MS-E2177
Seminar on Case Studies in Operations Research

Data-Driven Optimization of Used Car Inventory

Project Plan

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Client:
Kesko

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1 Background

Our client, Kesko, is a Finnish trading sector forerunner working in grocery trade, building and technical trade, and car trade. Kesko's car sector, K-auto, imports and sells attractive high-quality new cars and offer significant amount of multi-brand used cars in Finland.

The used car market plays a crucial role in Finland's automotive industry. Each year, significantly more used cars are sold than new ones. In 2024, around 600 000 used passenger cars were sold, compared to just around 75 000 of new cars (Tiedotuskeskus (2024)). With approximately 3.2 million cars on the road out of Finland's 5.2 million registered vehicles (Tiedotuskeskus (2024)), the demand for second-hand vehicles remains strong, making inventory management a key factor in a dealership's success.

For used car dealerships, profitability depends on having the right mix of vehicles in stock. A well-balanced inventory ensures that a dealership can meet customer demand efficiently, avoiding both overstocking slow-moving models and missing sales opportunities due to gaps in selection. However, managing this balance is challenging. Many dealerships still rely on the intuition and experience of their managers, with purchasing decisions made based on personal expertise rather than data-driven insights. This approach not only increases the risk of mismatching supply with demand but also requires a significant amount of manual work to assess and acquire the right vehicles.

An inventory optimization model could help dealerships overcome these challenges by bringing a more structured, data-driven approach to decision-making. By analyzing market trends and customer preferences, the model could improve inventory composition, reduce excess stock, and ease the workload of purchasing managers. Efficiency and responsiveness are extremely important in competitive markets, which means that optimizing inventory could lead to significant gains in both profitability and operational efficiency.

As a well-established field, optimal inventory management is a that applies mathematical models and data analytics to balance supply and demand efficiently. The aim of inventory management is to minimize the costs associated with holding excess stock and ensuring that products are available when needed. In the context of used car dealerships, inventory management requires a more dynamic approach as the inventory does not consist of standardized products but rather of used vehicles which vary in model, age, mileage and condition which makes the demand prediction more complex.

2 Objectives

This project aims to develop a data-driven inventory optimization model to enhance Kesko's used car trade by improving profitability and operational efficiency. The model will support purchasing managers in optimizing inventory composition, ensuring alignment with market demand and financial goals.

Key Objectives

1. **Optimizing Inventory Composition**: Develop a model that recommends the ideal mix of used cars for a rolling three-month planning horizon, with monthly updates.
2. **Maximizing Return on Capital Employed (ROCE)**: Rank cars based on profitability potential to ensure efficient capital allocation.
3. **Enhancing Decision-Making for Purchases**: Provide purchasing managers with data-backed recommendations on whether to acquire specific vehicles, offering a clear rationale based on expected sales performance, historical data, and market dynamics.

The key objectives are ranked based on priority, with a focus on the first two. By integrating advanced analytics and optimization techniques, this project will help Kesko's used car business with precise inventory planning, improved financial outcomes, and increased responsiveness to market fluctuations. The insights will further contribute to better resource allocation, reduced holding costs, and enhanced decision-making capabilities for purchasing managers.

3 Tasks

The project follows five key phases: project kickoff, literature review, data preparation and analysis, model implementation and testing, and reporting. Regular meetings with Kesko and Aalto course personnel provide guidance and support throughout each phase.

3.1 Project Kickoff

- **Setup work space:** The first step was to set up central platforms for collaborating on project tasks and communication, along with establishing a weekly work schedule.
- **NDAs and receiving Kesko's data:** We have signed non-disclosure agreements (NDAs) with Kesko and received data on their used car business, primarily consisting of cars for sale, purchased cars, and sold cars.
- **Clarifying objectives:** During the project scoping with Kesko, the objectives were clearly defined.

3.2 Literature Review

- **Review:** We have familiarized ourselves with the fundamental principles of inventory optimization and the broader aspects of supply chain management. Additionally, we have explored various approaches to this type of modeling problem in the literature, covering topics such as time series analysis, demand forecasting, assortment planning, inventory management and forecasting, pricing prediction models, dimensionality reduction, profitability and product assortment, and simulation.
- **Further analysis:** Once we have established the initial approach and models to test, we will dive deeper into resources related to their implementation and diagnostics. This process is expected to be iterative, with our focus changing based on the outcomes from the models we have tested.

3.3 Data preparation and analysis

- **Pre-processing the data:** The data from Kesko must undergo thorough cleaning to remove inconsistencies, errors, and missing values, ensuring accuracy and consistency for precise modeling. Additionally, dimensionality reduction techniques will be applied to refine the feature space, eliminating redundant or irrelevant variables to improve model performance as described in (Bilen (2021)).

- **Exploratory data analysis (EDA):** Basic descriptive statistics and visualizations will be applied to uncover trends and seasonal patterns, providing a clearer understanding of the data. Additionally, techniques such as multivariate regression models, clustering, and multiple correspondence analysis (MCA) will be used to identify relationships and extract meaningful patterns.

3.4 Model implementation and testing

- **Fitting models and variables:** We test the most suitable models and assess their fit through diagnostic evaluations. Based on our initial analysis, the inventory optimization model could take the form of static assortment models (Kök et al. (2015)), dynamic assortment models (Rusmevichientong et al. (2010); Sauré and Zeevi (2013)), or stochastic dual dynamic programming (SDDP) models (Downward et al. (2020); Livy-Li (2025)).
- **Choosing the best models:** The criteria for evaluating the models are yet to be established. Once suitable models have been identified, we move forward with the implementation and testing phase.
- **Validation and verification of the models:** We collaborate with Kesko and course personnel to validate our models. If necessary, we make adjustments and, when required, fit alternative models.

3.5 Reporting

The results will be reported through the course deliverables, which are project plan, interim report and the final report, with the exception of any sensitive information safeguarded by the NDA. This project plan provides an overview of the objectives and the planned progression of the project. The interim report will highlight any changes to the initial plan, along with the project's progress. The final version will include a literature review and a detailed description of the final model.

4 Schedule

Figure 1 shows the timeline for the execution of the project. The key date for the project is the crunch weekend, on the 22^{nd} of March. Here, we aim to progress the project as far as possible within a weekend.

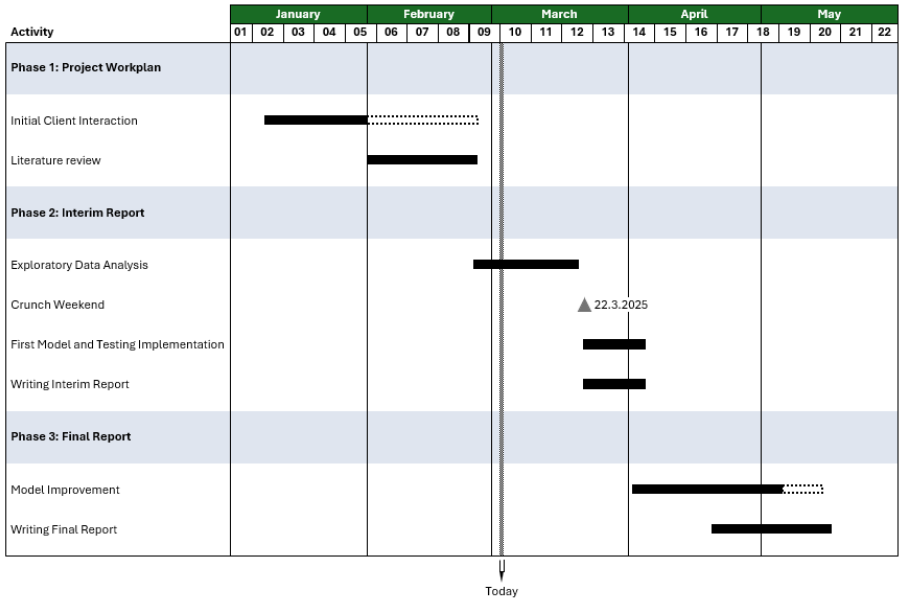

Figure 1: Project schedule on a Gantt chart

5 Resources

The team for the project has a strong mathematical and analytical background. It consists of one business analytics student and four Operations Research students — one of whom has another degree in economics. Thus, the team is well suited for tackling a problem such as data-driven optimization of a used car inventory.

The main point of contact from Kesko is Matias Tiainen, who works as a data scientist for the company. Matias has extensive experience in the modeling of used car demand and inventory optimization, having worked at the company for five years. Matias has a background from Aalto and has done the same course. The other contact from the company side is Mika Niemelä, who works as a Senior eCommerce manager for K Auto Oy. Mika has experience and expertise on ecommerce sales and development of digital tools for used car sales, meaning that they can provide assistance and direction for the project. Furthermore, from the university's side, Professor Ahti Salo acts as a general supervisor for the project and can offer assistance and direction in some situations.

Inventory optimization is a widely researched topic, with plenty of available scientific literature. Additionally, demand modeling is a widely researched field — even though the exact prediction of used car demand may have gained less attention. The scientific literature can act as a basis for the development of our methods for predicting demand and formulating the optimization problem.

For the practicality side, we have reserved Friday afternoons for meetings if deemed necessary. Furthermore, we have setup the date for a crunch weekend, where we will progress the work with a hackathon-type approach. The tools we will use will likely revolve around Python, but potentially Julia, Excel and PowerBI as well.

6 Risks

The risks related to the project are listed in Table 1.

Risk	Likelihood	Effect	Impact	Mitigation
Too ambitious targets	Low	Multiple solutions built, but none meet the requirements	High	Identify which of the problems are the most important and focus on those
Schedule risks	Low	We run out of time and objectives are not met	High	Set clear milestones and schedule "hackathon-style" working sessions for the group
Insufficient understanding of the requirements	Medium	Too much time used implementing complex solutions that might not create value for the client	Medium	Discuss requirements with the client throughout the course
Free riding	Low	Some group members do significantly less work than others	Medium	Schedule regular meetings and agree collaboratively on a fair workload distribution
Model not generalizable	Medium	Model built does not create value in real life context	Medium	Analyze the data to understand its limitations and conduct rigorous validation

Table 1: Risks related to the project

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