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Operations Scheduling in Reverse Supply Chains: Identical Demand and Delivery Deadlines

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Abstract

This study addresses an integrated operations scheduling problem in reverse supply chains, where delivery deadlines and identical demand are involved. The supply chains consist of contracted collectors, a manufacturer, and many secondary markets. Both collectors and manufacturer are capacitated. The manufacturer remanufactures returned/used products shipped from collectors and then ships finished products directly to demand points geographically dispersed in secondary markets, following order quantity and delivery due date that each demand point requests. Each demand point orders the same quantity, which can be true in supply chain practices (i.e., grouping demand points into customer zones). Furthermore, the manufacturer is imposed penalties for late deliveries. The problem is to determine shipping quantities from collectors to the manufacturer and the assignment of collectors and demand points to the manufacturer, subject to the capacity constrains on both collectors and the manufacturer. This paper formulates the scheduling problem as a bi-criteria mixed integer program with the objective of minimizing both total shipping and penalty costs and delivery lateness. For the problem with the order sizes of one unit, the total unimodularity of its constraint matrix allows for the development of a polynomial time algorithm. The problem where order sizes are the same is solved by a dynamic programming based algorithm. The respective numerical examples are provided to verify two problems and their corresponding solution approaches.

Keywords: Reverse supply chains; integrated operations scheduling; delivery deadlines; bi-criteria decision making; mixed integer programming.

1. Introduction

Reverse supply chains have gained considerable attention in industry and academia due to mounting regulatory pressure, growing environmental concerns, and increasing benefits (i.e., material conservation, reduced energy consumption and waste, and lower prices) (Guide, 2002). In reverse supply chains, returned/used products are shipped to inspection and disposition locations, where disposition actions are determined including reuse, remanufacturing, and recycling. The new and never used products are restocked to the forward distribution channels, while other products are sold for remanufacturing and recycling. Then remanufactured products are sold in secondary markets for additional revenue. In certain cases, companies are mandated to recycle used products because of hazardous materials (e.g., in the case of refrigerators in the U.S.). In such a case, reverse supply chains need to be not only well managed, but also tightly integrated (Blackburn et al , 2004). However, the planning and scheduling of reverse supply chain operations is a challenge due to highly variable return flows. The purpose of this paper is to develop optimization tools for integrated operations scheduling in reverse supply chains with remanufacturing.

The study was motivated by reverse supply chain practices in computer and electronic industry. Computers and electronic devices are returned or collected at the stores of retailers or wholesalers and then transported to collectors' facility, where returned products are inspected in terms of products' conditions. The new or unused products will

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