Quantitative Risk Management

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Course aims and intended learning outcomes

In this course, we develop the main theoretical concepts and modelling techniques of QRM. The goal for the students is to acquire practical tools to solve real life problems. We discuss risk management in the context of finance and insurance, but RM applies also to other sectors of the industry.

Main concepts include loss distributions, risk measures, interdependence and concentration of (extreme) risks, techniques derived from probabilistic modelling and statistical analysis, copula and extreme value theory. We also discuss corporate finance concepts like economic valuation of liabilities, capital, capital allocation and structure of capital.

The course is recommended to students who are interested in:
- Actuarial and financial mathematics
- financial risk management
- underwriting and market risk
- corporate finance

Through examples and case studies from the practice, we explain how sophisticated mathematical methods can be integrated in the efficient management of an insurance portfolio of risk. At the end of the course, students should be able to understand how a modern financial institution manages her risks.

Course content

A. The concept of risk, risk measures, and the pricing of risk (4 hours)
1. Definition of risk in insurance
2. Risk and risk measures, a coherent measure of risk
3. A simple example of pricing risk, what is the correct price?
4. The various components of an insurance price
5. Capital to cover the risk

B. Aggregation of risk and dependencies (4 hours)
1. Effects of diversification on the price
2. The right measure of dependency
3. A hierarchical dependency structure to avoid over specification
4. Pricing within a portfolio
5. Dependence structure and diversification benefits

C. Concept of capital and management of capital (4 hours)
1. The different perspectives on capital
2. Risk based capital and economic capital
3. Capital allocation, what is the right method for what purpose
4. How much capital does an insurance company need?
5. Structure of capital

D. Designing and implementing an internal model (4 hours)
1. History of the development of internal model
2. Purposes and goals of an internal model
3. Structure and architecture of an internal model
4. Model calibration and testing
5. Conditions for embedding the model in the business process

E. Modelling of economic scenarios, their Impact on capital management (4 hours)
   1. The influence of the economy on an insurance company
   2. Various ways to build economic scenario generators (ESG)
   3. The bootstrapping method to create scenarios
   4. Yield curve modeling and stress scenarios
   5. Testing of ESG

F. The new Solvency Regulations and the Role of Reinsurance (4 hours)
   1. New context for the industry and new solvency regulation
   2. Use of internal models and DFA
   3. How to optimize a reinsurance cover
   4. Case study: multi-lines and covers for catastrophic events

G. Adding time diversification to risk diversification (2 hours)
   1. Bank and insurance as risk bearer and the challenges ahead
   2. The example of natural catastrophes reserving
   3. Measures to mitigate risk and time diversification
   4. An investors' perspective on catastrophe risks

H. Entreprise Risk Management (ERM), towards a holistic approach to risk management (4 hours)
   1. The context of risk management: a changing risk landscape
   2. Risk management culture
   3. Risk and economic capital modeling
   4. Emerging risk management
   5. Risk controls and processes

Reading list

There is no book or article that covers the full set of chapters. Here are selected books and articles that would treat part of the course. In any case, the students will get a full set of slides for each chapter of the course.

This list is for those who want to deepen their knowledge in this field.

1. Practical Risk Theory for Actuaries by C.D: Daykin, T. Pentikäinen and M. Pesonen published by Chapman & Hall, second edition 1996
2. Dynamic Financial Analysis, 2004, in the Encyclopaedia of Actuarial Science, vol.1 pages 505-519, edited by J. Teugels and B. Sundt published by John Wiley & Sons, with Peter Blum.
3. Managing Bank Capital by Chris Matten, John Wiley, 2000
4. Modelling Extremal Events for Insurance and Finance by Paul Embrechts, Claudia Klüppelberg and Thomas Mikosch, Springer, 1997
5. Risk Management by Michel Crouhy, Dan Galai and Robert Mark Mc Graw Hill, 2001
6. From Principle Based Risk Management to Solvency Requirements, an analytical framework for the Swiss Solvency Test, SCOR book, 2008
7. Integrating Corporate Risk Management, by Prakash A. Shimpi, David Durbin, David S. Laster, Carolyn P. Helbling and Daniel Helbling, Swiss Re Book, 1999
8. Reinsurance, Principles and State of the Art, 2nd Edition, contribution book edited by Andreas Schwepcke, Verlag Versicherungswirtschaft, Karlsruhe, 2004
9. Quantitative Risk Management: Concepts, Techniques, Tools, revised edition by Paul Embrechts, Rudiger Frey and Alexander J. McNeil, Princeton University Press, Princeton, 2015
10. Actuarial Theory for Dependent Risks: Measures, Orders and Models, by Michel Denuit, Jan Dhaene, Marc Goovaerts and Rob Kaas, John Wiley & Sons, Chichester, 2005
11. Risk Management for Insurers, Risk Control, Economic Capital and Solvency II, by René Doff, Risk Books, London, 2007
12. Capital Ideas Evolving, Peter L. Bernstein, John Wiley & Sons, Hoboken NJ, 2007

13. The Value of Risk, Swiss Re and the History of Reinsurance, H. James, P. Borscheid, D. Gugerky and T. Straumann, Oxford University Press, Oxford, 2013

Articles

1. An Illustrative Example of Pricing Risk by Michel Dacorogna and Christoph Hummel, TECHNICAL NEWSLETTER SCOR GLOBAL P&C, 2008
2. Capital at Risk Michel Dacorogna and Christoph Hummel, Global Reinsurance, 1st of July 2005
3. Using the past to predict economic risks by Michel Dacorogna, Ulrich Müller and Roland Bürgi, TECHNICAL NEWSLETTER SCOR GLOBAL P&C, 20082
4. How much capital does a reinsurance need? by Jean-Luc Besson, Michel Dacorogna, Paolo de Martin, Michael Kastenholz and Michael Moller, The Geneva Papers, vol. 34, pages 159-174, 2009
5. Risk Aggregation, dependence structure and diversification benefit, by Roland Bürgi, Michel Dacorogna and Roger Iles, chap. 12, pages 265-306, in "Stress testing for financial institutions", edited by Daniel Rösch and Harald Scheule, Riskbooks, Incisive Media, London, 2008
6. From default probabilities to credit spreads: credit risk models do explain market prices, by Stefan Denzler, Michel Dacorogna, Ulrich A. Müller and Alexander J. McNeil, in Finance Research Letters, vol. 3, pages 79-95, 2006
7. The influence of risk measures and tail dependencies on capital allocation, by Davide Canestraro and Michel Dacorogna, SCOR paper 7, January 2010
8. Adapting the solvency regulation to times of crisis, accepting the riskiness of the situation, by Jean-Luc Besson, Michel Dacorogna, Philippe Trainar, SCOR paper 6, January 2010
9. Principle-based solvency: A comparison between Solvency II and the Swiss Solvency Test, by Michel Dacorogna and Philipp Keller, SCOR paper 8, March 2010.
10. Estimating Copulas for Insurance from Scarce Observations, Expert Opinion and Prior Information: A Bayesian Approach, by Philipp Arbenz and Davide Canestraro, ASTIN Bulletin, vol. 42(1), pages 271-290, 2012
11. Preparing for Solvency II, points of debate in the Standard Formula, by Michel Dacorogna, Ecaterina Nisipasu and Mathieu Poulin, SCOR paper 13, March 2011
12. Premium Calculation by Transforming the Layer Premium Density, by Shaun Wang, ASTIN Bulletin vol. 26, pages 71-92, 1996
13. Die Methode der verzerrten Wahrscheinlichkeiten in der Lebens- und Rentenversicherung, by Dieter Denneberg and Dimitri Kaplan, In: Blätter der Deutschen Gesellschaft für Versicherungsmathematik Bd./Jg. 23, pages 473-487, 1998
14. Conditional Expectation as Quantile Derivative, by Dirk Tasche, Quantitative Finance Papers (http://arxiv.org/abs/math/0104190), 2001
15. Expected shortfall and beyond, by Dirk Tasche in Journal of Banking & Finance, Elsevier, vol. 26(7), pages 1519-1533, July 2002
16. Capital allocation for credit portfolios with kernel estimators, by Dirk Tasche in Quantitative Finance, Taylor and Francis Journals, vol. 9(5), pages 581-595, 2009
17. Capital Allocation to Business Units and Sub-Portfolios: the Euler Principle, by Dirk Tasche in Quantitative Finance Papers (http://arxiv.org/abs/0708.2542), 2007
18. Coherent Allocation of Risk Capital, by M. Denault, in Journal of Risk, vol. 4 (1), pages 1-34, 2001
19. Risk capital allocation for RORAC optimization, by Arne Buch, Gregor Dorfleitner, Maximilian Wimmer in Journal of Banking & Finance, Vol. 35 (11), pages 3001-3009, November 2011
20. Coherent risk measures, coherent capital allocations and the gradient allocation principle, by Arne Buch, Gregor Dorfleitner, in Insurance Mathematics and Economics, Vol. 42(1), pages 235-242, February 2008
21. Some properties of Euler capital allocation, by Lars Holden, in (www.nr.no/~holden/capital-allocation.pdf), 2008
22. Sharing risk – An economic perspective, by Andreas Kull in ASTIN Bulletin; Vol. 39(2), pages 591-613, 2009

23. Does risk diversification always work? The answer through simple modelling, by Marc Busse, Michel Dacorogna and Marie Kratz, in SCOR Papers, no. 24, http://www.scor.com/en/sgrc/scor-publications/scor-papers.html, May 2013
24. Equalization reserves for natural catastrophes and shareholder's value: a simulation study, by Michel Dacorogna, Hansjörg Albrecher, Michael Moller and Suzane Sahiti in European Actuarial Journal, vol. 3 (1), page 1-21, July 2013
25. The risk-free-rate an inescapable concept, by Michel Dacorogna in SCOR Papers, no. 26 http://www.scor.com/en/sgrc/scor-publications/scor-papers.html, September 2013
26. What Is the Best Risk Measure in Practice? A Comparison of Standard Measures, by Susanne Emmer, Marie Kratz and Dirk Tasche, in Journal of Risk, 18(2):31–60, 2015
27. The impact of systemic risk on the diversification benefits of a risk portfolio, by Marc Busse, Michel Dacorogna, and Marie Kratz in Risks, vol. 2, 260-276, 2014
28. Exploring the dependence between mortality and market risks, by Michel Dacorogna and Meitner Cadena, SCOR Paper, no. 33, available on http://www.scor.com/en/sgrc/scor-publications/scor-papers.html, April 2015
29. Living in a stochastic world and managing complex risks, by Michel Dacorogna and Marie Kratz, available on http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2668468, July 2015
30. A change of paradigm for the insurance industry, by Michel Dacorogna, available on http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2692525, November 2015
31. The price of being a systematically important institution, by Michel Dacorogna and Marc Busse, available on http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2803113, July 2016
32. Approaches and Techniques to Validate Internal Model Results, by Michel Dacorogna, available on SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2983837, June 2017.

Teaching method

Most of the course will be lectures in front of students, but we will provide some exercises to deepen the understanding and discuss case studies coming from practice. Extensive slides will be distributed to the students and a research project will be used to conclude the course.

Assessment method and criteria

The assessment will be done through a research project. By team of two or three, the students will be given a research project to conclude in 8 weeks with a personal report of maximum 15 pages. The research can be done in a team, but the report must be individual.

Notes and prerequisites

Place and time of consultation hours

The course will happen over twice 8 days 2 to 3 hours per day (April 15th to April 21st and May 6th to May 12th). There will be consultation hours at the end of each lecture day from 5 to 6pm.