A Robust Approach for the Joint Lot-Sizing and Supplier Selection

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1 Introduction

With the rise of mass customization, companies tend to increase the number of finished products offered to their customers. As the large number of finished products leads to large inventory costs, these firms commonly adopt the assemble-to-order (ATO) strategy, where the components are assembled to end-items only when customers order the products. As the ATO strategy matches the end-item assembly with the demand, there is no need to manage the end-item inventory. Conversely, managing the stock of components appropriately is crucial, to assemble on-time without escalating inventory costs. Managing the component's stock is complex, because the assembly site is often close to the customer demands, whereas components are shipped from various locations, and the supplier's delivery lead times are often long and unpredictable [3]. Consequently, there is a need to develop purchase planning methods that are robust to uncertain lead times.

In this work, we investigate the situation of a company that pre-selected a set of suppliers for a given component and must place the orders based on the prices and delivery lead times offered by the suppliers. In other words, we aim to provide robust optimization approaches to decide when to order, how much to order, and from which suppliers, in the context of uncertain delivery lead time.

There exists a large body of literature on the supplier selection problems, since these problems have a critical impact on the operational costs of a firm. However, most of the literature focuses on the selection of an interesting set of suppliers. While the placement of orders to these pre-selected suppliers is also an important decision, there is less literature on this topic [4]. A few works consider uncertainties in this context, but they mostly focus on the price uncertainties. To the best of our knowledge, our work is the first to consider the lot-sizing problem with supplier selection under lead time uncertainties.

There is a growing amount of researches on classical lot-sizing problems under lead time uncertainty [1], but these works usually focus on finding the planned lead time for MRP systems with the lot-for-lot lot-sizing rule. On the contrary, we assume the use of mixed-integer linear programming lot-sizing models commonly used in advanced planning systems. Consequently, our work strongly contributes to the field of lot-sizing under lead time uncertainties. To the best of our knowledge, [2] is the only work proposing a robust optimization approach for lot-sizing under random lead times. [5] present a robust optimization model, but they ignore the fixed ordering costs.

2 Formal description of the problem and methodology

We give below a formal description of the robust supplier selection and lot-sizing problem under lead time uncertainties. The inputs of the problem are the demand d_t for each period t in the planning horizon $\mathcal{T}$, and the set of suppliers $\mathcal{S}$, where each supplier s has a different price p_s, and a fixed ordering cost o_s. The delivery lead time of each supplier s is unknown, but it takes value in the interval $[\bar{L}_s, \widetilde{L}_s]$. The problem is to decide the quantity Q_{ts} to order in period t to supplier s, to minimize the fix ordering costs, inventory and backordering costs for the worst possible lead time scenario.

In this talk, we present a mathematical formulation of the robust supplier selection and lot-sizing problem under lead time uncertainties, as well as the associated adversarial formulation. However, the number of scenarios representing possible lead time values grows exponentially with the number of periods and suppliers. Our first results indicate that these exact methods cannot solve some instances with ten periods. Consequently, we propose two heuristics to solve the problem. The first relies on the budget of uncertainty modeling approach, where we modify the mathematical model to consider the worst-case scenario per period rather than globally. The resulting model is transformed into the robust counterpart formulation, which is solvable over large planning horizons. The second method is a metaheuristic to find near-optimal solutions in a reasonable amount of time.

Références

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