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A hybrid heuristic for a stochastic production-inventory-routing problem

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Abstract

We consider a stochastic single item production-inventory-routing problem with a single producer and multiple clients. At the clients, demand is allowed to be backlogged incurring a penalty cost. Demands are considered uncertain.

A recourse model is presented where the production and routing decisions are taken before the scenario is known, and the quantities to deliver to the clients and the inventory levels are adjustable to the scenario. Valid inequalities are introduced and a hybrid heuristic that combines ideas from the sample average approximation method and from relax-and-fix approaches is proposed.

Preliminary tests based on randomly generated instances are reported showing that the hybrid heuristic performs better than the classical sample approximation algorithm for hard instances.

Keywords: Inventory routing, stochastic programming, sample approximation algorithm, hybrid heuristic.

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1 Introduction

We consider a single item stochastic production-inventory-routing problem (SPIRP) with a single supplier/producer and multiple retailers/clients. A vendor managed inventory approach is followed where the supplier monitors the inventory at the retailers and decides on the replenishment policy for each retailer. Inventory aspects are considered both at the supplier and at the retailers. Demand is allowed to be backlogged at the retailers and in that case a penalty cost is incurred. Backlog is not allowed at the supplier. Demands are considered uncertain, following a uniform distribution. A constant production capacity at the supplier is assumed. The decision maker has to decide the production and the distribution plans for a finite time horizon. The production plan consists in defining the production periods and the amount to produce in each one of those periods. The distribution plan defines the retailers that should be visited in each time period, the quantities to deliver to each visited retailer, and the corresponding route in each time period. For the distribution plan a single vehicle is considered. The goal is to minimize the production and routing cost plus the expected inventory and penalty for backlogged demand costs. We assume the production plan and the choice of which clients to visit in each time period (and consequently the routing) are first stage decisions, that is, such decisions must be taken before the scenario is revealed. The quantities to deliver to each client at each time period, and the inventory levels, can be adjusted to the scenario (known as second stage decisions). Such assumptions may hold for short planning horizons.

Complex problems combining production, inventory and routing decisions have been receiving a great attention in recent years. For a recent survey see [1]. Stochastic approaches for related inventory routing problems have been also considered, e.g. [2,3,4,5,8]. Among these [3,4,8] present heuristic approaches. A classical approach for handling stochastic problems is the sample average approximation (SAA) method, see [9]. In this method the expected inventory and penalty for backlogged demand costs are approximated by a sample average estimate obtained from a random sample. The resulting sample average approximating problem (SAAP) is solved for different samples in order to obtain a set of candidate solutions. Then these candidate solutions are tested on a larger sample and the best solution for that larger sample is chosen.

However, most of the deterministic production-inventory-routing problems reported in the literature are not solved to optimality. Therefore, solving each SAAP to optimality, within reasonable running time, may be impractical for