Expert Systems with Applications 39 (2012) 4149–4159

Contents lists available at SciVerse ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Variable neighborhood search for the inventory routing and scheduling problem in a supply chain

Shu-Chu Liu *, An-Zuo Chen

Department of Management Information Systems, National Pingtung University of Science and Technology, Pingtung 91207, Taiwan, ROC

ARTICLE INFO

Keywords:
Metaheuristic
Variable neighborhood search (VNS)
Inventory routing and scheduling problem (IRSP)
Supply chain
Integrated model
NP-hard

ABSTRACT

The inventory, routing and scheduling decisions are three major driving factors for supply chain performance. Since they are related to one another in a supply chain, they should be determined simultaneously to improve the decision quality. In the past, the inventory policy, vehicle routing and vehicle scheduling are determined sequentially and separately. Hence, the total cost (inventory, routing and vehicle costs) would increase. In this paper, an integrated model for the inventory routing and scheduling problem (IRSP) is proposed. Since searching for the optimal solution for this model is a non-polynomial (NP) problem, a metaheuristic, variable neighborhood search (VNS), is proposed. The proposed method was compared with other existing methods. The experimental results indicate that the proposed method is better than other methods in terms of average cost per day.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

The inventory routing and scheduling problem (IRSP) in a supply chain (SC) is to determine delivery routes from suppliers to some geographically dispersed retailers, inventory policy (e.g. replenishment frequency and quantity) for retailers and vehicle scheduling for different routes based on the minimal cost criterion (Raa & Aghezzaf, 2009; Zachariadis, Tarantilis, & Kiranoudis, 2009). The IRSP considering inventory policy, vehicle routing and vehicle scheduling simultaneously has gained attentions in designing distribution systems such as beverage industry since the coordination of inventory, routing and scheduling decisions between suppliers and retailers leads to a better overall performance in a vendor managed inventory (VMI) environment (Chopra & Meindl, 2004; Hall, 1987; Vidal & Goetschalckx, 1997). In the past, the routing is determined first (the retailers are partitioned into disjoint sets (routes) served by a specific vehicle) and then the replenishment frequency for each route is determined at stationary interval with fixed quantity. At last, the vehicle scheduling for different routes is determined based on the minimal replenishment cycle time criterion (Li, Chen, & Chu, 2010; Moin & Salhi, 2007; Raa & Aghezzaf, 2009; Zachariadis et al., 2009). The vehicle routing, replenishment frequency and vehicle scheduling are determined sequentially, separately and fixedly. Hence, the total cost (inventory, routing and vehicle costs) would increase. The purpose of this paper is to resolve the inventory routing and scheduling problem (IRSP) simultaneously and flexibly so that the total cost would decrease.

The IRSP is originally evolved from the inventory routing problem (IRP), in which the vehicle scheduling problem is ignored (Andersson, Hoff, Christiansen, Hasle, & Lokketangen, 2010). Since the vehicle scheduling problem becomes important in practice, the IRSP gains a lot of attentions recently. Aghezzaf, Raa, and Van Landeghem (2006) and Raa and Aghezzaf (2008, 2009) adopted column generation and saving heuristic to resolve the vehicle routing problem based on the minimal cost criterion. Then power-of-two (POT) policy is adopted to determine the replenishment frequency for each route. At last, the routes served by the same vehicle are scheduled based on the minimal replenishment cycle time criterion. However, the vehicle routing, replenishment frequency and vehicle scheduling are determined sequentially, separately and fixedly. Zachariadis et al. (2009) adopted an integrated local search for replenishment insertion timing and replenishment removal timing based on the minimal cost criterion to make inventory and routing decisions flexibly. Then tabu search is adopted to find the shortest path for each route. However, the local search may be trapped in the local optimum. In addition, the information of available vehicles and replenishment cycle times is assumed known. Until now, there are still few heuristic methods proposed for resolving the IRSP. Since the structure of IRP is similar to that of IRSP, the IRP is also reviewed. Bell, Dalberto, and Fisher (1983) adopted an optimization method to resolve the IRP. Since the IRP is an NP-hard problem, heuristic methods are needed. Federgruen and Zipkin (1984) developed a nonlinear integer programming model and adopted an exchange method to resolve the IRP. Golden, Assad, and Dahl (1984) adopted an insertion method to resolve the IRP. Anily and Federgruen (1990) proposed a new method to resolve the IRP. First of all, the customers are partitioned into several categories (routes) served by some specific

* Corresponding author. Tel.: +886 08 7703202 7911; fax: +886 08 7740306.
E-mail address: sliu@mail.npust.edu.tw (S.-C. Liu).

0957-4174/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2011.09.120

vehicles based on the minimal cost criterion. Then replenishment frequency for each route is determined separately at stationary interval. Since then, the method is adopted in other IRP literature (Anily, 1994; Anily & Federgruen, 1993, 1994; Gaur & Fisher, 2004; Jung & Mathur, 2007). The method can obtain the solution quickly especially when the problem size is large. Viswanathan and Mathur (1997) adopted SNJRP (stationary nested joint replenishment policy heuristic) to resolve the IRP based on the minimal cost criterion. The route is determined based on the vehicle capacity and minimal cost criterion. Power-of-two (POT) heuristics is adopted to determine replenishment frequency for retailers in each route. Campbell and Savelsbergh (2004) adopted a two-phase method to resolve the IRP. The first phase adopted an integer programming method to obtain the initial solution. The second phase adopted an insertion method to improve the initial solution. Gaur and Fisher (2004) adopted a randomized sequential matching algorithm (RSMA) to resolve the IRP. An insertion method was adopted to obtain the initial solution. Then a cross-over method was adopted to improve the initial solution. Sindhuchao, Romeijn, Akcali, and Boondiskulchok (2005) adopted a two-phase method for the IRP. The first phase adopted a column generation method to obtain the initial solution. The second phase adopted a very large-scale neighborhood search (VLSN) to improve the initial solution. Lee, Jung, and Lee (2006) adopted a tabu search method to resolve the IRP. Jung and Mathur (2007) adopted the fixed partition method to resolve the routing problem. Then power-of-two (POT) policy is adopted to resolve the inventory problem. Zhao, Wang, and Lai (2007) adopted GENI insertion method to resolve the routing problem. Then tabu search for power-of-two (POT) policy is adopted to resolve the inventory problem. Zhao, Chen, and Zang (2008) resolved the IRP with three layers: manufacturers, warehouse, and retailers. GENI insertion method is adopted to resolve the routing problem. Then Variable Large Neighborhood Search (VLNS) for power-of-two (POT) policy is adopted to resolve the inventory problem. The results show it is better than tabu search. In addition, the CPU time is efficient.

In this paper, an integrated model for the IRSP is proposed. Since searching for the optimal solution for this model is a non-polynomial (NP) problem, a metaheuristic, variable neighborhood search (VNS, which is the original type of VLNS and competitive in the combinatorial problem.), is proposed to find the optimal solution for the IRSP.

2. Model formulation for the inventory routing and scheduling problem

2.1. Assumptions and notations

2.1.1. Assumptions

- Only one supplier is considered.
- Each retailer is served by exactly one vehicle.
- Each route is served by one vehicle.
- The replenishment quantity for each route is less than or equal to the vehicle capacity.
- The arriving time for each retailer or the supplier is less than or equal to the working time per day.
- Each route begins and ends at the same supplier.
- A single type of products is considered.
- A homogenous fleet of vehicles is considered.
- Number of retailers is known.
- Retailers' demands are deterministic.
- Vehicle capacity is known.
- Unit vehicle cost per day is known.
- Unit distance cost is known.
- Unit holding cost is known.
- Service (loading or unloading) time and cost for each retailer and the supplier is known.
- Vehicle speed is known.
- Replenishment frequency is not fixed and once a day at most.
- Ordering cost and dispatching cost for the retailers are ignored.
- Ordering cost and inventory cost for the supplier are ignored.
- Each vehicle can serve several routes based on scheduling (Raa and Aghezzaf, 2009; Zachariadis et al., 2009).

2.1.2. Notations

Known variables

ψ	unit vehicle cost per day
w_i	loading time of supplier i (=0) or unloading time of retailer i (=1,…,N)
W	loading or unloading cost per unit time
cm	unit distance cost
c_{ij}	distance between i and j
h_i	unit holding cost
d_i	daily demand for retailer i
N	number of retailers
Q	vehicle capacity
WT	working time per day
Speed	vehicle speed (km/h)

Auxiliary variables

r	index of vehicles
i	index of supplier (i = 0) or retailers ($1 \leqslant i \leqslant N$)
j	index of supplier (j = 0) or retailers ($1 \leqslant j \leqslant N$)
t	index of replenishment timing ($1 \leqslant t \leqslant T$)
z_{it}	replenishment timing exists for retailer i at t, 1; otherwise, 0
e_{it}	inventory exists for retailer i at t, 1; otherwise, 0
sb_{it}	inventory quantity for retailer i at t
M	upper bound for demands, $M = \max(T_r \times d_i) + 1$
V_{tr}	retailer set at t served by vehicle r

Decision variables

x_{ijtr}	1, if i immediately precedes j served by vehicle r at t; 0, otherwise.
q_{it}	replenishment quantity for retailer i at t
T_r	replenishment cycle time for vehicle r
R	number of needed vehicles

2.2. Model formulation

Before the model for the IRSP is formulated, the relevant inventory cost, routing cost and vehicle cost are discussed first.

1. *Inventory cost*: The average inventory cost per day for all retailers served by vehicle r in a replenishment cycle time = $\frac{\sum_{t=1}^{T_r}\sum_{i\in V_{tr}}\left(sb_{it}+q_{it}-\frac{d_i}{2}\right)\times h_i}{T_r}$. The total inventory cost per day for all retailers served by all vehicles is $\sum_{r=1}^{R}\left[\frac{\sum_{t=1}^{T_r}\sum_{i\in V_{tr}}\left(sb_{it}+q_{it}-\frac{d_i}{2}\right)\times h_i}{T_r}\right]$.

متن کامل مقاله ← **دریافت فوری**

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات