) into their production strategies. Firms such as Fuji Xerox, Sony, Dell, and Apple have implemented a return service and remanufactured products for their customers (Xia et al., 2015). As one link of reverse logistics, remanufacturing is less dependent on virgin materials and more profitable compared with manufacturing (Teunter et al., 2003; Chen & Chang, 2013). It aims to restore the scrapped products at the end of their life cycles to their original function, with its costs and resource consumption being much lower compared with newly manufactured products. Accordingly, remanufacturing technology has become one of the most rapidly developing fields over the last few decades (Zhou et al., 2006; Chen et al., 2015; Liao et al., 2017; Hatcher et al., 2014).

Although remanufacturing has enough merit, this promising field is facing many challenges, which include the willingness of terminal customers to return the end of life (EOL) items, recognition for remanufactured products, and the environmental awareness of people (Jena & Sarmah, 2015; Caliskan Demirag et al., 2017; Wang et al., 2015). These factors will eventually lead to uncertainties in the market demand for remanufactured products, quality conditions, and the acquisition quantity of returned EOL items (Guide et al., 2003; Uruburu et al., 2013; Gao et al., 2015;

*Corresponding author
Email addresses: liaohaolan@163.com (Haolan Liao), deng_arbeit1@163.com (Qianwang Deng), sndlu@163.com (Neng Shen)