

## An integrated approach for robust inventory routing problem in a three-echelon distribution system

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### Abstract

This paper introduces the robust inventory routing problem with finite time horizon in three-level distribution systems considering uncertain demand and transportation cost. The vendor is responsible for replenishing distribution centers and distribution centers replenish geographically scattered customers. The products are distributed by capacitated vehicles and, depending on the decision variables, multiple vehicles are assigned to each distribution center. The inventories are kept both in distribution centers and customer sites. The objective is was to find a combined transportation and inventory strategy and minimize system cost while meeting the demand of each customer without shortage and ensuring feasibility regardless of the realized demands and transportation cost. The proposed system is integrated by a mixed integer linear programming (MILP) formulation for deterministic case of the problem. Moreover, the corresponding robust counterpart is formulated with regard to three different techniques of box, polyhedral and interval-polyhedral and analyzed using adjustable uncertainty parameters on a test bed. Finally, to cope with intractability of large size problems, an imperialist competitive algorithm is developed by genetic algorithm operators.

**Keywords:** Inventory Routing Problem, Distribution, Logistics, Robust Optimization, Imperialist Competitive Algorithm

### 1. Introduction

Coordination plays an important role in successful performance of all parts of supply chain. Since all parts of a supply chain are tightly connected, their coordination results in minimizing system cost and also better response performance for customers' requirements. Specifically, in distribution logistics, by considering integrity, producers and purchasers are not allowed to independently make decisions. Distribution problem as transportation problem and inventory management have been investigated by many researchers as inventory routing problem (IRP). The main body of IRP can be defined as solving three questions of how much to deliver, when to deliver and in what order to deliver. Features of IRPs can be categorized in terms of time horizon, topology, demand, routing, inventory policy, inventory decision, fleet composition and fleet size (Coelho et al., 2012). In real world situations, IRPs arise in various industries such as maritime logistics (Song and Furman, 2010), blood distribution (Hammelmayer et al., 2009), gas companies (Uggen et al., 2011), supermarket chains (Gaur and Fisher, 2004), vending machine chain (Huang & Lin, 2010), automobile industries (Alegre et al., 2007; Blumenfeld et al., 1987; Ohlmann et al., 2008), meat industry (Oppenet al. 2010), frozen food distribution companies (Custódio & Oliveira, 2006).