PhD proposal

Stochastic lot sizing: models and algorithms

Domain: Algorithmics-Graphs-Combinatorics

Keywords: Combinatorial optimization, Stochastic integer programming, Industrial operations management, Lot-sizing problem

Abstract

The present PhD proposal aims at studying an optimization problem arising in the context of production management for industrial companies. The problem deals with planning the production of goods on resources such as an assembly line, a chemical reactor or a mechanical machine. Production planning consists in deciding which products should be processed on the resource, when and in which quantity. Despite its rather simple definition, production planning is most often a complex task for industrial managers, especially if lot-sizing decisions are involved.

Lot-sizing arises in production whenever start-up operations such as tool changes are required between production runs of different products on a resource. In this situation, finding the right quantity to produce after a start-up, i.e. the lot size, requires reaching a good trade-off between start-up costs (indicating large lot sizes) and inventory holding costs (indicating small lot sizes) .

One of the key information needed to make lot-sizing decisions in practice is the timing and level of the customer demand for the products to be produced. In most cases, this information is not fully available at the time we build the production plan. We only have an estimation of the future demand obtained through commercial or statistical forecasts and there is thus some degree of uncertainty on the future demand to be satisfied.

The purpose of the proposed PhD thesis is to develop models and algorithms to solve lot-sizing problems in the presence of demand uncertainty. This will be done whithin the framework of stochastic integer programming.

Context

Nowadays, industrial companies increasingly find that they must rely on effective supply chains to successfully compete in the global market and networked economy. Supply chain management consists in coordinating material, information and financial flows through out the supply chain from raw materials extraction to finished good distribution with the aims of both fulfilling customer demand and improving financial profitability.

There is a huge variety of decisions that have to be made while managing supply chain activities. In the present PhD proposal, we focus on decisions related to one of the supply chain processes, namely short-term production planning. Production planning consists in deciding about the products to be made, the timing and level of production as well as the resources to be used. Despite its rather simple definition, production planning is most often a complex task for industrial managers who can be overwhelmed by the complexity of the problem. This is particularly the case when production planning involves lot-sizing and scheduling decisions.

Lot-sizing can be defined as the clustering of items for transportation or manufacturing at the same time. Lot-sizing arises in production whenever start-up operations are required in order to prepare

the production resource for the processing of a new product. Start-up actions can involve many different operations such as cleaning, preheating, tool change, machine calibration or test runs. Start-up costs account e.g. for the additional workforce needed to prepare the resource, for the production loss during the resource downtime, for the raw materials consumed during start-up operations, etc. To minimize start-up costs and obtain a more efficient use of production resources, production should be run using large lot sizes. However, this generates inventory as the production cannot be synchronized with the actual demand pattern. Namely, products must be held in inventory between the time they are produced and the time they are actually used to satisfy customer demand. This generates inventory holding costs mainly because of tied up capital.

The objective of lot-sizing is thus to reach the best possible trade-off between start-up and inventory holding costs while taking into account both the customer demand satisfaction and the technical limitations of the production system.

As can be seen from the above description, one of the key information needed to make lot-sizing decisions is the timing and level of customer demand. Most existing models and solution algorithms assume that demand is determiniscally known and seek to build the best production plan meeting the mean expected demand (see e.g. Jans and Degraeve, 2008). However, in practice, future customer demand often has to be forecast and is thus known with some degree of uncertainty. Not taking into account forecast errors while planning the future lot-sizes may lead to stockouts, late delivery or expensive rush productions.

There is thus a strong industrial need to develop approaches to solve lot-sizing problems where the stochastic nature of customer demand is explicitly considered.

Objectives

The purpose of the proposed PhD thesis is thus to develop models and solution algorithms for lot-sizing problems involving demand uncertainty.

This will be done within the framework of stochastic programming. This area of mathematical programming focuses on modelling and solving optimization problems involving unknown parameters. Stochastic programming models assume that the behaviour of the problem parameters subject to uncertainty can be described using probability distribution. The idea is then to identify decisions which are feasible for all or nearly all possible outcomes of the uncertain parameters while minimizing the expected cost.

We will first focus on a simple version of lot-sizing problems where the production of a single product on a single production resource is considered. Several more realistic extensions such as multi-product, multi-resource or multi-stage problems of this basic problem will then be considered.

Workprogram

- Identify and compare different ways of modelling demand uncertainty
- Development of a model and solution algorithm for the basic lot-sizing problem involving a single product and a single resource
- Development of a model and solution algorithm for one or several extenions of this basic problem.

Prerequisite

- Research master in computer science or applied mathematics
- Good knowledge of the operations research and probability/statistics fields
- Good programming skills (C, C++)

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References

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