Effective Zero-Inventory-Ordering Policies for the Single-Warehouse Multiretailer Problem with Piecewise Linear Cost Structures

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We analyze the problem faced by companies that rely on TL (Truckload) and LTL (Less than Truckload) carriers for the distribution of products across their supply chain. Our goal is to design simple inventory policies and transportation strategies to satisfy time-varying demands over a finite horizon, while minimizing systemwide cost by taking advantage of quantity discounts in the transportation cost structures. For this purpose, we study the cost effectiveness of restricting the inventory policies to the class of zero-inventory-ordering (ZIO) policies in a single-warehouse multiretailer scenario in which the warehouse serves as a cross-dock facility. In particular, we demonstrate that there exists a ZIO inventory policy whose total inventory and transportation cost is no more than 4/3 (5.6/4.6 if transportation costs are stationary) times the optimal cost. However, finding the best ZIO policy is an NP-hard problem as well. Thus, we propose two algorithms to find an effective ZIO policy: An exact algorithm whose running time is polynomial for any fixed number of retailers, and a linear-programming-based heuristic whose effectiveness is demonstrated in a series of computational experiments. Finally, we extend the worst-case results developed in this paper to systems in which the warehouse does hold inventory.
(*Approximation Algorithms; Zero-Inventory-Ordering Policies; Inventory; Transportation; Truckload (TL); Less than truckload (LTL)*)

1. Introduction

In recent years, many companies have realized that important cost savings can be achieved by integrating inventory control and transportation policies throughout their supply chains. Thus, the problem faced by these companies is to find an optimal replenishment plan, i.e., an inventory and transportation strategy, so as to minimize total inventory and transportation costs over a finite planning horizon. The difficulty in designing a coordinated strategy, however, is compounded by the fact that typically these companies rely on external third-party logistics providers for the