Aalto University
School of Science

ILMARINEN

MS-E2177

SEMINAR ON CASE STUDIES IN OPERATIONS RESEARCH

Pricing of Junior Mezzanine Tranches of Collateralized Loan Obligations

PROJECT PLAN

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PROJECT MANAGER

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1. Introduction

In this project, assigned to us by Ilmarinen Mutual Pension Insurance Company, we develop a method to assess the relative prices of the junior mezzanine tranche of a collateralized loan obligation (CLO). This method models and simulates the cash flow structure of a CLO, from which the pricing of the junior mezzanine note is derived.

A CLO is a structured asset-backed security that compounds a pool of corporate loans (the collateral) with notes of varying cash-flow priority (the obligations). One benefit of compounding numerous loans in a customized asset class is the diversified the risk of individual corporate loans. Another benefit of structuring assets is that a standardized prioritization scheme in interest income payments allows for creation of notes with varying credit quality. Specifically, the interest or principal proceeds from the loan portfolio are first distributed to the notes (called tranches) that have the highest priority in the payment waterfall, that is, the senior CLO notes. Then, the payments for mezzanine notes are made in their prioritization order, and finally the residual cash flow is paid to an equity piece.

Alternative CLO modelling schemes are typically divided into static and stochastic approaches. Static approach relies on the computation of the average outcome or explicit computation of cash flow distributions. The stochastic approach uses simulation to generate different possible cash flow scenarios, from which the distribution of outcomes can be derived. For comparison of these two approaches, see e.g. Sepci et al. (2009). Being the second to last in the payment waterfall, the junior mezzanine tranche is relatively prone to risk, and hence unlikely but high losses are relevant. For this reason, we have chosen the stochastic approach that reveals the tail probabilities in a straightforward manner.

The resulting simulation model can be used to generate possible outcomes of a particular CLO. The model can also be used to present fair prices of the junior mezzanine tranche in terms of the generated cash flow distribution. By adjusting the parameters of the model, sensitivity analysis can be done with regards to the particular parameters of interest.

2. Scope

The scope of this project is determined by the number of CLO characteristics considered in the model. The set of 27 different CLO characteristics to be considered, provided by the client, were divided into 3 categories: (i) essential characteristics that comprise the minimum scope of the project, (ii) possible characteristics that may be included in the model if they are adequate for the schedule of the project, and (iii) characteristics that are unlikely to be included in the model. The characteristics of each category (i)-(iii) are presented in Tables 1-3 below. Some characteristics provided by the client, such as average spread of the portfolio or subordination of the tranches, are implied by the modelled collateral portfolio, and hence need not to be considered explicitly.

Table 1: Essential CLO characteristics. These characteristics are essential in that these have to be defined in order to the most elementary cash flow model to function.

Variable	Class
Buffer for any trigger levels in the CLO (especially OC tests)	General
Legal final maturity	General
Length of reinvestment period (the period during which principal proceeds are reinvested in loans instead of returned to AAAs)	General
Amount of senior secured loans and second lien loans	Asset portfolio
Expected recovery rates for the loans (or, loss given default)	Asset portfolio
Expected default rates for the loans	Asset portfolio
Thickness of the tranche	Liabilities
Coupon of the tranche	Liabilities

Table 2: Possibly included CLO characteristics. These characteristics will be considered after the basic model for CLO is implemented.

Variable	Class
Age of the CLO (i.e., time elapsed since issuance)	General
Distribution of sectors, e.g. how much oil & gas and metals & mining	Asset portfolio
Losses and defaults incurred so far	Asset portfolio

Table 3: CLO characteristics which are unlikely to be included. These characteristics are either unquantifiable or considered less relevant for the CLO model.

Variable	Class
Length of non-call period (time during which the bonds cannot be redeemed)	General
Regulatory compliance of the bond (regulations have changed over the past few years and some CLOs can be out of date in terms of compliance)	General
Quality of the CLO manager	General
Quality of lead arranger (the investment bank that originally brought the CLO to the market)	General
Market liquidity of the loans (especially the distressed ones)	Asset portfolio
Amount of unpriced assets (the ones for which there are no quotes at all in the market)	Asset portfolio
Current and original rating of the tranche	Liabilities
Market liquidity of the tranche (number of interested buyers)	Liabilities

3. Tasks and assignments

The project is divided into certain tasks. Most of these tasks need to be approached together as a group, but some workload can be assigned to each group member separately. The main areas are data collection, client management, modelling, results, reporting, literature review, and project management.

1. Data Collection

Data collection is essential for the project as financial data is needed for both developing and validating the model. In order to build a useful data set, we need to carefully define an initial scope in terms of input variables. A well-defined initial scope in turn helps focus data collection only on required variables. Inclusion of additional items is evaluated continuously if additional details are needed to improve accuracy of the model. Additionally, we expect the data to be in a non-standard format so a standard data structure has to be decided. Data collection is also closely related to client management since we consider the client as the main provider of data. In addition to the data collection aspect, client communication and feedback throughout the project is necessary in order to align project outcomes with client expectations.

2. Modelling a CLO

The mathematical model is the core of the project. Modelling a CLO consists of two phases: the modelling of the assets (collateral portfolio) and the set of liabilities (the issued notes). In a stochastic approach, the asset model generates a random time-until-default for each loan, and the periodical proceeds can then be computed considering the defaulted borrowers. The concept of time-until-default for financial instruments was first introduced by Li (2000). In this paper, Li also presented a method to combine the default probabilities of individual loans to a joint probability distribution using Gaussian copulas; if default correlations will be included in the project scope, this approach will be used. Modelling the set of liabilities consists of modelling the payment waterfall and different triggers of a CLO that ensure sufficient collateralization of the senior CLO notes.

First, loans are modelled separately and as a portfolio. These intermediate results are then used for modelling the liability side. After the cash flows of the assets and liabilities are modelled, the pricing of the tranches can be found in terms of their discount margin (i.e., the excess internal rate of return in addition to the market reference rate of LIBOR). The fair discount margin of a tranche is the margin with which the present value of the expected cash flow stream is par.

3. Results

In order to create a useful model, both the model and the results need to be validated and verified. The model may have to be refined depending on the validation and verification. The first version of the model will be simpler– more parameters and variables will be added as needed. Additionally, in the end, an input and output summary is required for using the model.

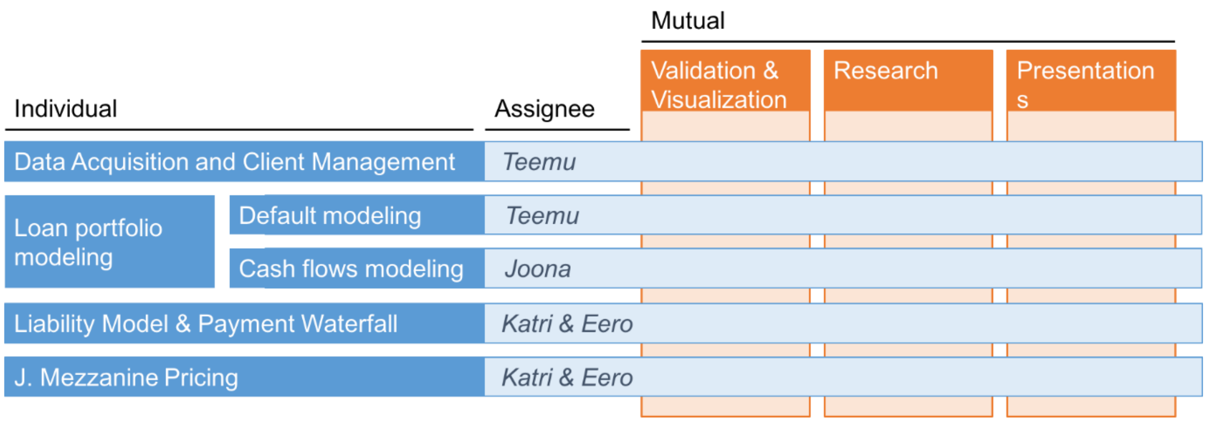
4. Reporting

Reporting is an important part of the project as well. The reporting consists of three parts: this project plan, a midterm status report, and a final report. Each part includes also a presentation with slides. Reporting is done to track the process and to explain the work done. The reports are the deliverables for the school course this project work is part of.

5. Other tasks done throughout the project

Literature review is done on the approaches and models used before for similar problems. Making a literature review consists of collecting the sources and making syntheses based on them. Data collection and the literature review are the first parts of this project.

Project management is mainly done by the project manager selected among our group members. It includes communication with our client and our professor as well as progress tracking and risk mitigation. Other tasks are assigned according to the following chart.

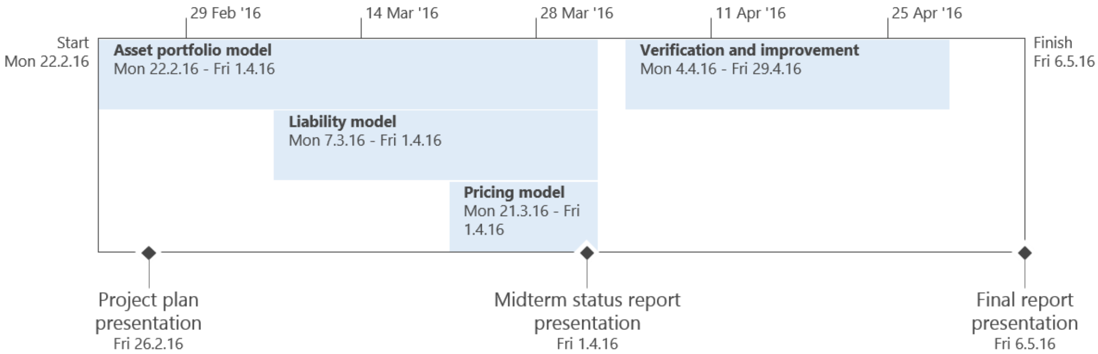


4. Schedule

The following external deadlines for deliverables have been set. Thus the project is to be completed on 6.5.2016.

Deliverable	Deadline	Presentation
Project plan	24.2.2016	26.2.2016
Midterm status report	30.3.2016	1.4.2016
Final report	4.5.2016	6.5.2016

Project plan has been made according to the waterfall model. However iterative and agile methods can be utilized inside each stage and especially the model tuning has been planned to be carried out in this way.



5. Risks

Risks pertinent to the project were qualitatively assessed on two dimensions: likelihood and effects. Likelihood was assessed on a three step scale from “Low” through “Moderate” to “High”. No specific probability range estimate was associated with the scale. (e.g., “Moderate” likelihood would correspond to 1%-10% probability of realization.) Effects were assessed on a similar three step range to indicate their magnitude. Their impact was also briefly described and roughly differentiated as either additional time consumption or reduction of output quality. Mitigation measures for each risk were then identified in order to both reduce the likelihood of realization as well as the impact on the project if the risk was to realize.

In brief, data quality and coverage was identified as the primary concern in terms of both likelihood as well as impact. Preliminary feedback from the client already indicates that currently prevalent illiquidity in the loan markets reduces the available information available to model the behavior of loans underlying CLOs. This emphasizes the need to both secure an as-wide-as-possible dataset for the analysis as well as adapt the approach to suit the available data in order to reach adequate output quality.

Additionally, tooling mismatches and excessively wide initial scoping were identified as posing both moderate likelihood of realization and magnitude of impact in either time consumption or output quality. Failure in developing a valid model, while clearly posing a large impact in output quality, was deemed to be very unlikely. Initial readiness from the client to limit the scope of the project was interpreted to also imply low pressure from the client to increase the initial scope as the project progresses.

Risks	Likelihood	Effects	Mitigation measures
Mismatch between tool selection and sophistication of analysis	Moderate	Moderate; rework progress to date on new platform	Develop hypotheses and initial approach of analysis, match tooling to expected requirements

Inadequate data quality or coverage	High	Moderate; Inaccurate output (overfitting, bias)	Secure as-wide-as-possible dataset from client, emphasize standard format across data
Model validation failure	Low	High; Finished model produces clearly erroneous output	Conduct continuing validation of the model during development and address errors straight away
Too ambitious initial scope	Moderate	Moderate; Spreading efforts too thin – lack of focus produces lackluster results on all fronts	Assess potential items on "ROI" and client input basis, focus scope only on items deemed most important
Scope creep	Low	Moderate; see above	Align scope and expectations with the client from the get-to

6. Resources and References

The project team is composed of four Aalto University students: project manager Teemu Seeve and project group members Joona Kanerva, Eero Lehtonen, and Katri Selonen. The project contact person on the Ilmarinen side is Dr. Janne Gustafsson. Dr. Gustafsson can be also utilized as an expert practitioner source for information.

The primary data resource is the CLO data to be used for construction of the model. This data will be provided by Ilmarinen. Project data is saved in a shared Microsoft OneDrive folder. All project group members have access to the folder. The software needed for the modelling is planned to be Microsoft Excel. If problems arise, other software available from Aalto IT may be utilized. Particularly, Monte Carlo simulation will first be attempted using tools available in Excel, and adoption of specialized risk assessment tools such as @Risk will be considered if the need arises.

Earlier research in the studied topics will be used. If literature is not found in Aalto library or System Analysis Laboratory or available free online, Ilmarinen will obtain reasonably priced literature to be used by the project group and later retained by Ilmarinen. Thus far following useful references have been identified:

[1] Sepci, A., Krishnamurthy, D., Eder, C., 2009, Pros and cons of different CLO models, *Risk professional*

[2] Li, D. X., 2000, On Default Correlation: A Copula Function Approach, *The RiskMetrics Group*

[3] McNeil, A., J., Embrechts, P., (2005). *Quantitative risk management: Concepts, techniques and tools.* Princeton university press