Aalto University
School of Science

ILMARINEN

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SEMINAR ON CASE STUDIES IN OPERATIONS RESEARCH

Pricing of Junior Mezzanine Tranches of Collateralized Loan Obligations

MIDTERM REPORT

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1. Project status check

The project has been progressing according to the schedule. We have developed an elementary model for the cash flows of CLOs' tranches. This model (i) generates default times and recovery rates of the loans in a CLO's portfolio, (ii) calculates cash flows generated by the portfolio's loans, (iii) divides the proceeds of the portfolio to the different tranches of the CLO according to the prioritization scheme. This procedure can be then repeated numerous times to obtain cash flow distributions of the CLO tranches. We present the current status of the CLO model in this section.

Currently, the following features of the asset model are available. First, we have standardized portfolio data of hundreds of different corporate loans. Secondly, the model generates default times according to the credit ratings and historical default data on defaults of loans of different credit ratings. The historical default data was obtained from [1], and as the default time generation procedure we used is inverse cdf sampling. Thirdly, the recovery rates of each loan are generated from a uniform distribution with a mean that corresponds to historical averages. In the future, the recovery rate calculation scheme will be expanded to take into account market prices of the loans, but currently this approach yielded unrealistic results. After the default times and recovery rates are generated, the asset model calculates the cumulative interest and principal proceeds yielded by the portfolio in a straightforward manner.

The liability model and Monte Carlo scheme comprises the rest of the current model. The liability model divides the proceeds of the loan portfolio to the according to a standard payment waterfall of a CLO, provided by the client. The tranche properties of this model were also made according to data provided by the client. This liability model divides proceeds from the loan portfolio to pay the interest and principal payments of each tranche and ensures sufficient collateralization for the senior tranches by preponing principal payments. The Monte Carlo scheme is put on top of the asset and liability model, yielding numerous realizations of cash flow streams of each tranche. These generated cash flows can be used to obtain distributions of the internal rates of returns of the tranches, and from these the discount margins of the tranches could be calculated to obtain pricing data.

The client was visited and the current status of the project was presented to match the groups and client's views on the current state of the project, and to discuss the future steps of the project. The client was mostly content with the current state of the project.

2. Updated task scheme and next steps

Some of the task assignments changed, but mostly they have remained the same. Unlike planned earlier, the portfolio modeling was divided between the whole team so that everyone had something to do already from the beginning. Katri did data standardization for easier changing between portfolios. Eero did the Monte Carlo scheme for other to use in their

parts. Teemu generated the default times and did default data acquisition. Finally, Joona did market-price derived recovery rate calculation.

The initial task assignments were held for upcoming model expansion, and for example, the recovery rate still need more work. Also the liability task assignments remained unchanged. Katri examined the acquired CLO data and did standardization for it. Eero did the preliminary liability side model that utilizes the generated default times and recovery rates.

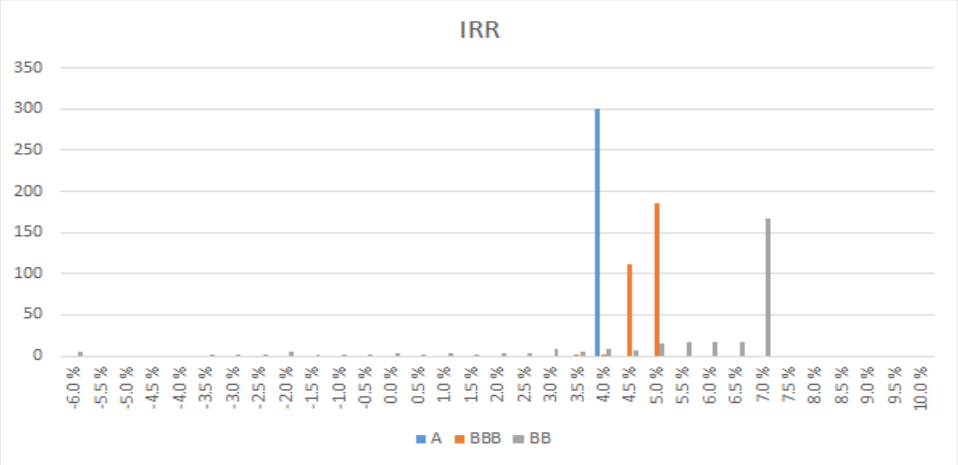
The next steps of the project consist mainly of improving the model in different ways. These steps include, for example, (i) enabling the model to perform sensitivity analysis of initial par subordination levels, (ii) specification of the appropriate risk metrics and pricing scheme to be calculated from the IRR distributions, and (iii) modelling of the reinvestment period to some extent (many loans have maturities shorter than the reinvestment period and therefore the model would not be very sensible without implementation of this).

Nevertheless, some improvement remains in the earlier work too. Specifically, the time resolution will be increased to quarterly instead of yearly intervals, and the recovery rate calculations require some refining. Moreover, some kind of validation of our model's performance is needed and the probability of underperformance w.r.t benchmark will be determined.

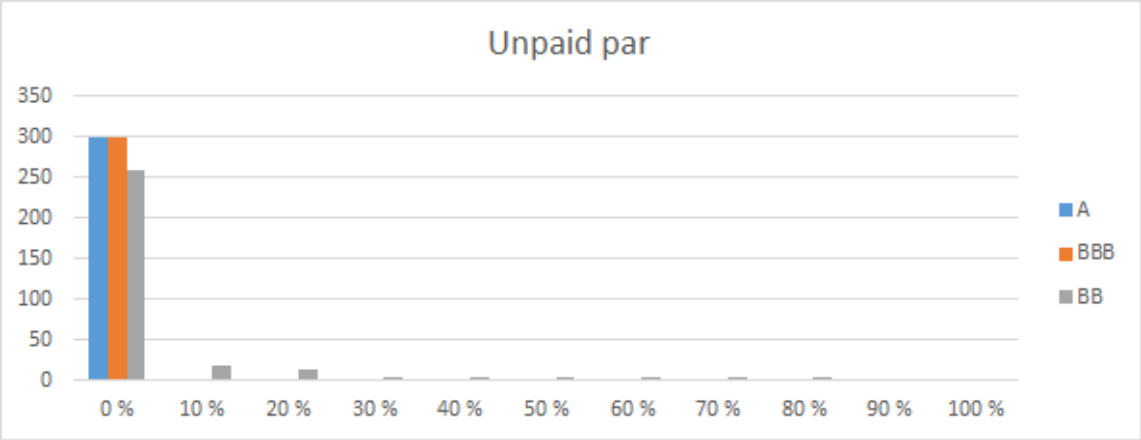
3. Results from minimum viable model

The minimum viable model has been successfully used to verify that parts of the model interact correctly with each other.

In the following figures are illustrations of the realizations from Monte Carlo runs of the minimum viable model. From the first figure can be seen that the internal rates of return are typically higher with higher risk and the variation in IRR is higher for the lower ranked tranches. We note that the BB tranche typically gets high returns, but carries a risk of loss, which can be seen from the long left tail of the IRR distribution of the BB tranche. The lower IRR of the tranches is accompanied with smaller risk, and the IRR of the A tranche did not fluctuate between different runs.



The simulated distribution of the unpaid par is consistent with the results from IRR calculations. Only the juniorest BB tranche faces par losses and the higher credit tranches faced no par losses at all in these simulation runs.



These preliminary results show that the model is working and should be developed further for higher accuracy.

4. Updated risks

Risks pertaining to the project were assessed in the project plan on two dimensions: likelihood and magnitude of effects (see Figure 1). Notably data quality and model validation issues were identified as major risks due to their high likelihood and high impact respectively.

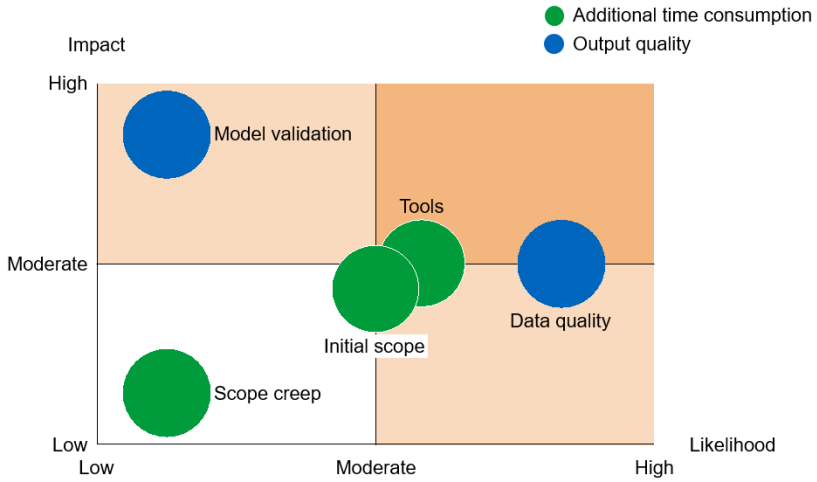


FIGURE 1: INITIAL RISK ASSESSMENT

As the project has progressed, some of the risks have realized to an extent while some have been successfully mitigated and the outcome of some is still uncertain. Of the two major risks identified previously, validation of the model has seen limited success and data quality has met expectations to a limited extent. Scope has been constrained to a manageable size and Excel has been found to perform to expectations and the team's current assessment is that

the currently planned features should be also implementable in Excel. See Figure 2 for an updated assessment.

Further assessing the two major risks, the preliminary output and behavior of the model has been presented to the client to a positive response. Since the implementation is still underway, it is important to revisit the topic with the client in addition to performing internal sanity checks among the team. Therefore the assessment of model validation is kept unchanged.

Data quality in turn has been found to meet expectations with regard to loan portfolio and CLO data, with ideally more combined portfolio-CLO datasets being available. However, lack of loan market data has been one cause of issues in determining loan recovery rates. Hence the risk has been partly realized, and its impact has been mitigated by increased team efforts as well as client consultation. Nevertheless the issue remains partly unsolved and there remains some risk of further complication. Both impact and likelihood of further data quality issues is therefore slightly reduced while it is still acknowledged as a major risk going forward.

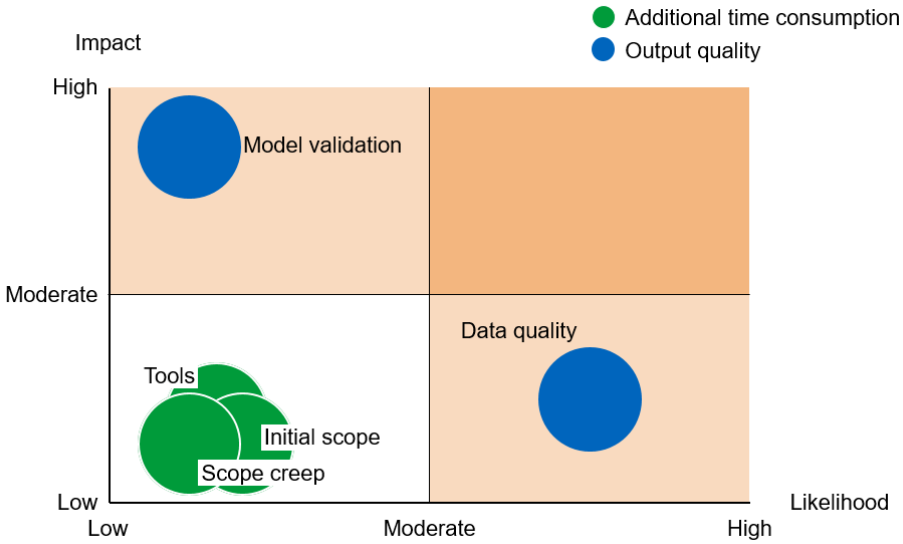


FIGURE 2: UPDATED RISK ASSESSMENT

5. References

[1] Moody's Investors Service, (2016), Corporate Default and Recovery Rates, 1920-2015