Daily Logistics Planning With Multiple 3PLs: A Case Study in a Chemical Company

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ABSTRACT
The importance of efficient logistics management for chemical industry considered to be one of the important issues in process industries. Motivated from a chemical factory operating in Turkey, cost efficient daily logistics planning using multiple third party logistics providers (3PL) with different contracting schemes are analyzed. In order to reduce planning time and maximize the physical vehicle capacity utilization, problem of the company is formulated as a mixed integer mathematical model, and a two-phase solution approach is proposed. Using the real life daily shipment requirement data the proposed model and the solution methodology is tested. Furthermore, impact of various company practices and types of different transportation pricing schemes are analyzed to better design 3PL contracts. The initial results are very promising where optimum solution for large scaled problem can be obtained in seconds and the daily shipment planning can be updated dynamically whenever it is necessary. The analysis indicates that cost savings through holistic planning is robust to contracting schemes and specific clauses are not always needed to guarantee certain service quality. We believe that the efficiency achieved through the integration of such techniques can become highly attractive for further applications in the industry.

Keywords: logistics management, mixed integer programming, chemical industry, case study.

1. Motivation

Process sectors are the leading sectors in most of the countries. In Europe, the chemicals sector contributes 2.4% of EU GDP [1]. Recent studies report that logistics operations are key aspect of the chemical industry as production and consumption locations are mostly separated and estimated to be as high as 15 % of the GDP in some of the developing countries [2]. Thus, supply chain in process industry needs to be improved in terms of efficiency and responsiveness. The study is motivated from one of the leading chemical products factory in Turkey, which produces raw material to different manufacturing sectors as well as sell directly to individual consumers or retailers. Company produces a large number of products for a set of customers that are dispersed all over Turkey. As most of the producers in the chemical sector, the company outsourced its final product delivery to multiple third party logistics providers. The problem on hand is to develop a decision support tool that assigns the daily orders to appropriate shipments, deciding on the 3PL company, vehicle type as well as the respective load compositions and stop-over points of the vehicles, in order to reduce the total transportation cost and prevent late deliveries.

The simplest version of this problem can be modeled as “one dimensional bin-packing” problem such that some ‘objects’ of different size, in our setting delivery orders have to be packed into a set of bins, i.e. vehicles with given capacities. The objective is to minimize the cost associated with using the bins. Even for identical capacity bins, bin-packing problem can be shown to be NP-hard [3], so that in most decision support systems heuristics are suggested. There are various solution approaches for the bin packing problem. Ghiani et al. [3], summarizes the common greedy approximation algorithms while Scholl et al. [4] offer a good survey of existing solution procedures, as well as a good exact algorithm that they have developed. Different than heuristic approaches, Carvalho [5] used exact solution methodologies like column generation and branch-and-bound for the bin-packing problem. However the daily logistics planning problem is much more complex than bin-packing problem, since vehicle types may not be identical. Moreover, most of the 3PL contracts include restriction on the maximum number of locations that should be visited and objective function may include cost elements other than unit vehicle cost.

The study most similar to our case belongs to Çetinkaya et al. [6]. In order to improve the outbound supply chain activities of Frito-Lay, a leading firm on the FMCG sector, Çetinkaya et al. [6] conducted a study to optimize Frito-Lay's inventory and transportation decisions simultaneously. At first, they develop a mixed integer programming (MIP) model which considers inventory lot-sizing and vehicle routing decisions, including inventory holding, truck loading, dispatch and mileage costs, as well as, production, storage, and truck capacity constraints. Furthermore, direct and partial shipment options are also taken into account while constructing the MIP model. In our study, inventory costs are not incurred by the producer. Thus we do not need to consider inventory related costs. Instead, different cost structure of different 3PL companies will be taken into account to minimize the outbound transportation costs. Likewise, González-Ramírez et al. [7] considered a real-life problem of a parcel company, serving in Monterrey, Mexico; where the service region of the parcel company is divided into districts and each district is served by a single vehicle. They formulated a mathematical model and used a heuristic approach to solve this problem.

The remainder of the paper is organized as follows: In the following section, we introduce the daily logistics planning problem. The notation used in the paper together with the formulation of the daily logistics planning problem as MIP is explained in section 3. We propose a two-stage the solution technique in section 4. We will illustrate our solution approach with a case study and discuss the initial findings in section 5. We conclude with final remarks in section 6.

2. Problem Definition

One of the leading chemical product factories in Turkey produces raw material to different manufacturing sectors as well as products for individual consumers or retailers. The company produces a large number of products for a set of customers that are dispersed all over Turkey. As most of the producers in the chemical sector, the company outsources its final product delivery to third party logistics providers. Company cooperates with four different 3PL providers to send their items. These companies have various conditions on pricing. These different pricing structures are as follows:

Company # 1 has two types of unit transportation price per kilogram for each final delivery location. If the order is more than certain amount, 3PL is required to deliver the order directly to customer and charges for "direct delivery" price per kg (cost type 1). If the order is less than the pre-determined threshold, 3PL takes the order to its local distribution center and distribute the order from there. If this is the case, company # 1 charges for "partial shipment" price per kilogram which is typically more than the unit "direct delivery" price for identical delivery location (cost type 2). For partial deliveries the maximum number of delivery location (on city center basis) is limited to 4. For shipments that requires more than 4 stop-overs, 3PL company charges extra "stop-over fee". Having extra stop over points also delays the delivery of the orders. Thus, it is undesirable for the chemical company. The company # 1, has a minimum shipment load condition (minimum tonnage per vehicle), i.e. if the total load of the vehicle is less than the agreed minimum tonnage, chemical company pays a unit fee per kilogram for the weight difference to complete the tonnage (cost type 3).

Company # 2 and 3 use similar pricing structure. If there is only one delivery point for the shipment, i.e. single order is enough for full truckload, the pricing is per vehicle per location (cost type 4). Otherwise, if there are orders with different delivery points "partial delivery" pricing is charged per kilogram per location (cost type 5). When only one order is enough for shipment, actually there is no decision that needs to be made. As long as direct shipment (cost type 4) is cheaper, company prefers to send the order to its final location directly. Even if there are more than one agreed 3PL carriers that can serve for the order, we can calculate the threshold weight for each final delivery location that will provide the minimum cost for the company. These threshold weights for each