RMBI 4210- Quantitative Methods for Risk Management (2020-21 Spring Term)

General Information

- Lecture: Mon Wed 12:00 - 13:20
- Instructor: Prof. Yue Kuen KWOK <*maykwok@ust.hk*>
- TA: Jingjing WANG <mawjj@ust.hk>

Course Objective and Description

This course illustrates the use of various quantitative techniques (statistical analysis, optimization and simulation methods) and financial engineering principles (hedging and arbitrage), in the quantification and management of financial risks. The topics include characterization of financial risks, hedging of market risks, immunization of bond risks, credit portfolio and loss distribution, Value-at-Risk and expected shortfall, coherent measures of risk and economic capital, credit yield curve modeling, hazard rates and calibration, credit default swaps and structured credit products, Bernoulli mixture models, exponential default models, CreditRisk+, CreditMetrics and Gaussian copula models of default correlation.

Course Content

1. Financial risks: Loss distribution and risk measures
    1.1 Wall Street fails Main street
        - Systemic risk
        - Black Monday in 1987: market failure arising from program trading
        - Long Term Capital Management: failure of convergence arbitrage
        - Barings Bank failure: loss of risk control
        - Model risk: Constant Proportional Debts Obligations
        - Legal risk: Lehman Brothers' mini-bonds
    1.2 Hedging of market risks
        - Dynamic hedging of options
        - Minimum variance hedge ratio
        - Duration measure and bond immunization

1.3 Portfolio loss distribution
- Credit risk: Loan portfolio losses
- Fitting of loss distribution

1.4 VaR (Value-at-Risk) and Expected Shortfall
- VaR calculations
- Expected shortfall
- Coherent risk measures
- Risk control for expected utility-maximizing investors
- Economic capital
- Extreme Value Theory

2. Reduced form models of defaults: Hazard rates

2.1 Implied probability of defaults and credit yield curves
- Credit yield curves
- Credit spread and default intensities

2.2 Exponential models of joint defaults
- Joint survival of two obligors
- Multi-obligor extension
- Simulation algorithm

2.3 Credit derivatives
- Credit default swaps
- Synthetic Collateralized Debts Obligations

2.4 Hazard rates and credit derivatives pricing
- Implied hazard rate and calibration
- Building blocks of credit derivatives pricing

2.5 Counterparty risks
- Nature of counterparty risk
- Credit value adjustment

3. Default correlation models

3.1 Mixture models for modeling default correlation
- Bernoulli mixture models
- Fractional losses and correlation of defaults

3.2 CreditRisk+
- Mixture Poisson distribution

- Independent sector risk factors
- General sector analysis

3.3 CreditMetrics and Gaussian copula models

- Credit migration of firm credit indexes
- Gaussian copula models
- Monte Carlo simulation

Assessment Scheme

The assessment is based on the 80-minute mid-term test and 2-hour final examination.

Grading policy

80-minute mid-term test (31 March, Wednesday)	40%
2-hour final examination	60%

Student Learning Resources

Lecture Notes:

Lecture notes and homework set can be downloaded from Canvas.

References

1. Hull, J., *Risk Management and financial institution*, 4th edition (2015), Prentice Hall. (downloadable from HKUST Library)
2. Jorion, P., *Financial risk manager handbook plus test bank: FRM Part I/Part II* (2011), John Wiley & Sons.
3. Bluhm, C., Overbeck, L., Wagner, C., *Introduction to credit risk modeling*, second edition (2010), Chapman & Hall/CRC.

Teaching Approach

Lectures:

- Focus on the use of quantitative techniques in the modeling of market and credit risks.
- Emphasize on the quantitative understanding of risk measures, like Value-at-risk and expected shortfall, and their limitations.
- Understand the mechanism of default correlation via the mixture models
- Review of industrial practices in risk management and lessons learned from real life credit cases.

Tutorials: worked examples and problem solving skills.

Intended Learning Outcomes

Upon successful completion of this course, students should be able to understand:

1 Nature of various forms of financial risks: market risk, credit risk, liquidity risk.

2 Hedging of market risks in options

3 Bond yield, duration measures and horizon rate of return, and the techniques of immunization of bond portfolio.

4 Quantitative measures of portfolio risk using VaR and expected shortfall, and their limitations.

5 Set economic capital and determine risk-adjusted return on capital.

6 Estimation of VaR and expected shortfall using the extreme value theory.

7 Generate the credit yield curves from tradeable prices of defaultable bonds.

8 Understand funding cost arbitrage and counterparty risk of credit default swaps.

9 Derive the implied hazard rate from zero-coupon bond prices and build the building blocks for pricing credit derivatives.

10 Model default correlation among risky obligors using the mixture models.

11 Understand the popular industrial code CreditRisk+

12 Understand the popular industrial code CreditMetrics for modeling credit portfolio risk.

13 Understand the role of copula functions to model default correlation.

14 Generate the loss distribution of a portfolio of risky assets using Monte carlo simulation

Course Schedule

Week	Content	Remarks
1	Characterization of financial risks	Topic 1.1
2	Hedging of market risks	Topic 1.2
3	Bond yield, duration measures and immunization	Topic 1.2
4	Portfolio loss distribution	Topic 1.3
5	VaR and expected shortfall calculations	Topic 1.4

6	Coherent risk measures: economic capital and extreme value theory	Topic 1.4
7	Implied probability of default and credit yield curves	Topic 2.1
8	Exponential models of defaults	Topic 2.2
9	Credit default swaps and collateralized debts obligations	Topic 2.3
10	Hazard rates and calibration	Topic 2.4
11	Bernoulli mixture models of correlated defaults and contagion model	Topic 3.1
12	Poisson mixture model: industrial code CreditRisk+	Topic 3.2
13	CreditMetrics and copula models of default correlation	Topic 3.3