Aalto University
MS-E2177 - Seminar on Case Studies in Operations Research

Project Plan

Optimal investment trategy for nonlinear life insurance liabilities

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1 Background

The Fennia Group consists of Fennia, Fennia Life, and Fennia-service Ltd. Together, the companies offer their clients competitive and high-quality non-life and life insurance services. Fennia's insurance activities date back to the 19th century, and the Fennia Group provides various risk management and insurance services for enterprises, their personnel, entrepreneurs, and private households, as well as flexible client financing solutions.

Fennia offers clients non-life property and casualty insurance products, and subsidiary Fennia Life offers both savings and risk life insurance products. Investments of both insurance companies are managed using a group-level asset and liability management strategy that separates assets into a hedging portfolio that is backing the long liabilities and an investment portfolio that consists of excess capital.

The hedging portfolio's goal is to generate returns required by liabilities as well as replicate liability market risks to minimize risk coming from covering liabilities. This way, the excess capital in the investment portfolio can use the majority of the group's risk capacity with the sole goal of accumulating the group's own capital.

While market sensitivities of the parent company's products are straightforward, Fennia Life has offered more complex voluntary savings and pension products with a guaranteed minimum rate of return for savings and an option to get extra benefits if the current interest rate level exceeds the guaranteed rate. To meet these promises, its assets must generate returns that match the guaranteed rate and the option in all scenarios. In addition, liabilities are valued with market interest rates, and the value of assets must match or exceed the market consistent present value of future cash flows for the company to stay solvent in the regulatory framework.

Moves in market interest rates affect liability value significantly. Moves lower in interest rates increase the present value of guarantees that essentially behave as fixed-rate bond instruments. On the other hand, moves higher in interest rates, as well as expected volatility of rates, increase the expected value of extra benefits paid to policyholders and the option present value. The value of the guarantee and option combined form the market-consistent value liability that needs to be covered with suitable financial instruments. Due to the complexity of policy terms, no financial instrument can fully replicate the sensitivities of liabilities, and the hedging/investment strategy needs to be planned carefully to optimally balance the return expectations and risks for the Fennia's own capital as well as transaction costs.

2 Objectives

The main goal of the project is to form an optimal investment or hedging strategy for Fennia Life for liability matching. The excess return of assets compared to liabilities should be maximized while the risk to the own capital of the company (adverse mismatch between asset and liability values) should be minimized.

The project aims to build a model for simulating the expected return and mismatch of a multitude of insurance policies and hedging instruments under an investment or hedging strategy.

This model will take simulated yield curve paths as arguments for the insurance policies and hedging instruments, and be able to balance the assets and liabilities in the balance sheet for optimal results.

The investment and hedging strategy will be based on literature reviews, client input and team analysis.

The goal for the model implementation is to be a clean and cohesive program, that can be easily run with different data and be expandable or adaptable to other similar problems with low effort. The code that is of high quality including comments, and the development will be documented using version management.

3 Tasks

The main tasks consist of a literature review into pricing bonds and non-linear products as well as data handling, developing, testing and reporting the model.

After the literature review, the team builds a rudimentary model that is able to value one bond and one liability contract, matches the NPVs and then simulates the resulting cash flows and show the mismatch between them.

After this has been built, the team iterates on the built model to incorporate a more diverse set of hedging products, as well as more sophisticated hedging strategies.

The initial tasks have been divided functionally, with each member taking charge of the coding and literature of a certain subject, with every member helping each other to balance the workload evenly. The initial division has been the following:

- Assets (designing asset pricing models): Touko Haapanen
- Liabilities (implementing liabilities valuation and cash flow projections): Leevi Kaukonen
- Hedging strategy & simulation (researching and designing hedging strategies): Joel Vääräniemi and Matvei Zhukov
- Overall project management, hedging strategy, assets, liabilities: Vlad Burian

This initial division is to ensure that each area of the problem has someone dedicated to working on it and understanding it (and is supposed to work as an initial division of labour). Since not all tasks require the same amount of time, members may work on each other's areas. If, for example, the team notices that the liabilities implementation is done, the person in charge of it will be moved to work on some other area, such as hedging strategy.

4 Schedule

Below is a Gantt chart of the tentative schedule. The tasks that are being worked are divide into the rudimentary Excel model and the overall Python implementation. Tasks that are done are marked with teal, while the green areas indicate the tentative schedule for the tasks being worked on.

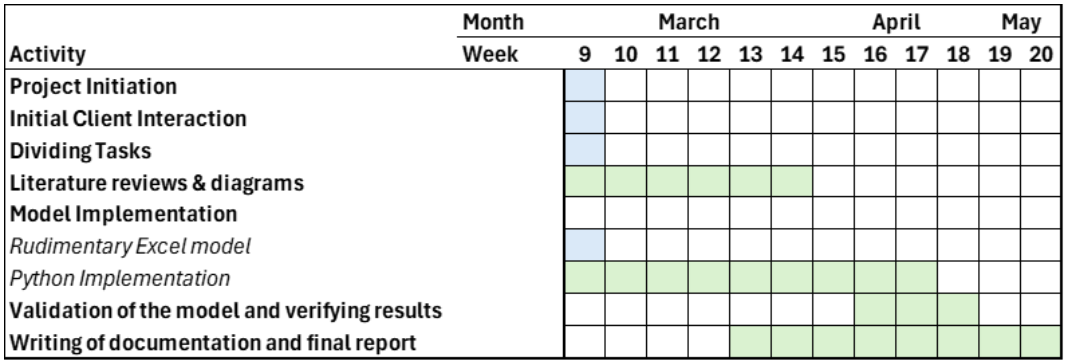

Figure 1: A Gantt chart of the project plan.

5 Resources

The project team consists of two Applied Mathematics students, two Systems and Operations Research students and one pure Mathematics student, with multiple members having completed either degrees or minor studies in economics, finance or financial engineering. Therefore, the team has understanding of mathematics, statistics and financial derivatives.

The team's main contact at Fennia is Timo Salminen (CFA, FRM), Fennia's Head of Capital Management. Timo has extensive experience in asset and liability management as well as in mathematics and financial derivatives. The course teacher Professor Ahti Salo is a general supervisor and offers guidance to issues related to the course.

Other contacts include Fennia Life's Chief Actuary Anssi Puranen. Fennia has also provided the team with their proprietary simulation data for both a risk-neutral market scenario and a realistic market scenario, which has data enhanced by expert opinion and macroeconomic scenario modelling. There is also extensive literature written on the topics of asset liability management, optimal hedging and investment strategies and financial derivatives.

6 Risks

Risk	Probability	Effect	Impact	Prevention
Team member inactivity, group dynamic problems	Low	Loss of motivation & cohesion, poor results	High	Weekly meetings and touchpoints, goodwill
Result does not satisfy client	Low	Unsatisfied client	High	Active communication with client
Members lack time to work on project	Low	Missed deadlines	Medium	Weekly meetings and continuously set running goals
Not understanding complex financial concepts	Medium	Method's and models may be implemented incorrectly	High	Continuous check-ups and validation with client, rigorous self-screening
Too ambitious goals	Medium	Time wasted on too complicated models or overly detailed analysis	Medium	Active communication and expectation management with client, developing a minimum viable product first

Table 1: Risks related to the project, along with an assessment of the impacts and possible measures to mitigate the risks.