



Aalto University
School of Science

MS-E2177

Seminar on Case Studies in Operations Research

Modelling the procurement costs of subcontracted metal parts in machine manufacturing

PROJECT PLAN

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Client:

Normet

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1 Background

Normet Group is a company in the underground mining and tunnelling business. They design and produce specialized vehicles that improve their customers' processes in terms of safety, efficiency and sustainability. The assembly takes place in a Finnish factory after they have received the subcontracted metal parts from different worldwide suppliers.

The metal parts represent a big part of the manufacturing cost of the equipment which Normet sometimes struggles to understand because of a lack of transparency with some suppliers. The cost of these parts generally depends on different elements such as raw material, labour, electricity, order quantity etc. Furthermore, smaller suppliers buy from distributors that themselves sell big factory lots. This creates delays in how the raw material prices are affected by the steel price index.

Overall, we can distinguish two types of suppliers:

- The suppliers who belong to the “white box”. Normet and they agree over the prices depending on the raw material prices. This is the best type of suppliers for Normet.
- The “grey box” suppliers. There is not the similar transparency as above but the prices follow the same dynamics. There is a clear reaction to raw material prices but it is not fully clear for Normet.

Normet thus faces the challenge of understanding procurement costs. They know that they are not getting good deals with some suppliers.

That is why they expect us to build a procurement cost model as a function of various factors. This model will help them forecast their future cost developments and also find out those suppliers that could be considered as outliers (i.e., they have higher costs than what they could expect).

2 Objectives

The main objective of the project was determined by the project brochure and clarified with Normet in meetings: a model that explains the procurement cost for selected metal parts as a function of major cost elements. The model is used for two purposes:

1. To forecast future cost development
2. To identify which parts exhibit abnormal cost development (costs higher than should be expected based on the model)

The model can be tailored to different types of items, as there are differences in the cost drivers across different types of items. We expect that the most important cost drivers are steel price, ordering quantity, and weight of the item. We will also evaluate if other potential drivers, such as labor cost indexes and electricity prices, exhibit significant correlation with unit prices of items. The end product is to produce a mathematical model which Normet can use for the above-mentioned purposes.

The exact scope for items included in our modelling is not yet defined, but it is limited to the subcontracted metal parts that we have data from (approximately 12 000 unique items). The scope will be focused on a set of items whose price variation at least some of our explanatory variables (from which we have data from) are able to explain.

3 Tasks

The project consists of five partially overlapping phases: project initiation, literature review, data analysis and model formulation, testing and implementation, and writing. These are supported by meetings with Normet and course personnel. The tasks under each of the overall phases are listed and explained in the following sections.

3.1 Project initiation

Setup work environment. The very first task has been to setup internal information sharing platform and communication channel for the group. Besides, the group has agreed on the preliminary weekly working schedule and practises.

NDAs and receiving Normet's data. We have signed non-disclosure agreements (NDAs) with Normet and received purchase data about the sub-contracted metal parts, including most importantly their purchase prices, ordered quantities, suppliers, and descriptions of their properties, such as weight. We have also received information about the supplier-specific price breaks - intervals of ordering quantity, where the unit price stays the same for the same item. Besides, Normet has provided us steel price index data and forecasts for six months ahead.

Scoping and clarifying objectives. The scope defines which suppliers and items are included in our modelling. While scoping the project with Normet, the objectives are crystallized.

Gathering data from external sources. Not all required data are provided by Normet but need to be gathered by the group from public sources, such as part of the steel price index data. Other potentially useful data include labor indexes and electricity prices, among others.

3.2 Literature review

Literature scanning. We have familiarized ourselves with the basic principles of cost modelling in procurement. We have also evaluated the overall approaches to this type of modelling problem from literature, including time series and regression methods. Besides, we have gathered relevant materials from previous operations research courses,

such as prediction and time series analysis, statistical inference, and multivariate statistical analysis.

Detailed analysis. After defining the approach and initial models we are going to try first, we look for more detailed material about their implementation and diagnostics. This will likely be an iterative process, where the search is refocused based on the implementation results of previous models.

3.3 Data analysis and model formulation

Pre-processing data. The data from Normet and external sources needs to be cleansed so that the data is consistent, excluding biased observations such as rush orders and rebuilds. Besides, we need to combine and integrate different data sets for further analyses.

Exploratory data analysis (EDA). We calculate basic descriptive statistics and create simple plots to make sense of the purchase data. In EDA, our goal is also to determine analytical metrics, with which we can detect parts that exhibit similar cost patterns. Then we can group items based on these properties and try to apply similar models to items within the same group. We investigate the relationship between purchase prices and different variables to assess which type of model with which variables included with which lags should be tried first.

Fitting models and variables. We fit the most potential models with different variables and evaluate the fit diagnostics. The models will likely be different for different item groups. Based on initial analysis, the most potential explanatory variables are steel price, weight, and ordering quantity. Our initial thoughts are that the model could be multiple linear regression model, where steel price affects purchase price with a lag. We start with the simplest possible model and add complexity if needed.

Choosing the best models. The evaluation criteria for models are not yet defined, but will likely be some kind of metric related to minimizing forecasting error. After identifying satisfactory models for all items in our scope, we proceed to the testing and implementation phase with these models. If necessary, we continue iterating to find a better model fit. If we cannot identify a satisfying model within the time, budget

and resource constraints of the course, we continue to the next phase with the models that we have found.

3.4 Testing and implementation

Validation and verification of the models. We collaborate with Normet to validate our models. Besides, the technical correctness will be ensured with help of the course personnel. In case the validation or verification fails, we make the required changes - and if needed, fit different types of models probably with different variables.

Final forecasts. The models will be implemented for our first objective, to forecast the future cost development of the selected subcontracted metal parts for the next six months.

Detection of abnormal cost development. The models will be implemented for the second key purpose, to detect metal parts with abnormal cost development. This could require data analysis efforts besides using the model.

3.5 Documentation of results

Reporting will be done through the deliverables of the course except for the sensitive information covered by NDA, such as the exact prices, names of suppliers and metal parts with abnormal cost development, which is shared separately with Normet.

Project plan. Will be prepared on schedule and updated during the week when it is presented. (~5 pages + presentation slides.)

Interim report. Will be done 1-2 weeks before the deadline, which should suffice as the length is ~3 pages (+ presentation slides).

Final report. We start working on the project report early on to ensure all our relevant work is appropriately reported - not just the results. (~25-30 pages + presentation slides.)

3.6 Supportive activities

Meetings with Normet. Interaction with our client Normet will be important to first familiarize ourselves with the context, set appropriate scope and crystallize objectives. For the remainder of the project, we will have weekly check-up meetings with Normet to ensure we are progressing to the right direction and to get answers to the questions that will arise.

Meetings with Aalto. Interaction with the course personnel helps us determine the most suitable methods, validate that our results are technically correct, and to ensure that we are progressing according to the course requirements. Besides, we are expecting valuable feedback from our peer group and other groups from our presentations.

4 Schedule

The schedule of the tasks is in the Gantt chart below.

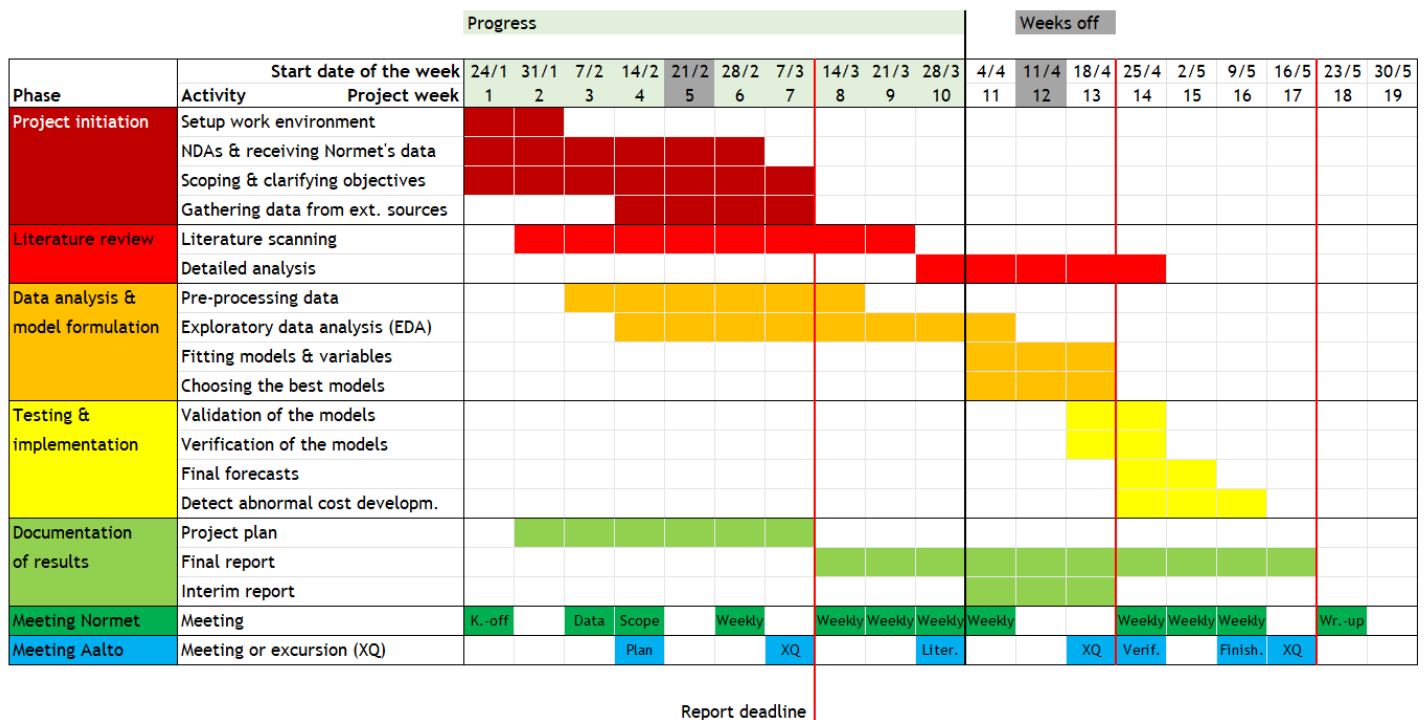


Figure 1: Gantt chart of the project schedule.

5 Resources

The team consists of four master's level students, Benoist, Eero, Matias and Niklas. All team members have some background in mathematics and problem solving. Also the team has a different variety of skills in programming, which are expected to be beneficial for the project. We have not yet distributed any roles for the project, except the role of project manager, and will assign them further on based on interests and skills.

Matias is a master's student in Mathematics and Operations research and has studied computer science as his minor. Eero is a master's student majoring in Operations Management and minoring in Systems and Operations Research, with passion to improve operations of companies with analytical approach. Niklas is a master's student in Mathematics and Operations research and Leadership and Change Management as a minor. Benoist is an exchange student majoring in Industrial Engineering and Management with Logistics Supply Chain as a minor.

So far, Normet has provided with the purchasing data along with product specifications which will need processing. Also we have received historical steel indices containing also future forecasts. We will be first using multiple programming language based on individual preferences and then translate them into one single program. We will use the library services provided by Aalto University library to search for literature. We are having weekly meetings with Normet to show intermediate results from our analyses, get expert insight into the results as well as clarify potential issues to ensure we progress towards the right direction.

6 Risks

Table 1 presents the risks related to the project. The risks are ranked according to probability and impact, and we describe what measures we are planning to take to minimize the risks.

Risk	Prob	Impact	Effects	Measures
Communication issues with the client	Low	Medium	Deliverables are not what the client wanted	Frequent meetings with the client
Low information value from data	Medium	Medium	Not able to build model	Focus on research and provide insight that way
Not finding a suitable approach	Medium	High	Does not answer questions correctly	Measure performance frequently
Not enough time to finish implementation	High	Medium	More narrow scope or lower quality	Well-defined roles, prioritizing tasks
Team member absence / Slow progress	Medium	Medium	Narrow down scope	Frequent meetings and try to make the project work fun

Table 1: Risks related to the project and measures to mitigate them.