Benefits of Dynamic Routing in a Distribution System with Single Warehouse and Multiple Retailers

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ABSTRACT

The author investigates a distribution system consisting of one warehouse and multiple retailers. First, they study the characteristics of a dynamic allocation policy associated with dynamic routing policy. The authors, then, conduct simulation study to investigate the performance of different forms of dynamic routing policies under both symmetric and asymmetric scenarios. The author’s numerical findings show that both SLIF (Static Least Inventory First) routing and DLIF (Dynamic Least Inventory First) routing outperform static routing significantly. In addition, DLIF routing provides more savings compared to SLIF routing. When the asymmetry among retailers is not significant, both SLIF routing and DLIF routing can be used as good heuristic dynamic routing policies given that they are easy to execute.

Keywords: Distribution System, Dynamic Allocation, Dynamic Least Inventory First (DLIF), Dynamic Routing, Inventory Control, Static Least Inventory First (SLIF)

INTRODUCTION

Transportation policy is a key factor to the management of a warehouse-retailer system, because vehicles are integral to the supply chain, and hence, transportation policy influences supply-chain performance. In most cases, the transportation policies used are static routing policies, under which the route used for delivery is the same whenever the same set of retailers is being visited. Static routing policy is easy to execute by drivers, because they get more familiar with the static route. Static routing also saves planning and management cost, as the same route is deployed all the time. However, competitiveness depends on providing high availability of goods. Under some circumstances, changing route, i.e., changing the sequence of retailers for delivery, may help to improve system performance, as it decrease the expected shortages at the retailers. The authors have consulted for a soft drink distribution company located in Tianjin, China. Being the contracted soft drink supplier, this company delivers soft drinks to many restaurants located in different areas in Tianjin. These restaurants face various stochastic consumer demands and place orders...
with the soft drink company, which in turn, schedules the delivery for all restaurants. The goal of this company is to deliver the drinks to all the restaurants as soon as possible. Due to high volatility in consumer demands for soft drinks, order size and order time from each restaurant vary significantly from time to time. However, all restaurants expect on-time delivery. The soft drink company has been using static routing policy, i.e., following a single static route all the time, for a while. Recently, it starts to receive complaints on delayed delivery from some restaurants, especially during holiday season and busy hours. The problem faced by this soft drink company is what could be a better routing policy?

Motivated by the problem faced by this soft drink delivery company we have consulted for, in this paper, we study dynamic routing policy, under which the route is allowed to change when the same set of retailers is being visited, and further, the route is permitted to change while the vehicle is traveling a previously planned route. We are especially interested in investigating under what circumstances dynamic routing outperforms static routing, and, if so, to what extent. Our second motivation in doing this research is that technology is available to facilitate dynamic routing. In particular, transport companies already deploy technology to route (or reroute) vehicles (e.g., UPS can reroute their trucks even if the truck is already on the route). Given that technology is already in place, it behooves supply-chain researchers to learn when and how to take advantage of such technology to implement dynamic routing.

We study a single warehouse multi-retailer distribution system. The contribution of this research is two-folded. (1) Dynamic routing policy and dynamic allocation policy (i.e., allocation quantities to the retailers are determined sequentially, instead of simultaneously, as the vehicle travels the route) are considered explicitly in the same model. Though many existing models study both transportation and inventory-management policies simultaneously, few published models explicitly address dynamic routing in conjunction with a corresponding inventory-management policy. Savelsbergh and Goetschalckx (1995) compare the efficiency of static versus dynamic routes in a stochastic inventory-routing problem. The dynamic routing policy considered by Schwarz et al. (2006) allows the route to change whenever the same set of retailers is visited, but not in real time. The dynamic routing policy studied in this paper even allows the route to change in real time, i.e., while the vehicle is traveling a route. (2) Given the easiness for execution, our dynamic routing policies serve as good heuristics in a more generous setting. Our numerical results show that, compared with static routing, the dynamic routing policies studied in this paper significantly improve system performance, even when the optimal form of inventory-management policy associated with the dynamic routing policies are not clear yet.

LITERATURE REVIEW

There is a vast literature deals with both transportation and inventory-management policies. Unfortunately, most of the existing models study static routing policy. Only a few models address dynamic routing policy, e.g., Federgruen and Zipkin (1984), Qu et al. (1999), and Schwarz et al. (2006). We classify the related literature into three categories. Category (I) studies inventory-management policy under given transportation policy. Category (II) studies transportation policy under given inventory-management policy. Category (III) considers both transportation and inventory-management policies as decision variables.

This study falls into category (II). In this paper, we evaluate the performance of dynamic routing policy. Our work can be viewed as extending Schwarz et al. (2006) by incorporating fully-dynamic routing policy, under which the route is permitted to change while the vehicle is traveling a previously planned route. Our work also extends Kumar et al. (1995) by combining dynamic allocation and dynamic routing in the same model. Although the model we examine is very stylized, we are able to use it to get some
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