

Machine Learning for Inventory Control under Stochastic Lead Times

Uncertainty in supplier lead times is a persistent challenge in inventory management. Traditional models often assume fixed or well-behaved stochastic lead times, but in practice, variability can significantly impact service levels and cost performance. Conventional policies such as base-stock or (s, Q) rules can become inefficient when lead times are volatile. Recent advances in machine learning offer new ways to design prescriptive decision models that adapt to such uncertainty without requiring strong distributional assumptions.

This thesis aims to investigate how machine learning techniques can be applied to improve inventory control in single-echelon systems with stochastic lead times. The study will focus on prescriptive approaches that directly recommend replenishment decisions rather than predicting demand or lead times. By leveraging simulation and benchmarking, the thesis will compare machine-learning-based policies against classical inventory control rules. The central research questions are:

How can machine learning methods be used to prescribe replenishment actions in systems with stochastic lead times?

How do machine learning-based policies compare to traditional base-stock or order-up-to policies in terms of cost efficiency and service levels?

What are the conceptual advantages and limitations of ML models in handling lead time uncertainty?

To address these questions, the thesis will begin with a literature review on inventory models with stochastic lead times and prescriptive analytics in operations management. A simulation environment will then be developed to evaluate benchmark policies under varying lead time distributions and demand conditions. Machine learning approaches (such as reinforcement learning or supervised prescriptive models) will be implemented and tested against these benchmarks. Performance will be assessed using cost, service level, and robustness criteria to derive insights into the potential and limits of ML for inventory control under uncertain lead times.

This topic is suitable for a student with knowledge of **inventory** models (e.g., OPM 502 or similar). Solid **programming skills** are required; the implementation will be done in **Python**, using standard scientific and machine-learning libraries (NumPy, pandas). Prior exposure to machine learning or reinforcement learning is advantageous but not mandatory, as the necessary methods can be learned during the thesis.