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Robust inventory management under joint demand and lead
time uncertainty

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1 Introduction

Today, the growing importance given to the reactivity of production systems and service
level places the efficiency of supply systems at the centre of companies’ concerns. Among the
various factors influencing the performances of supply systems, the impact of different sources of
uncertainty has been the focal point of many research work for many years. Most of the existing
works consider uncertain demand or delivery lead time. Although some works are interested
in the integration of these two sources of uncertainty [1], these works are most often based
on restrictive assumptions : 1) demand and lead time distributions are assumed to be known
2) discrete lead time are approximated by mean of continuous distributions 3) autocorrelation
of demand and dependencies between these two sources of uncertainty are ignored. In many
real-world problems, uncertain demand follow autocorrelation patterns, and in some cases,
the lead times are influenced by the demand of previous periods. Indeed, a succession of high
demand leads to a saturation of suppliers and thus increases delivery lead time. In practice, not
taking these correlations into account in procurement policies can lead to sub-optimal decisions
and loss of efficiency.

2 Robust optimization approach

In supply problems, it is not uncommon for the classical models aiming to optimise the
average performance of systems to be replaced by approaches allowing performance guarantees
to be obtained. Although the first works in this direction date back to the 1950s [6], the
recent development of Robust Optimisation ([2] and [3]) have led to the development and
application of new approaches to supply management. [4] applied the approach of [3] to a single-
product, multi-period supply problem with uncertain demand in single- and multi-echelon
supply systems. Since then, a lot of papers have extended their works and studied robust
approaches to inventory problems. [5] have extended this work using different uncertainty
sets. However, these latest contributions focus mainly on product demand uncertainties. The
problem of delivery lead time uncertainty has been little studied in a robust context. The
work of [7] is the only one to propose a robust approach by considering uncertainties on the demand and the delivery lead time. Unlike the previous work, the robust model is solved using a column and constraint generation method, allowing us to obtain less conservative robust solutions. However, uncertainties in demand and delivery lead time are modelled by two separate uncertainty sets, ignoring possible dependencies between these two sources of uncertainty, and the demand is supposed to be i.i.d. over the different periods.

3 Contribution and initial results

Our work focuses on developing robust models and the definition of uncertainty sets that allow the integration of demand and delivery lead time uncertainties. We consider a periodic review inventory model for a single product over a finite planning horizon when demand backlogging is allowed. The obtained robust model defines the quantity to order at each period and is solved with a constraint and column generation algorithm. The objective function minimizes the sum of unit ordering costs, holding costs, and backlogging costs over the planning horizon. We study the impact of different correlation assumptions on the proposed robust solutions (demand autocorrelation, dependencies between demand and delivery lead time) and propose different approaches to incorporate these correlations into an uncertainty set that jointly controls demand and delivery lead time. The proposed solutions are evaluated and compared according to economic criteria such as worst and average costs as well as service level.

Références


