UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Actuarial Statistics

2627-2-F1602M019

Learning objectives

1. Knowledge and Understanding

The course aims to provide students with the essential tools required to:

- assess economic phenomena characterized by uncertainty;
- model insurance products;
- understand and manage risk;

according to the fundamental principles of statistical and actuarial science.

Students first acquire a solid understanding of the insurance market, the main characteristics of life and non-life insurance business, and the quantitative methodologies used to value technical provisions under different accounting principles, as well as the assessment of risks within the Solvency II framework.

The course then introduces students to collective risk theory, Generalized Linear Models (GLMs), and the fundamentals of statistical extreme value analysis, enabling them to develop skills in risk quantification, prediction, and management. These competencies are illustrated through non-life insurance applications and provide a sound foundation for the assessment of emerging risks (e.g., climate and cyber risks) as well as market risk in financial contexts.

2. Applying Knowledge and Understanding

Students develop the ability to apply statistical and actuarial techniques to the pricing and risk management of both life and non-life insurance products, including premium calculation, technical provision valuation, and the assessment of the main sources of risk under the Solvency II standard formula.

Particular emphasis is placed on the use of Microsoft Excel to understand the main pricing and reserving techniques under both local GAAP and Solvency II.

The course also provides hands-on experience with statistical software, including SAS for data management, graphical analysis, and the implementation of frequency–severity GLMs, and MATLAB for modelling the right tail of insurance loss distributions.

Each year, the course is complemented by seminars and guest lectures delivered by insurance professionals, with the aim of strengthening the connection between the theoretical concepts covered in class and their practical application in real-world insurance practice.

3. Making Judgements

Students learn how to complement statistical methods with the ability to interpret and critically evaluate data in order to support strategic business decision-making.

The course develops students' ability to assess the guarantees and coverages available in insurance markets, the associated risks, and the principal approaches to pricing and risk evaluation. These assessments are examined within the broader context of the key financial indicators used by insurance companies and the impact that different sources of risk have on capital requirements, competitiveness, and overall business performance.

Students are encouraged to critically reflect on decision-making processes in actuarial and financial contexts.

4. Communication Skills

The course enhances students' ability to communicate the results of statistical and actuarial analyses in a clear, rigorous, and comprehensive manner, presenting both qualitative and quantitative evidence through written reports, graphical tools, and critical discussion.

Students become familiar with the technical terminology of the insurance industry and gain insight into the professional role of actuaries in insurance companies, financial institutions, and organizations involved in the management of complex risks.

Particular attention is devoted to Risk Management principles and practices.

5. Learning Skills

The course promotes the development of an effective learning approach that integrates actuarial statistics with related disciplines, including insurance economics, actuarial techniques, risk analysis, and Risk Management, while highlighting their implications for actuarial practice.

The integration of theoretical foundations with practical applications fosters active and long-lasting learning, providing students with the knowledge and professional skills required for successful entry into the actuarial and insurance industries.

Contents

- Overview of the Italian insurance market and the main regulatory framework.
- Types of insurance coverage in life and non-life insurance.
- Pricing methodologies for life and non-life insurance products.
- Valuation of technical provisions in life and non-life insurance under different valuation frameworks (local GAAP, Solvency II, and IFRS 17).
- Introduction to the Solvency II regulatory framework.
- Collective risk theory for non-life insurance; calculation and risk-based customization of pure premiums using Generalized Linear Models (GLMs); SAS laboratory sessions on insurance pricing using real-world

datasets and the estimation of frequency–severity GLMs.
- Statistical analysis of extreme values (fundamentals of classical and conditional Extreme Value Theory): inferential methods and insurance applications, including MATLAB-based implementation of the Peaks-over-Threshold approach on real datasets and the pricing of Excess-of-Loss (XL) reinsurance contracts.

Detailed program

Lectures are supported by slides and supplementary materials based on public reports, regulatory documents, and authoritative institutional sources (e.g., the website of the Italian Insurance Supervisory Authority, IVASS) for all topics concerning insurance regulation.

To support the quantitative components of the course, students are provided with Microsoft Excel, SAS, and MATLAB files. These materials are discussed during lectures and laboratory sessions, encouraging students to perform *what-if* and sensitivity analyses by modifying key actuarial assumptions and valuation parameters (e.g., first- and second-order technical bases).

Throughout the course, practical examples and real-world case studies are presented to illustrate the quantitative relevance of the concepts and methodologies introduced.

Detailed contents

- The Italian insurance market and the regulatory framework.
- Types of insurance coverage in life and non-life insurance.
- Pricing methodologies for life and non-life insurance products.
- Valuation of technical provisions in life and non-life insurance under different accounting and regulatory frameworks (local GAAP, Solvency II, and IFRS 17).
- Introduction to the Solvency II regulatory framework.

Non-Life Insurance Pricing: Selected Topics

- Fundamentals of insurance risk, with particular emphasis on non-life insurance.
- Collective risk theory and actuarial technical bases.
- Insurance pricing models.
- *A priori* and *a posteriori* risk classification and premium personalization.
- Methods for estimating rating relativities.
- Generalized Linear Models (GLMs): model specification, statistical inference, and practical applications using SAS.

**Extreme Value Theory and Insurance Applications: Selected Topics
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- Fundamentals of Extreme Value Theory (classical and conditional EVT).
- The Peaks-over-Threshold (POT) approach.
- Heavy-tailed (Pareto-type) loss distributions and estimation of the tail index.
- Introduction to reinsurance: treaty structures, catastrophic events, and the pricing of Excess-of-Loss (XL) reinsurance.
- Practical applications using MATLAB.

Prerequisites

Students are expected to have a basic knowledge of economics, financial mathematics, descriptive statistics, and the main discrete and continuous probability distributions.

Basic proficiency in standard software tools (e.g., Microsoft Excel) is encouraged. However, all computational tools and software applications used in the course are introduced and explained during lectures and laboratory sessions by the instructors.

Teaching methods

The course is delivered through face-to-face lectures, combining theoretical instruction with practical activities, including problem-solving sessions, case studies, Excel-based applications, and programming exercises in SAS and MATLAB.

Approximately 60–70% of the course consists of direct instruction (Didattica Erogativa), while 30–40% is devoted to interactive learning activities (Didattica Interattiva). Students are actively engaged in the discussion of problems, practical examples, and exercises, as well as in the use of virtual laboratories for the analysis of real insurance datasets.

The course is complemented by seminars and guest lectures delivered by insurance professionals and industry experts. These sessions address current issues in the insurance sector and provide students with insights into recent developments in the actuarial profession.

Assessment methods

The assessment is designed to verify that students have:

1. understood the rationale underlying the different statistical methodologies and are able to identify the most appropriate contexts for their application;
2. acquired sufficient familiarity with statistical techniques to analyse insurance datasets and draw sound, well-reasoned conclusions;
3. developed the ability to interpret the results of statistical and computational analyses, placing them in the appropriate context and critically evaluating potential limitations arising from the characteristics of the dataset under consideration.

The assessment primarily emphasizes conceptual understanding, problem-solving skills, and the critical interpretation of statistical results rather than mathematical formalism.

Assessment consists of an oral examination including open-ended questions, practical exercises where appropriate, and the discussion of problems and case studies developed using Excel, SAS, and MATLAB.

The final grade reflects a balanced evaluation of both the theoretical knowledge and the practical skills acquired throughout the course.

Textbooks and Reading Materials

The main source of course material is the e-learning platform, where students can find all the materials they need

to prepare for the exam, in particular:

- lecture notes (including case studies and Excel computations);
- exercises with solutions;
- a guide to SAS and Matlab (including the statistical library EVIM for extreme value analysis);
- slides of seminars presented by insurance experts.

Students may wish to look into the following additional references:

- Part I: Daboni, L. (1993): Lezioni di tecnica attuariale delle assicurazioni contro i danni, Edizioni LINT Trieste (Chapters 1-4); Boland, P. J. (2007): Statistical and Probabilistic Methods in Actuarial Science, London: Chapman&Hall/CRC (Chapters 1, 2).
- Part II: Mc Neil, A., Frey, P., Embrechts, P. (2015): Quantitative risk management: Concepts, techniques and tools. Princeton University Press (Chapter 5).
- Part II and III: www.qrmtutorial.org : companion website for the book by Mc Neil, Frey, Embrechts (2015), with slides, case studies, datasets, programs.

Semester

Spring semester.

Teaching language

Italian.

Sustainable Development Goals

QUALITY EDUCATION | GENDER EQUALITY | INDUSTRY, INNOVATION AND INFRASTRUCTURE