Aalto University
School of Science

MS-E2177

Seminar on Case Studies in Operations Research

# Optimal currency hedging policy in global pulp markets

## PROJECT PLAN

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UPM

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# Contents

# 1 Background

When a company trades its goods in a different currency than the domestic currency of the company, it is exposed to currency risk, sometimes called foreign exchange risk. Imagine that a company produces a commodity in its home country, which means the production expenses will be measured in the currency of that country. The company also measures its profits in the same currency. The company sells the commodity abroad, which means the earnings will be measured in the foreign currency. The currency risk arises because there is a risk of an unfavourable change in the exchange rate between the domestic currency of the company and the foreign currency in which the price of the commodity is determined.

Currency risk can be managed, or *hedged*, in different ways. One method is that the company takes a currency position to project the future cash flow, by either buying or selling currency forwards. A forward contract is a customized contract between two parties to buy or sell an asset at a specified price on a future date [1]. A future is similar, but a more standardised type of contract [1]. Future and forward contacts can be made on currency, which means that by entering a forward contract to sell some amount of currency at a later time, the company can essentially lock in their future exchange rate today. When the company sells their commodity at the future date and receive foreign currency, they can sell it at the previously agreed exchange rate in the forward contract. In this way, the company is completely protected against unfavorable changes in the exchange rate. This is called a *perfect hedge* if the price of pulp in the future is known and it is possible to take an equal and opposite position [1]. The downside is of course that the firm have to pay a premium for this insurance. The other, perhaps even more undesirable downside, is that if the exchange rate were to change in the company's favour, they will not benefit since they have locked in the exchange rate.

If the company in question wants to benefit from a possible favourable change in the exchange rate, they could use options instead of futures and forwards. Options give the buyer the right to, but not the obligation, to buy or sell an asset at a specified time in the future, in this case, the asset would be a certain currency [1]. In other words, the currency option protects the company from an unfavorable change in exchange rate, but if the change is in the company's favour, they can simply choose not to exercise the option and thus advantage from the positive change. Using forward and option contracts, it is possible

to construct different hedging strategies. However, we are interested in mitigating both upside and downside risk, so option strategies will focus more in large changes. The optimal currency hedging strategy would minimize the variance of a portfolio consisting of the asset and the hedge while being affordable and maintainable.

In this project, we will do a case study on currency hedging in the global commodity market of pulp. Our client is UPM, a Finnish forest industry company that produces, among other things, pulp, label materials, communication- and specialty papers and wood products. The UPM Pulp is part of the UPM Biorefining Business Area. Pulp is a clean, wood-based, renewable and biodegradable raw material [2]. It can be used to produce paper, tissue, board and specialty paper. UPM produces both hardwood and softwood pulp products. Hardwood pulp is made from eucalyptus or Nordic birch, while softwood is made from pine and spruce [3]. Hardwood and softwood pulp prices are somewhat dependent on different factors, and it is not necessarily the best solution to hedge them in the same way. For this reason, we will study them independently to see if the optimal hedging strategy differs for different pulp types.

Since UPM is a Finnish company, it measures its profits in EUR. Most of UPM's production facilities are located in Finland, except from one pulp mill which is situated in Uruguay. However, the customers can be in any currency region, which introduces a currency risk. The pulp price is determined in USD, which means that we need to hedge against changes in the EUR–USD exchange rate. To make matters a bit more complicated, the pulp price is correlated with the EUR–USD exchange rate.

# 2 Objectives

Our goal is to find the optimal hedging strategy for UPM with regard to pulp sales. The objective is to create a portfolio for hedging the foreign exchange risk that our client faces. In our first solution, we will hedge using an opposite currency position. Then, we will try out a portfolio of futures, forwards or options. Perfect hedging may not be possible if futures with suitable terms are not available, and perhaps not even the best solution. A common way to hedge if perfect hedging is not available is using *minimum variance hedge*, i.e. using a hedging instrument such that the variance of a portfolio consisting of the asset and the hedge is minimized [1].

Assume that our client will sell an amount of pulp at time $T$, and that the delivery is worth $x$. This situation is hedged with $h$ units of forward contracts of the underlying currency pair with spot price $F$. At time $T$, the cash flow is [1]

$$y = x + (F_T - F_0)h. \tag{1}$$

By finding the variance of y, and then minimizing it, by setting the derivative with respect to $h$ equal to zero, we find the minimum variance hedge as [1]

$$h = -\frac{\mathrm{Cov}(x, F_T)}{\mathrm{Var}(F_T)}. \tag{2}$$

Minimum variance hedge does not take into account the investor's risk preferences. Risk preferences can tell if the investor is risk averse, risk seeking or risk neutral [4]. If an investor especially wants to avoid large risks they are risk averse. If they are indifferent to the risk and wants to choose the option with the highest expected return, they are risk neutral [4]. Risk preferences can be modeled using, for example, Expected Utility Theory (EUT) [4]. This is done by introducing a utility function and maximising the expected utility of the portfolio containing the asset and hedge [5]. However, utility functions can be hard to define. We have discussed risk preferences in a meeting with our client, and they suggested that we study different utility functions for comparison. We mutually agreed to try out two different objectives:

1. Maximize the expected value (risk neutrality)
2. Protect against extreme unfavourable events (risk aversion)

We can then compare our simulated strategies to see if the recommended strategy is different depending on which of the objectives above we choose. Forwards will be used in order to achieve risk neutrality and options for risk aversion.

# 3 Tasks

## 3.1 Client interaction

We have had three meetings with our client UPM so far. In the initial meeting, the client presented a more detailed background about the problem, and we discussed the objectives and goals of the project.

After the first meeting, we received our data, and on the second meeting, we could ask questions about the data. In the second meeting, we also discussed the scoping of the project and clarify objectives. In the third meeting, we presented a project plan for the client, got valuable feedback and answers to some important questions.

We plan to have frequent meetings in-person to keep the client up to date on our progress and discuss the best way to move forward. Further meetings will be scheduled when needed, but we plan to at least have meetings a few weeks before the deadlines for the report submissions. In this way, we can present our work for the client and get feedback before the submissions. Apart from meetings in person, we use email and a Slack channel [6] to communicate about meetings and shorter questions.

## 3.2 Reporting

The reporting of the project consists of a project plan, an interim report and a final report. The interim report is quite short and summarizes the progress in the project so far, as well as possible updates to the project plan. The final report is the most extensive deliverable in this project. It includes necessary background information about the project, a literature review and reports the methods and results of the project work. In addition, it includes assessments of the results and of the project as a whole.

## 3.3 Research

**Literature review** An important part of the project is to review the literature about the topic. This research is needed for us to be able to select the best hedging strategies for our problem. We will search for articles about optimal currency hedging to get information about hedging strategies to try out, and articles about hedging in the pulp or forest industry, to learn more about hedging in these markets in general. We search for literature using the university library tools.

**Study of correlations between pulp price and exchange rate** The data we have received from the client consists of historic time series of pulp prices, for both hardwood and softwood pulp and from both the European and Asian markets. Moreover, we received historic data for the exchange rate of EUR–USD and other currency pairs. We want to

study the correlations between pulp prices and exchange rates. The pulp price is known to be dependent on the EUR–USD exchange rate, but we do not know how correlated they are and in what way. Finding out more about the correlation could possibly help us in selecting hedging strategies to use.

**Selection of hedging strategies** Different hedging strategies and approaches are available. Our objective is to find out which ones to implement by studying literature, test them, compare them in different scenarios and choose the best strategy that we recommend.

## 3.4 Implementation

We want to start simple and begin by implementing a solution where we hold a hedging portfolio consisting only of forwards. The next step is to integrate our findings about the correlation into our solution. After implementing a model with a portfolio of forwards, we would like to extend our solution by implementing a model with a portfolio of forwards and options.

## 3.5 Testing

Throughout the implementation, it is important that we check if the model is doing what we want it to do. After implementing our models, we will compare them according to some metric of our choice, and check how they perform in different scenarios. The metrics could be for example:

- Efficiency: How effective is the strategy compared to the base case
- Complexity: How easy is the strategy to maintain
- Cost: How much do the strategies transactions cost

The base case here is defined by us, the most natural choice for the base case would be no hedging at all. The goal is then to compare how well out implementations perform in the historical time-series provided by the client. We will also need to find out what happens in edge cases, when the exchange rate change drastically in either direction. We will simulate data to test the models in the scenarios containing unexpected or large movements.

# 4 Schedule

Figure 1 shows the schedule of the tasks related to this project.

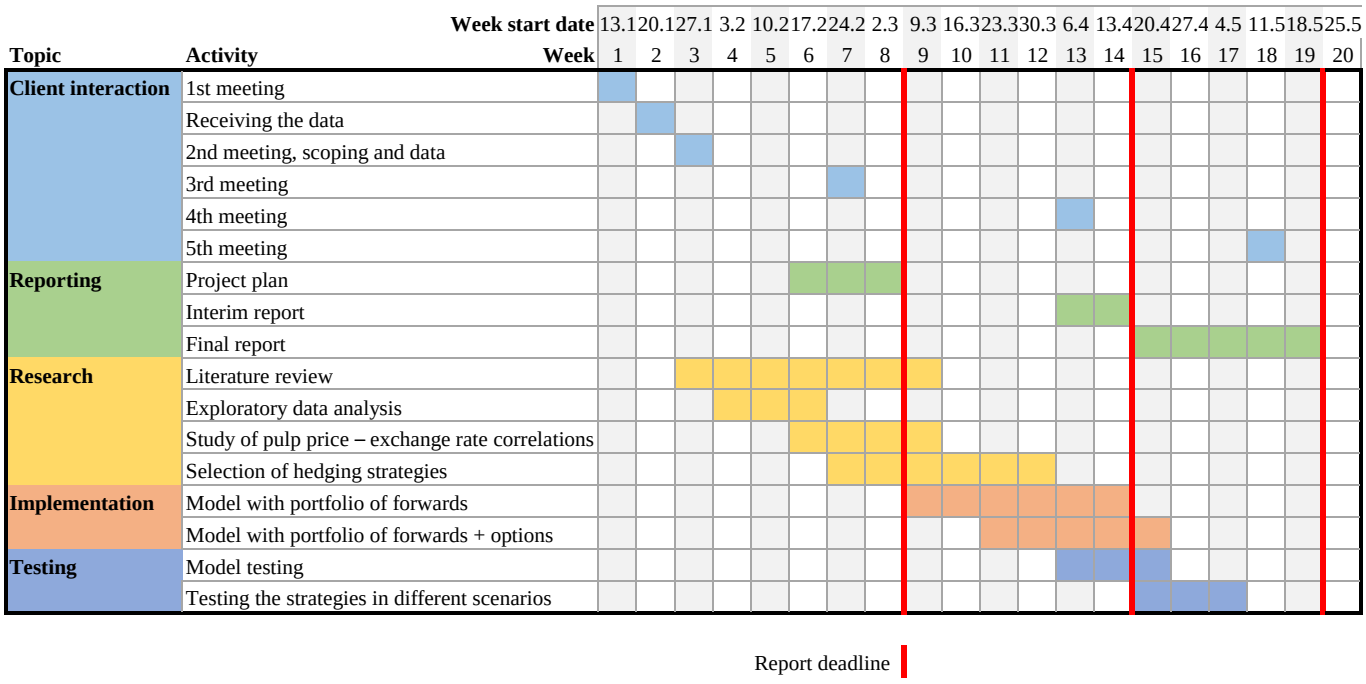


Figure 1: Gantt chart of the project schedule. The week numbers correspond to weeks of the course.

# 5 Resources

Our team consists of four members: Matias Linnankoski, Joni Karras, Elin Nyman and Zhongqing Yang. Matias is a Mathematics student who is studying Financial Engineering as his minor, and is working as our project manager. Elin is a master's student majoring in Systems and Operations Research. Yang, a master's student of Advanced Energy Solutions, majoring in Sustainable Energy in Buildings and Built Environment, who also has studied a minor in the field of Sustainable Energy Systems and Markets. Joni has a major in Math and Operations Research with undergraduate degree in Economics from University of Helsinki.

Our knowledge of financial modelling and hedging is not extensive, so we will have to study the basics of these areas to learn more and

come up with possible approaches.

Our client has provided us historic time series of both hardwood and softwood pulp prices, for both the European and Asian markets, as well as the EUR–USD and other exchange rates. We have also received 12 month forward rates and both 3 and 12 month implied volatilities for the EUR–USD currency pair for the past 15 years. The client is also available to help us and answer our questions.

When it comes to what tools we are going to use, we have chosen GitHub [7] as our version control system. We will use Python 3 as our programming language. We will use the library services provided by Aalto University library to search for literature.

# 6 Risks

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

| **Risk** | **Probability** | **Impact** | **Effects** | **Mitigation measures** |
|---|---|---|---|---|
| Member absent in April-May | Certain | Medium | If the project is late and there is much work left in April and May, the smaller team size might result in delays and high workload. | The roles and schedule should be well-defined to ensure progress. Elin will have a larger role in the early and mid-stages of the project. |
| Too complicated solution | Medium | High | Project delivery is hard or impossible to implement with client's tools. | Focus on the main task and keep it simple. Always discuss with the client about implementing new features to the model. |
| Unrecognized bias on model | Medium | High | Final model is trained with too little and specific data set. Or over-trained and hence is biased. | Discuss on guidelines of selecting a proper time frame for modelling correlations between time series. |
| Blindness for unexpected events | Low | High | Final model does not account for rare, extreme events. | Give guidelines on how model should be used e.g. when a sharp, big movement in exchange rate occurs. |

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

## References


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