



Robust inventory management under joint demand and lead time uncertainty

Benoit Loger, Guillaume Massonnet, Fabien Lehuédé, Alexandre Dolgui,
Stefan Minner, Burakhan Sel

► To cite this version:

Benoit Loger, Guillaume Massonnet, Fabien Lehuédé, Alexandre Dolgui, Stefan Minner, et al.. Robust inventory management under joint demand and lead time uncertainty. ROADEF 2023 : 24ème congrès annuel de la Société Française de Recherche Opérationnelle et d'Aide à la Décision, Rennes School of Business, Feb 2023, Rennes, France. hal-04011259

HAL Id: hal-04011259

<https://hal.science/hal-04011259>

Submitted on 2 Mar 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Robust inventory management under joint demand and lead time uncertainty

Benoit Loger¹, Alexandre Dolgui¹, Fabien Lehuédé¹, Guillaume Massonnet¹,
Stefan Minner^{2,3}, Burakhan Sel²

¹IMT Atlantique, LS2N

4 rue Alfred Kastler - La Chantrerie - 44307 Nantes - France

{benoit.loger,alexandre.dolgui,fabien.lehuede,guillaume.massonnet}@imt-atlantique.fr

²TUM School of Management, Chair of Logistics and Supply Chain Management

Technical University of Munich

Arcisstraße 21 - 80333 Munich - Germany

{stefan.minner,burakhan.sel}@tum.de

³Munich Data Science Institute

Technical University of Munich

Walther-von-Dyck-Straße 10 - 85748 Garching bei München - Germany

Keywords : *Inventory Management, Robust Optimization.*

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

- [1] Oussama Ben-Ammar et al. Supply planning and inventory control under lead time uncertainty : a literature review and future directions. *IFAC-PapersOnLine*, 55(10) :2749–2754, 2022.
- [2] Aharon Ben-Tal and Arkadi Nemirovski. Robust convex optimization. *Mathematics of Operations Research*, 23(4) :769–805, 1998.
- [3] Dimitris Bertsimas and Melvyn Sim. The price of robustness. *Operations Research*, 52 : 35–53, 2004.
- [4] Dimitris Bertsimas and Aurélie Thiele. *A Robust Optimization Approach to Supply Chain Management*. Integer Programming and Combinatorial Optimization. Springer Berlin Heidelberg, 86–100, 2004.
- [5] Hamed Mamani, Shima Nassiri and Michael R. Wagner. Closed-Form Solutions for Robust Inventory Management. *Management Science*, 63(5) :1625–1643, 2016.
- [6] Herbert Scarf. *A min-max solution of an inventory problem*. Studies in the mathematical theory of inventory and production, Stanford University Press, 201–209, 1958.
- [7] Andreas Thorsen and Tao Yao. Robust inventory control under demand and lead time uncertainty. *Annals of Operations Research*, 257 :207–236, 2017.