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Reliable Back-up Facility in Distribution Network

Rimmi Anand[a]*, Vijay Kumar[a]

[a]*Computer Science and Engineering Department, Thapar University, Patiala, Punjab*

Abstract

The designing of reliable facility location is an important way to evade against unexpected facility disruptions. In this paper, a facility allocation for distribution supply chain is designed that intend to achieve the effectiveness of system under site dependent facility disruptions. The proposed mixed integer model is implemented in commercial optimization solver CPLEX 12.6.3. The Lagrangian relaxation approach is used to solve the model. It is compared with CPLEX solver on randomly generated twenty test instances. The performance gap and computational time is used to measure the performance of proposed model. The experimental results reveal that the proposed model has capability to generate an optimal solution.

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Keywords: CPLEX; Distribution chain design; Facility location; Lagrangian relaxation; Reliability.

* Corresponding author.
E-mail address: rimmi.gemini@gmail.com

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1. Introduction

Finding the optimal distribution center location is a problem that occurs in all stages of the supply chain planning process. It is an important aspect in planning a new supply chain from scratch. Companies are entering new markets and need to establish a distribution structure which ensures a smooth distribution even in disruption conditions. It is just as important for re-evaluating existing supply chains: the environment is not stable over a period of years, which requires adaptation of the existing network structure for distribution. The disruption may occur randomly and can cost heavy on organizations budget. With the acquisition of reliability factor, while designing a network for the distribution system, backup distribution structures or a consolidation is required. The challenge lies for distribution planners to find optimal locations in their planning process. Optimal in a distribution planning context mainly refers to a cost-minimal solution by taking into consideration accessibility of customers. Quantitative, data-based facility location models support distribution planners in modeling the reality while accounting for various logistical aspects.

Facilities are critical infrastructures of service networks and supply networks, and locating facilities properly is highly important for providing products, information or services to customers both efficiently and sustainably. In real life, facilities may occasionally fail to work due to disruptions such as earthquakes, hurricanes, terrorist attacks, and equipment breakdowns. These disruptions substantially increase both the service costs and customer dissatisfaction because customers may have to seek service from locations other than their preferred facilities or because their demand may be delayed or even abandoned after a disruption, which may lead to higher transportation costs, order delays or a loss of market shares.

The main contribution of this paper is to study capacitated facility location within distribution network in the presence of facility disruptions. The proposed model considers both partial and complete random disruptions of unreliable distribution centers. The aim of this model is to choose reliable facility location and demand assignment that minimize the expected fixed location cost, emergency cost (for supplying from reliable DCs in the case of disruption), and shipping cost. The Lagrangian Relaxation-based approach is used to solve the integer programming is considered. The proposed model is tested on twenty test problem instances.

The rest of this paper is structured as follows. Section 2 describes the work done in the field of facility location problem. The mathematical formulation of reliable facility location is given in Section 3. The proposed solution is presented in Section 4. Section 5 presents the datasets, parameter setting, and experimentation results. Finally, Section 6 summarizes the contribution of this paper.

2. Literature Review

The facility location problem is both a classical optimization problem and a fundamental problem in designing supply or service networks, and it has been extensively studied over the past several decades. There is an abundant body of literature on both deterministic and stochastic facility location problems [1-6]. However, a majority of the literature addresses primarily demand and cost uncertainties, and relatively fewer studies consider the influence of facility disruptions [5]. Most recently, both academics and practitioners have realized that facility disruptions may be triggered by various factors and may occur frequently, and an increasing number of studies are investigating ways to improve the reliability of facility networks by planning for facility disruptions [8-10].

There are two main research streams on tackling facility disruptions. The first one seeks to improve the availability of facilities by increasing redundancy and utilizing backups. These models always explicitly consider the disruption probabilities when designing a facility network. Snyder et al. [10] study the reliable P-median problem and the reliable un-capacitated fixed-charge location problem, which simultaneously optimize the operating cost under regular circumstances and the expected cost when disruption occurs. By analyzing the trade-off curves of both costs, the authors note that substantial improvements in reliability can always be obtained with only slight increases in the regular cost. Cui et al. [11] proposed Lagrangian relaxation and continuous approximation algorithm on Snyder's work. Also, by extending using site-specific failures. Berman et al. [12] study the reliable P-median problem on a network and propose several exact and heuristic algorithms, ultimately revealing that facilities become more centralized or even co-located as the failure probability increases. Shen et al. [13] propose a scenario-based stochastic program and a nonlinear integer program for the reliable facility location problem with heterogeneous failure probabilities. They prove that both models are equivalent. Li et al. [14] consider the correlated effect of disruptions and propose a continuous approximation approach for the reliable facility location problem. Tang et al.