Minimizing transportation cost of a joint inventory location model using modified adaptive differential evolution algorithm

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Received: 28 November 2010 / Accepted: 16 August 2011 / Published online: 14 September 2011
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Abstract Transportation is a key issue in supply chain management and is a major concern for a company. This paper considers a joint-location inventory problem involving a set of suppliers producing different products and a set of retailers where some retailers are treated as distribution centers (DCs). The problem is to determine which retailers to be assigned as DCs, which retailers to receive direct shipments, how much of the retailer’s demand to allocate to the DCs, and how much of the DC’s demand is to be met by different suppliers. The problem is formulated as a mixed integer model and it has been solved through an adaptive differential evolution algorithm known as modified J. Adaptive Differential Evolution. The solutions obtained are compared with that of simple genetic algorithm. This paper also shows that the proposed model is robust in nature and offers near-optimal results for different distributions. The sum of the cost of establishing some retailers as DCs and the total transportation cost incurred in shipping products from the suppliers to the retailers via DCs(for some retailers) or directly (for the other retailers) is also compared with the total transportation cost incurred when all the products are shipped directly from the suppliers to the retailers.

Keywords Supply chain · Distribution centers · Transportation cost · Adaptive differential evolution · Simple genetic algorithm

1 Introduction

The decision-making in a supply chain can be classified into three levels of hierarchy: strategic, tactical, and operational. Network design, flow of goods, cost-effective location of facilities, etc. are considered as strategic level decisions while the tactical level decisions deal with inventory management, transportation, etc. These decisions should be made in an integrated manner as recent researches have shown that tactical level decisions are greatly influenced by the strategic level decisions [12]. The efficiency of the logistic system depends upon many factors; one of them is to find the location of facilities to be opened in such a way that customer demand can be satisfied at minimum cost. There has been a recent paradigm shift towards integrated supply chain with the success of a firm depending on its ability to integrate supply chain members seamlessly. This seamless linkage of supply chain members requires creation of distribution centers (DCs) that further connect manufacturers to their retailers. This establishment of DCs often involves a considerable amount of risk due to its enormous start-up investment and volatile customer demand patterns. However, this paper assumed a constant demand and concentrates on reducing the startup investment by optimizing the number of DCs.
Most of the supply chain problems are, however, classified according to the capacity of the facilities. Some of the problems assume that there is no limit on capacities of the facilities. When the facilities have a certain capacity, the problem is referred to as a capacitated location/allocation problem. The balanced allocation problem deals with the optimal assignment of product flows between multiple DCs and a set of retailers. This problem arises when configuring a supply chain between a set of manufacturers and a set of retailers via more than one distributor. In this paper, some of the existing retailers are converted into DCs without creating extra distributors. The problem can be viewed as the combination of multiple choice mixed-integer problem with capacitated location–allocation problem simultaneously.

The body of literature on multistage logistic problems is largely dealing with different models relevant to different situations. Multistage supply chains usually consist of DCs or warehouses as intermediate stages. In this regard, Weber [13] proposed location theory in which he studied the location of a single warehouse among customers so as to minimize the transportation cost between them. A plethora of researches have been carried out in location theory. Sweeney and Tatham [10] proposed an improved model for solving long-run multiple warehouse location problems. They have solved the problem based on a set of geographical warehouse locations in such a way that demand is satisfied and a satisfactory level of customer service is maintained with an optimal total distribution cost over a long planning horizon. Akinc and Khumawala [1] have formulated a model based on capacitated warehouse location problem and they have solved it by using efficient branch and bound algorithm. Daskin and Owen [2] provided an overview of facility location modeling. Other representative set of researches included the works by Schaffer [8] and Napolitano [6]. Recently, Ozsen et al. [7] considered a centralized logistic system in which a single company owns the production facility and the set of suppliers, and they have established warehouses that store retailer’s inventory and demonstrated the potential savings in terms of dollar that a company achieves by allowing its retailers to be sourced by more than one warehouse.

Eppen [3] demonstrated the benefits of a centralized supply chain by grouping retailers over a completely decentralized supply chain through a multilocation newsboy problem. He considered a single-period model with N retail outlets. Shen et al. [9] further extended his work by combining the location, transportation, and nonlinear inventory costs in the same model. We have extended the work of Shen et al. [9] by incorporating a set of retailers having uncertain demand and a single supplier, and the proposed problem has been formulated under the banner of a nonlinear integer programming model. The retailer, to whom we have chosen as DC, received shipments from the supplier and further distributed it directly to the other retailers.

Here, we have introduced the concept of choosing some retailers as DCs by considering a set of suppliers and retailers having constant demand. Now, the proposed problem became unique in nature in such a way that some retailers may be allowed to get shipments directly from the suppliers while the rest receive shipments from the DCs. This relaxation allows some retailers to get direct shipments that are valid on the basis that some retailers may already be facing a huge demand and may pose serious operational issues in case they are being assigned as DCs or being first sent to a DC and then shipped to those retailers. The proposed model can be used by some Indian companies like Big Bazaar, Pantaloons, Vishal Mega Mart, etc. These companies have their retail outlets in various cities and each retail outlet sells different kinds of products which come from different plants situated in different parts of the

![Fig. 1 Two-stage supply chain model](image-url)