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Optimizing allocation in a warehouse network

Enrico Malaguti [1,2]

Dipartimento di Ingegneria dell'Energia Elettrica e dell'Informazione
Università di Bologna, Bologna, Italy

Giacomo Nannicini [3]

IBM T.J. Watson
Yorktown Heights, NY, USA

Dimitri Thomopulos [4]

Dipartimento di Ingegneria dell'Energia Elettrica e dell'Informazione
Università di Bologna, Bologna, Italy

Abstract

We study the allocation problem faced by an international retail company operating e-commerce: the firm wants to determine the initial allocation of goods to warehouses, so as to provide customers in local markets with high level of service. We represent the movement of goods through the warehouse network to the customers using linear and quadratic integer programming models, and provide a computational evaluation using real data.

Keywords: Allocation, Logistic Network, Multiperiod Planning.

1 Introduction

We consider an allocation problem that is of interest to an international retail company operating e-commerce on a global scale. The retailer sells on lo-

[1] Supported by MIUR-Italy, grant PRIN 2015
[2] Email: enrico.malaguti@unibo.it
[3] Email: nannicini@us.ibm.com
[4] Email: dimitri.thomopulos@unibo.it

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cal markets thorough dedicated websites, where customers can order available goods from an online catalog. Ordered goods are then shipped to customers by express delivery service. The retailer manages a network of warehouses consisting of a main warehouse in the European Union and other warehouses outside Europe, each one associated with a local market. European customers are always served from the main warehouse, while other customers can be served from the local warehouses or from the central warehouse. Thus, even after the initial allocation of goods to the warehouses, there can be a continuos flow of goods from the central and local warehouses to the customers. The origin and destination of the shipment define different levels of service for an order. A shipment from a local warehouse allows fast shipping and is associated with better level of service, while an intercontinental shipping requires longer time. We study the problem that the retail company faces when deciding the initial allocation of goods into warehouses. On the one hand, the company can store items at local warehouses, thus maximizing the level of service and minimizing shipping cost, although the initial acquisition of goods at local warehouses has (on average) larger cost. In addition, items cannot travel from the local to the main (European) warehouse, implying that an item allocated at a local warehouse cannot be sold on a different market. On the other hand, the retailer can store items in the central warehouse, having more flexibility (each item can be sold to any local market, and at the end of the season unsold items are already consolidated in a single location for salvaging) and smaller acquisition cost for the initial stock. Flexibility is obtained at the cost of providing a lower level of service, potentially losing a share of the sales, and having a larger shipping cost.

We model and study the problem for increasing levels of detail. We consider a multi-period planning problem, and we initially assume that the demand and price of goods are given for each period. In this case, the problem is decomposable and solvable by inspection assuming that there is no constraint linking the different item categories (e.g., capacity or assortment constraints at the warehouses). Then, we consider the case in which prices can be set in each period, and demand is determined accordingly. In particular, we study the case of discrete price levels, each one associated with an expected demand. We formulate optimization models to deal with these cases, and provide a computational evaluation on real-world data obtained from a retailer.

The problem we consider has the structure of classical location-allocation problems, but it is also an inventory problem with elements of network flows and pricing. Two main elements characterize our paper and its motivating application in e-commerce: first, our models incorporate explicitly the sensi-