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Supply planning model for remanufacturing system in reverse logistics environment

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Abstract

This paper discusses the remanufacturing process of reusable parts in reverse logistics, where the manufacturer has two alternatives for supplying parts: either ordering the required parts to external suppliers or overhauling returned products and bringing them back to 'as new' conditions. We propose a general framework for this remanufacturing environment and a mathematical model to maximize the total cost savings by optimally deciding the quantity of parts to be processed at each remanufacturing facilities, the number of purchased parts from subcontractor. The model is newly introduced and developed in the reverse logistics literatures. The model is validated through a set of experimental data reflecting practical business situation and sensitivity analyses are conducted on various parameters to gain insight into the proposed model.

Keywords: Supply planning; Remanufacturing; Reverse logistics

1. Introduction

With the increased environmental concerns and stringent environmental laws, reverse logistics has received growing attention throughout this decade. Reverse logistics can be defined as the logistics activities all the way from used products no longer required by the customer to products again usable in the market. In many cases, the original manufacturer is in charge of collecting, refurbishing, and remanufacturing of used product. An example is Hewlett–Packard, which collects an empty laser-printer cartridge from customers for using again (Jorjani, Leu, & Scott, 2004).

Reverse logistics can be categorized various types according to the product recovery option. Thierry, Salomon, Nunen, and Wassenhove (1995) suggested various product recovery options as direct reuse, resale, repair, refurbishing, remanufacturing, cannibalization, and recycling. Also, these options are to be reclassified into three broad categories such as reuse, recycling, and remanufacturing. In reuse, the returned product can

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be used more than once in the same form after cleaning or reprocessing, such as container, pallet, and bottle. On the other hand, recycling denotes material recovery without conserving any product structure, for example, metal, glass, paper, and plastic. Finally, remanufacturing, the subject of this study, is an industrial process in which worn-out products are restored to like-new condition, such as electronic machine, toner cartridge, and automobile part. For remanufacturing, discarded products are completely disassembled through a series of industrial process in factory environment. Usable parts are cleaned, refurbished, and put into part inventory. Then the new product is reassembled from the old and, where necessary, new parts to produce a fully equivalent and sometimes superior in performance and expected lifetime to the original new product (Lund, 1998).

Remanufacturing is distinctly different from the repair operation, since products are disassembled completely and some of parts are returned to like-new condition, which may include cosmetic operations. It is a process whereby companies can become more environmentally efficient through reusing and reduction the amount of materials used. Remanufacturing can be crucial to the survival of companies, because the permanent goodwill of the company is at stake. In this paper, we propose a general framework and a mathematical model for remanufacturing system in reverse logistics environment.

This paper is organized as follows. In next section, we introduce some key literatures relevant to this study. In Section 3, a general framework and mathematical model for remanufacturing system are proposed. Section 4 provides an analysis of the model using an illustrative example and some insights into the proposed model. Finally conclusions and further researches are addressed in the last section.

2. Related literature

Since there are numerous researches on remanufacturing system which address many various topics from definition to practical cases in real industry, only key relevant literatures are introduced in this section. Guide, Jayaraman, and Srivastava (1999) discuss the characteristics of the remanufacturing environment to distinguish from other manufacturing environments and examine the production planning and control function of remanufacturing firms. The impact of remanufacturing in economy is studied by Ferrer and Ayres (2000), and more fundamentally Sundin and Bras (2005) provide arguments for why used products should be remanufactured.

Many analytic and quantitative approaches are also found in various problems such as forecasting, production planning/control, inventory control/management, and location. A good overview on quantitative models for recovery production planning and inventory control is given by Fleischmann et al. (1997). They survey the recently emerged field of reverse logistics and subdivide the field into three main areas, namely distribution planning, inventory control, and production planning. And they point out the lack of a general framework and mathematical model for reverse logistics environment. Der Laan and Salomon (1997) propose an hybrid manufacturing/remanufacturing system with stocking points for serviceable and remanufacturable products, which will be a part of our framework. Jayaraman, Patterson, and Rolland (2003) propose a general mixed-integer programming model and solution procedure for a reverse distribution problem focused on the strategic level. The model decides whether each remanufacturing facility is open considering the product return flow. On the contrary, our study deals with remanufacturing execution, at operational level.

In the practical case study for remanufacturing, Wendy and Chris (2001) attempt to quantify the life cycle environmental benefits achieved by incorporating remanufacturing into a product system, based on a study of Xerox photocopiers in Australia. They found that remanufacturing can reduce resource consumptions and wastes generation if a product is designed for disassembly and remanufacturing. Dyckhoff, Souren, and Keilen (2004) deal with the expansion of supply chain to closed loop systems and analyzed the material flow in the automotive cycle. Guide (2000) reports a survey of production planning and control activities at remanufacturing firms in the United States. Although the practical case studies for remanufacturing are most restricted, they establish the higher propriety of research for remanufacturing.

However, only few researches are found for development of a general framework and mathematical model about remanufacturing system. Therefore, in addition to the previous researches on the various