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Solvency II: Quantum Risk Modeling

Material:

Presentaciones PDF, Ejercicios: Python, R, Excel y JupyterLab.

Course S II Duration: 40 h

Preperatory Course Duration: 24 h

Course SII Quantum Price: 8.000 EUR

Preperatory Course Price : 5.000 EUR

OBJECTIVE OF THE SOLVENCY II COURSE

The objective of the course is to show the participant the requirements of the Solvency II Directive, the recent IFRS 17 regulation: insurance contracts, as well as risk appetite and stress testing methodologies in insurance companies.

The course proposes the use of artificial intelligence and quantum computing for the modeling of economic capital, reserves, premiums and claims. As well as for the optimization of portfolios and the management of assets and liabilities in insurance companies.

It explains how to measure market, operational, life and non-life insurance subscription risks, catastrophes, credit and liquidity to which insurance companies are exposed. The requirements of the risk self-assessment known as ORSA ("Own Risk and Solvency Assessment") are exposed.

The content of the course places special emphasis on the modules of life and non-life insurance underwriting risk, valuation of life and non-life insurance provisions, advanced modeling of claims and biometric risk.

The directives of the standard formulas and internal models are reviewed, and compared, to know the advantages and disadvantages of each one.

IFRS 17, is fully explained. The impact it will have on insurance companies, costs and benefits is shown, as well as the main methodologies for valuing insurance contracts. The relationship between IFRS 17 and Solvency II is also explained.

Internal market and credit risk models are delivered, as well as advanced asset and liability management exercises, among other techniques: immunization, temporary interest rate structure, cash flow matching and stochastic optimization of assets and liabilities.

Reduced form, structural and portfolio approach models are explained to measure credit risk for insurance companies.

For risk mitigation, Insurance-Linked Securities are explained, among others, longevity bonds, swaps, weather derivatives, etc.

This intensive course, in addition to providing the participant with risk management knowledge, does so with methodologies to create scenarios, measure risk appetite and tolerance, and develop stress tests.

To ensure the participant's learning, we complement the theory with practical exercises and real data, in Excel with VBA, and macros in both R and SAS.

Real financial statements are analyzed to measure the impact of the scenarios and stress tests, as well as the required IFRS sensitivities.

OBJECTIVE OF THE INTRODUCTION COURSE

The objective of the preparatory course is to offer the participants, before entering the Solvency II, IFRS 17 and Stress Testing course, prior knowledge that maximizes the quality of teaching and homogenizes the level of the participants.

There are a total of seventeen modules from various disciplines, among others,

Quantum computing, quantum mechanics, R and Python programming, statistics, probability, finance, machine learning, probabilistic machine learning, introduction to financial risk, and actuarial science for non-actuaries. The preparatory course will improve the understanding of the Solvency II course.

During the preparatory course, the participants will be required an extra-class activity to improve learning.

WHO SHOULD ATTEND?

This program is aimed at risk professionals, actuaries, managers, analysts and consultants in the insurance sector. For a better understanding of the topics, it is recommended that the participant have knowledge of statistics and mathematics. The participant will know not only the theory but practical exercises in Python, R and Excel.

PREPARATORY COURSE

Module 1: Probability

Objective: Explain some elementary concepts of the mathematical theory of probability. It exposes which are the probability distributions used in financial and insurance risks and how to estimate parameters. The importance of probability in Solvency II is explained.

- Introduction to probability
- Combinatorial analysis
- Conditional probability and independence
- Random variables
- Density and distribution functions
- Expectation, variance, moments
- Probability distributions
- Frequency distributions, Poisson, Binomial, Negative Binomial
- Loss distributions, lognormal, EVT, gyh, beta, gamma, weibull, etc.
- Random Vectors
- Distribution fitting and parameter estimation
- Use of probability distributions in Solvency II
- Exercise 1: Probability distribution fits in R

Module 2: Statistics

Objective: Inferential statistics consists of a set of techniques to obtain, with a certain degree of confidence, information from a population based on information from a sample. Statistics is essential for the construction of models and their validation.

- Introduction
- Variables and data types
- Descriptive statistics
- Inferential statistics
- Random samples and statistics
- Point estimate
- Estimation by intervals
- Hypothesis tests
- Importance of statistics in Solvency II
- Exercise 2: Descriptive statistics in Python of data from an insurance company
- Exercise 3: Hypothesis testing in R

Module 3: Finance

Objective: To review the concepts of the value of money over time, financial mathematics, valuation of annuities, bonds, and valuation models Capital Asset Pricing Model and Arbitrage pricing theory. The models are essential for the valuation of assets and liabilities of an insurance company.

- Value of money over time
- Financial mathematics and annuities
- Bond valuation
- Duration and convexity
- CAPM and APT model
- Stochastic processes
- Monte Carlo simulation
- Exercise 4: Valuation of bonds in Excel
- Exercise 5: Estimation of duration and convexity in Excel

- Exercise 6: Estimation of the CAPM and APT in Excel
- Exercise 7: Monte Carlo Simulation and Stochastic Processes in R

Module 4: Programming in Python

Objective: Explain what the Python programming language is and its functionalities. It explains what Jupyter is and how to install it. Expose basic notions of programming and the libraries that will be used to develop Solvency II models.

- Introduction to Python
- Environment and library installation
- Jupyter
- Import and export of data
- basic programming
- statistical tools
- regression libraries
- finance bookstores
- Machine Learning Libraries
- Quantum Libraries
- Exercise 8: Programming in Python

Module 5: Programming in R

Objective: Explain what R and Rstudio are and how to install them. Explain basic notions of R programming and the libraries used to develop Solvency II models.

- Introduction to R
- Environment and library installation
- R Studio
- Import and export of data
- Basic programming
- Statistical tools
- Regression libraries
- Finance bookstores
- Actuarial science bookstores
- Exercise 9: programming in R

Module 6: Machine Learning

Objective: Automatic machine learning, in English machine learning, essential for systems to be intelligent, allows the development of predictions based on data and improves the projections of traditional models. The use of machine learning and deep learning algorithms is introduced. The benefits of machine learning in risk management for insurance companies are explained.

- Introduction Machine Learning
- Differences with statistics
- Supervised and unsupervised models
- decision trees
- Support Vector Machine
- K-means
- Assembly Learning
- Random Forest
- neural networks
- Introduction to ensemble models
- Introduction to Deep Learning
- Exercise 10: Estimation of the Support Vector Machine and Random Forest
- Exercise 11: Deep learning algorithm creation

Module 7: Introduction to Financial Risks

Objective: Lay the theoretical foundations on the financial risks that impact insurance companies, explain the types of risks and the sources of such risks. Understand the probability and impact of events that trigger financial risk in insurance companies.

- What is risk?
- Financial risks in insurance companies
- Probability and Impact
- Sources of financial risks
- Differences between financial and non-financial risks
- Market risk
- Interest rate risk
- Liquidity risk
- Credit risk
- Operational risk

Module 8: Actuarial Sciences

Objective: Introduction of actuarial sciences for participants without actuarial training. A brief introduction to life and non-life insurance is presented, as well as actuarial mathematics.

- What do actuaries do?
- Introduction to Life insurance
- Introduction to Non-Life insurance
- Type of contracts
- Introduction to Life Insurance Reserves
- Introduction to Non-Life Insurance Reserves
- Margin Based Pricing
- Introduction to actuarial mathematics
- Introduction to Life Insurance
- Introduction to Non-Life Insurance
- Exercise 12: Modeling the distribution of the severity and frequency of claims in Excel and R
- Exercise 14: Simulation of the current values of an Annuity of a life annuity.

Module 9: Quantum computing and algorithms

Objective: Quantum computing applies quantum mechanical phenomena. On a small scale, physical matter exhibits properties of both particles and waves, and quantum computing takes advantage of this behavior using specialized hardware. The basic unit of information in quantum computing is the qubit, similar to the bit in traditional digital electronics. Unlike a classical bit, a qubit can exist in a superposition of its two "basic" states, meaning that it is in both states simultaneously.

- Future of quantum computing in insurance
- Is it necessary to know quantum mechanics?
- QIS Hardware and Apps
- quantum operations
- Qubit representation
- Measurement
- Overlap
- matrix multiplication
- Qubit operations
- Multiple Quantum Circuits
- Entanglement
- Deutsch Algorithm
- Quantum Fourier transform and search algorithms
- Hybrid quantum-classical algorithms

- Quantum annealing, simulation and optimization of algorithms
- Quantum machine learning algorithms
- Exercise 15: Quantum operations

Module 10: Introduction to quantum mechanics

- Quantum mechanical theory
- wave function
- Schrodinger's equation
- statistical interpretation
- Probability
- Standardization
- Impulse
- The uncertainty principle
- Mathematical Tools of Quantum Mechanics
- Hilbert space and wave functions
- The linear vector space
- Hilbert's space
- Dimension and bases of a Vector Space
- Integrable square functions: wave functions
- Dirac notation
- operators
- General definitions
- hermitian adjunct
- projection operators
- commutator algebra
- Uncertainty relationship between two operators
- Operator Functions
- Inverse and Unitary Operators
- Eigenvalues and Eigenvectors of an operator
- Infinitesimal and finite unit transformations
- Matrices and Wave Mechanics
- matrix mechanics
- Wave Mechanics

Module 11: Introduction to quantum error correction

- Error correction
- From reversible classical error correction to simple quantum error correction
- The quantum error correction criterion
- The distance of a quantum error correction code
- Content of the quantum error correction criterion and the quantum Hamming bound criterion
- Digitization of quantum noise
- Classic linear codes
- Calderbank, Shor and Steane codes
- Stabilizer Quantum Error Correction Codes

Module 12: Quantum Computing II

- quantum programming
- Solution Providers
- IBM Quantum Qiskit
- Amazon Braket
- PennyLane
- cirq
- Quantum Development Kit (QDK)
- Quantum clouds

- Microsoft Quantum
- Qiskit
- Main Algorithms
- Grover's algorithm
- Deutsch–Jozsa algorithm
- Fourier transform algorithm
- Shor's algorithm
- Quantum annealers
- D-Wave implementation
- Qiskit Implementation
- Exercise 16: Grover, Fourier Transform and Shor algorithm simulation

Module 14: Quantum Machine Learning

- Quantum Machine Learning
- hybrid models
- Quantum Principal Component Analysis
- Q means vs. K means
- Variational Quantum Classifiers
- Variational quantum classifiers
- Quantum Neural Network

1. Quantum Convolutional Neural Network
2. Quantum Long Short Memory LSTM

- Quantum Support Vector Machine (QSVC)
- Exercise 17: Quantum Support Vector Machine

Module 15: Quantum computing in insurance companies

- Building Blocks of Payoff Valuation

1. Distribution Loading
2. Payoff Implementation
3. Calculation of the Expected Value

- Amplitude Estimation

1. Amplitude Estimation based on Phase Estimation
2. Amplitude Estimation without Phase Estimation

- Grover's Quantum Search Algorithm
- Insurance-related Payoffs

1. Overall Payoff

- Insurance-related Quantum Circuits

1. Whole life insurance
2. Dynamic Lapse

- Quantum Hardware

1. simulator
2. royal hardware

- Exercise 18: Insurance-related Quantum Circuits

Module 16: Tensor Networks for Machine Learning

- What are tensor networks?
- Quantum Entanglement
- Tensor networks in machine learning
- Tensor networks in unsupervised models
- Tensor networks in SVM
- Tensor networks in NN
- NN tensioning
- Application of tensor networks in credit scoring models
- Exercise 19: Neural Network using Tensor Networks

Module 17: Probabilistic Machine Learning

- Probability
- Gaussian models
- Bayesian Statistics
- Bayesian logistic regression
- Kernel Family
- Gaussian processes

1. Gaussian processes for regression

- Hidden Markov Model
- Markov chain Monte Carlo (MCMC)

1. Metropolis Hastings algorithm

- Machine Learning Probabilistic Model
- Bayesian Boosting
- Bayesian Neural Networks
- Exercise 20: Gaussian process for regression
- Exercise 21: Bayesian neural networks

SOLVENCY II COURSE, IFRS 17 and STRESS TESTING

Module 1: Solvency II

Objective: Explain how Solvency II reflects the new risk management practices to define the necessary capital and manage financial and insurance risks. Solvency Capital Requirement SCR, Minimum Capital Requirement MCR and the three pillars of Solvency II are explained in detail.

- The Solvency II Directive and EIOPA
- General structure
- Basel II and III experience
- Implementation Schedule
- Asset Valuation
- Technical Provisions

1. Segmentation
2. Products

- Liability Analysis: Best Estimate and Margin Risk
- Own Resources: Tier 1, Tier 2 and Tier 3
- MCR-Estimate and Calculation
- SCR-Standard Formula
- Internal Model Directives
- Pillar 1: Own resources for solvency

1. Solvency Capital Requirement (SCR)
2. Standard Approach
3. Internal Model
4. Technological aspects and implementation
5. Minimum Capital Requirement (MCR)

- Pillar 2 Supervision Process and Own Risk and Solvency Assessment (ORSA)

1. ORSA definition and scope
2. The ORSA role

- Pillar 3 Transparency Requirements

1. Financial Condition Report
2. Solvency II Directive

- IFRS

1. Residual Margin
2. Risk Margin
3. Best Estimate

Module 2: Standard Formula Methodology

Objective: Explain the formulas of the standard approach for the estimation of the SCR and MCR. Understand the risks of insurance companies. Explain in detail the mathematical formulas and possible expected values.

- Technical specifications for the preparatory phase part 1
- Dependency Structure
- Risk mitigation techniques
- Market risk

1. Interest rate risk
2. Equity risk
3. real estate risk
4. Spread Risk
5. Concentration Risk
6. liquidity risk

- Credit risk

1. Counterparty risk
2. LGD and PD calculation

- Operational risk

1. Standard Formula

- Underwriting risk: Non-life

1. Reserve Risk
2. Premium Risk
3. catastrophic risk

- Underwriting Risk: Life

1. Mortality Risk
2. Longevity Risk
3. Morbidity Risk
4. Disability Risk
5. Portfolio Fall Risk
6. Expense Risk
7. Revision risk

- Technical Health Risk
- Technical specifications for the preparatory phase part 2
- Determination of the risk-free interest rate
- Exercise 1: Estimation of SCR Mkt of interest rate and Mkt Spread in a bond portfolio and SCR Mkt of equities in a stock portfolio.

Module 3: Approval of Internal Models

Objective: Define what internal models are and explain the guidelines on the use of internal models that insurance companies must take into account so that the supervisory authorities approve and continue to allow the use of internal models to calculate solvency capital.

- Pre-application
- Application
- Evaluation and right to withdraw the application
- Decision on the application: Terms and conditions
- Monitoring

Module 4: Own Risk and Solvency Assessment (ORSA)

Objective: ORSA is the acronym for Own Risk and Solvency Assessment and explains the set of processes used to assess risks according to capital needs. The management framework, the ORSA process and the ORSA reports are explained in detail.

- ORSA Scope
- Regulatory context:
- management framework
- ORSA process
- ORSA report
- Government system
- Entity risk
- Stress test and scenario analysis
- Capital requirements and solvency assessment
- Business plan and capital planning

Term Structure of Interest Rates

Module 5: Modeling of interest rate term structure (ETTI)

Objective: The relevance of adequately modeling the term structure of the interest rate or yield curve is crucial for the adequate valuation of the liabilities of the insurance company. It explains how to build the curve, the role of stochastic models and extrapolation methodologies among many other topics.

- Yield Curve Concept
- nelson siegel
- Yield curve smoothing and term structure models
- Interpolation Methods: Cubic Splines
- Extrapolation Methods: Wilson-Smith
- stochastic modeling

1. Cox–Ingersoll–Ross model
2. Heath–Jarrow–Morton model

- Selecting objective variables
- Principal component analysis
- Selection of scenarios
- Vacicek's model
- Vacicek interest rate model
- Libor Market Model
- Interest rate curve in EIOPA

1. basic curve
2. Last Liquid point
3. volatility adjustment

4. Flow matching adjustment
5. Implementation of extrapolation

Exercise 2: Principal Components Exercise in python
Exercise 3: Estimating Nelson Siegel parameters in python
Exercise 4: Interpolation in Excel
Exercise 5: CIR simulation calculator and Vasicek python
Exercise 6: Caplet and Swaption using Libor Market Model in Excel and VBA
Exercise 7: Wilson-Smith extrapolation method in Excel and R

IFRS 17

Module 6: International Financial Reporting Standard IFRS 17 and IFRS 4

Objective: The IFRS 17 standard profoundly changes the approach to accounting for insurance, moving from a traditional scheme, based on historical values, to an approach closer to the "economic value" of the contracts. The methodologies and measurements of the insurance contract are explained.

- **IFRS 4 valuation of insurance contract liability**
- Objective and scope
- Current exit value
- Projection of estimated future flows
- Liability-adjusted market rate
- risk margin
- Current value approach
- **IFRS 17: Insurance Contract**
- Objective and scope
- Typology of insurance contracts
- Disaggregation and classification of IFRS 9 contracts
- Differences with IFRS 4
- Implementation dates
- IFRS 17 enhancements to current accounting practices
- Implementation costs
- Information on profitability

1. Estimation of the present value of future cash flows
2. risk adjustment
3. Contractual service margin

- Difference in income statement with IFRS 17
- Methodologies and measurement of insurance contracts

1. Building Block Approach (BBA)
2. Variable Fee Approach (VFA)
3. Premium Allocation Approach (PAA)

- IFRS 17 and Solvency II
- Exercise 8: Impact of economic scenarios on the balance sheet, income statement and future cash flows by valuation of life insurance contracts, under the IFRS 17 approach, including risk adjustment and contractual service margin in Excel and R.

VALUATION OF PROVISIONS

Module 7: Valuation of Life Insurance provisions

Objective: The Guidelines on the valuation of Life insurance technical provisions are shown to increase the coherence and convergence of the professional practice of all types and sizes of insurance companies. Fermac Risk shows the European experience of this practice.

- Deterministic Life Insurance Models

- Deterministic portfolio valuation
- Stochastic portfolio valuation
- Technical Life Risk
- Protection against technical risk of life with options
- Contracts with PB
- Contracts without PB
- unit link
- Variable Annuities
- Reinsurance
- Dynamic Fall Model (Lapse rate)
- Rescue Options
- Profit Sharing Option
- **Exercise 9: Life Insurance Portfolio Valuation Tool, includes:**

1. Vasicek interest rate simulation
2. Stochastic Mortality Risk Simulation
3. Lapse rate modeling
4. Options using black sholes model.

- Exercise 10: Variable Annuities using Black Sholes model

Module 8: Valuation of Non-Life Insurance provisions

Objective: The Guidelines on the valuation of Non-Life insurance technical provisions are shown to increase the coherence and convergence of the professional practice of all types and sizes of insurance companies. Some traditional and modern techniques for calculating the reserve are explained.

- The technical provision for benefits. Regulations in Solvency 2
- Aggregate Claims Modeling
- Frequency Distributions
- Distributions of the claim amount
- Analytical methods
- Monte Carlo Simulation
- Triangle-based methods for calculating Loss Reserving Provisions

1. Grossing up
2. link ratio
3. Chain Ladder
4. Bornhuetter Ferguson

- Stochastic methods for calculating the Provision for benefits.

1. Mack's method
2. Bootstapp Method

- Machine Learning in Non-Life Insurance

1. Claims reserving based on Bayesian neural networks
2. Chain Ladder Neural Network

- Exercise 11: Fit frequency using negative binomial and Poisson
- Exercise 12: Claims amount adjustment using lognormal, gamma, weibull, exponential and G-H in python and R
- Exercise 14: Estimation of accident rate distribution with Monte Carlo simulation in R
- Exercise 15: Chain-Ladder Neural Network
- Exercise 16: Estimating provisions using the Run Off Chain Ladder
- Exercise 17: Estimating provisions using Bootstrap in R

MARKET RISK

Module 9: Value at Risk (VaR) and Expected Shorfall in life and non-life lines

Objective: Explain the concept of the Value at Risk VaR and the Expected Shortfall in the life and non-life branches. The treatment of returns and volatility using GARCH models is explained.

- Introduction to VAR

- VAR in life insurance
- VAR in the non-life business
- Volatility Estimation
1. GARCH(1,1)
2. GARCH Multivariate
3. EWMA
- Volatility Forecasting
- Parametric Models
1. Normal VaR
2. t-student distribution
3. lognormal distribution
- Linear Model for Stocks and Bonds
- Quadratic model for options
- VaR extensions
1. Expected Shortfall or Tail VaR
2. Conditional VaR
- Cash flow mapping
- Exercise 18: Simulation and forecasting volatility using GARCH(1,1) and multivariate model in R
- Exercise 19: estimation of the internal model of VaR and Expected Shortfall in life and non-life insurance

Module 10: Parametric VaR with Extreme Value Theory

Objective: Explain the theory of extreme value to apply it to internal models. This distribution allows estimating the probability of truly extreme events. The pros and cons of these distributions in insurance practice are explained.

- EVT Extreme Value Distributions
1. gumbel
2. Frenchet
3. Weibull
- Generalized Pareto distributions
1. Exponential
2. Pareto
3. Beta
- Threshold estimate
- Model Selection
1. Hill and Mean Excess Plot
- Generation of random EVT values
- EVT estimation under Bayesian approach
- Disadvantages of EVT
- Exercise 20: Estimation of Graphs: Mean Excess, Q-Q and Hill plot in R
- Exercise 21: Maximum likelihood parameter estimation of GDP in SAS and R
- Exercise 22: VaR estimation by EVT in SAS and R

Module 11: Historical Simulation and Monte Carlo

Objective: VaR is explained by Monte Carlo simulation applied to insurance companies. Being the best methodology to estimate the VaR in a time horizon of one year.

- VaR Historical Simulation
1. Adjust for volatility
- VaR Monte Carlo simulation
1. Simulation with a risk factor
2. Simulation with multiple risk factors
3. Variance Reduction Methods
- Normal Multivariate Distribution and T-Student
- VaR Monte Carlo based on Gaussian copula and t-student copula
- Exercise 23: VaR estimation: using Monte Carlo Simulation and Historical Simulation in Excel and R

- Exercise 24: Historical Simulation Backtesting
- Exercise 25: VaR using Gaussian copula and tStudent in SAS and R

Module 12: Market Risk

Objective: Good market risk practices for insurance companies are explained. The results of the SCR under the standard formula are compared against the internal models.

- Standard Formula on Market Risk
- Sub-modules in market risk

1. Interest rate risk
2. Equity risk
3. real estate risk
4. Spread Risk
5. Concentration Risk
6. liquidity risk

- SCR VaR 99.5%
- Internal and partial models
- Internal Market Risk Model
- VaR for interest rate risk

1. Stochastic Process Selection
2. VaR using stochastic process of an asset
3. Simulation with principal components
4. Scenario Simulation

- VaR for interest rate risk with principal components
- Spread VaR
- exchange rate VaR
- Equity VaR
- Concentration and correlation risk modeling
- VaR of Options

1. Delta Normal VaR
2. Delta Gamma VaR
3. Monte Carlo simulation

- Boundary Structure
- Exercise 26: Estimating the VaR of options with Monte Carlo simulation in Excel and R
- Exercise 27: Cash Flow mapping and VaR estimation of a bond portfolio
- Exercise 28: VaR estimation of non-life and life risk

Module 14: Stress Testing and Backtesting

Objective: Stress testing is one of the best tools for managing market risk. Consider exceptional but plausible events. Insurance companies will also need to validate internal models with backtesting.

- Stress Testing Approaches
- Historical Stress Testing
- Reverse Stress Test
- Stress testing in correlation
- Stress testing on volatility
- Multivariate stress testing
- Backtesting

1. Kupiec`s Test

- Frequency Conditional Coverage
- Analysis of losses in the tail of the distribution
- Clean and dirty backtesting
- Exercise 29: Stress testing on a correlation matrix in Excel
- Exercise 30: Backtesting of VaR in Excel

Module 15: Credit Risk Structural and Reduced Form Models

Objective: Structural credit risk models require financial information from the company and have proven to be efficient during the pandemic. These models help measure the credit risk of fixed income investments, particularly bonds.

- Structural Models
1. Merton's model
2. KMV model
- reduced form models
1. Jarrow-Turnbull Model
2. Duffie and Singleton Model
3. Neutral default probabilities
4. Conversion of default currents into discrete PDs
5. Adjustment of reduced form models to historical databases
6. Construction of default probability curves
7. Validation with Falkenstein and Boral Test
8. Jump to default
9. zero coupon bonds
10. voucher with coupons
11. convertible bonds
12. CDS Valuation
- Exercise 31: Structural model in R and Excel
- Exercise 32: Construction of default probability and hazard rate curves in Excel and SAS
- Exercise 33: Bonus and CDS valuation in Excel with VB
- Exercise 34: Internal model of market and credit risk
1. CIR simulation of fixed and variable income interest rates
2. Jarrow-Turnbull-Lando model for credit risk with transition matrices.
3. Comparison against standard formulas.

Module 16: Credit Risk Portfolio Models

Objective: It explains how to model the credit risk of investment portfolios of bonds, loans and credit derivatives. The credit risk of reinsurers is explained. The creditmetrics and Creditrisk+ approaches to economic capital estimation are shown.

- Rating Models
- PD and LGD estimation
- default correlation
- asset mapping
- Economic Capital Models
1. creditmetrics
2. Credit risk +
3. One-factor model
- Reduced Form Models
- Counterparty Risk
- Reinsurance Counterparty Default Risk
- Credit Risk in Reinsurance portfolio approach
- Concentration Risk
- Credit Risk in the Credit Insurance portfolio approach
- Exercises 35: Economic capital with a unifactorial model using Monte Carlo Simulation in Excel and SAS.
- Exercise 36: Economic capital: CreditRisk+ in SAS
- Exercise 37: Economic capital: Creditmetrics in Excel
- Exercise 38: Economic Capital of the bond portfolio

Module 17: Non-Life Underwriting Risk

Objective: This risk is divided into three large blocks, the risk for premiums: it refers to future claims that may arise during and after the period for which the solvency calculation is made, that is, that the expenses plus the losses due claims are greater than the premiums received. The risk due to reserves due to two causes, the miscalculation of provisions and fluctuations in the actual number of claims around the midpoint. The third is catastrophic risk.

- Analysis Standard Formulas
1. Underwriting risk: Non-life
2. Reserve Risk
3. Premium Risk
4. catastrophic risk
5. Health underwriting risk
- Non-Catastrophic Risk
1. Internal models Premium Risk
2. Internal model Reserve Risk
- catastrophe risk
- Internal model using Monte Carlo Simulation
- Internal model using Multiyear approach
1. VaR estimate 99.5%
- Catastrophic Risk Modeling
1. Frequency and Severity
2. catastrophe science
3. Tsunamis
4. Hurricanes: Frequency, Regions
5. Hurricane Modeling
6. Earthquakes, frequency and severity
- Quantum computing to estimate insurance capital
1. Introduction
2. Fundamentals and Notations of Quantum Mechanics
3. Classical surplus process with quantum mechanics
4. Quantum algorithm to predict the insurance capital
5. premium gate
6. Claim Gate
7. The expected reserve in an insurance company
- Exercise 39: VaR for Premium risk in Excel and Python
- Exercise 40: VaR for Reserve risk in R
- Exercise 41: Internal non-life underwriting risk model and comparison against standard formulas in SAS and R
- Exercise 42: Quantum computing to estimate capital

Module 18: Life Underwriting Risk

Objective: This risk is divided into Biometric Risk (mortality, longevity, disability/illness), Portfolio Fall Risk, Expense Risk, Revision Risk, and Catastrophe Risk. A comparison of results between the SCR by standard formula and internal models is shown. Traditional mortality models and others with advanced machine learning techniques are explained.

- Biometric Risk
1. Mortality Risk
2. Longevity Risk
3. Morbidity Risk
- Portfolio drop risk

- Expense risk
- Revision risk
- Catastrophic risk and pandemics
- Actuarial models for pricing
- Behavioral Risks
- Dynamic Mortality Tables
- Mortality models

1. Model Lee Carter
2. Singular Value Decomposition
3. Stochastic Mortality Model
4. Longevity Risk
5. improvement factors
6. longevity index

- Mortality Risk Models using Machine Learning
- Continuous Models:

1. Cox-Net, Cox Tree, Cox XGBoost, Survival Tree, Random Survival Forest

- Discrete Models:

1. Random Forest, LightGBM, XGBoost Logistic, GAM CatBoost

- Analytical Survival Distributions
- Internal Risk Model Life Insurance
- Risk management

1. Gamification
2. Behavioral risk analysis
3. Insured Linked Securities

- Exercise 43: Stochastic Mortality Shock Model in SAS
- Exercise 44: Lee Carter, Makeham and Logit model in SAS
- Exercise 45: Internal Model Life Insurance Risk

1. Monte Carlo simulation
2. Lee Carter model
3. Model and simulation of interest rate term structure
4. Copulas in Excel and R

- Exercise 46: Discrete and Discrete Mortality Models: Cox XGBoost, Survival Tree, Random Survival Forest, and LightGBM

OPERATIONAL RISK

Module 19: Operational Risk

Objective: Explain both the advanced management of operational risk in insurance companies and an introduction to the measurement of this risk to obtain a distribution of losses.

- Introduction Operational Risk
- Loss Event Management
- Risk Control Self Assessment
- Scenario Based Assessment
- Key Risk Indicators
- Capital estimation LDA approach
- Exercise 46: Estimation of Economic Capital of 5 business units, aggregated and individual, using the following Frequency and Severity distributions:
- Frequency

1. Poisson
2. Negative Binomial

- Severity

1. lognormal
2. burr
3. gamma

4. Weibull
5. Inverse Gaussian
6. GDP EVT
7. LogLogistic
8. G-H 4 parameters
9. Mixture of Lognormals
10. lognormal-EVT
11. Alpha Stable

- Poisson-Gamma Bayesian approach
- Lognormal partition and GDP
- Scenarios with Expert criteria
- Exercise 47: Selection of the best distribution using goodness-of-fit tests in Excel
- Exercise 48: Estimation of economic capital with truncated data
- Exercise 49: Internal model using Monte Carlo Simulation with effect of deductible / insurance excess in R
- Exercise 50: Internal model with Monte Carlo Simulation with frequency distribution with Gaussian copulas in R
- Exercise 51: Internal model with Monte Carlo Simulation of aggregate losses of business units with t and frank copulas in R
- Exercise 52: Comparison of internal models with Recursive Panjer, Fast Fourier Transformation and Monte Carlo Simulation in R and Excel

RISK MANAGEMENT AND MITIGATION

Module 20: Insured Linked Securities (ILS)

Purpose: ILS are defined, broadly, as financial instruments whose values are driven by insurance loss events. The instruments are linked to catastrophes, mortality and longevity. They help the transfer and mitigation of risk as well as the diversification of capital.

- Definition Insurance-Linked Securities
- derivatives market
- Derivatives and bonds linked to Property and Casualty risk

1. Weather Derivatives
2. Catastrophe Bonds
3. Catastrophe Derivatives

- Derivatives and bonds linked to longevity and mortality risk

1. Longevity Swaps
2. Longevity Bonds

- Risk management in ILS portfolios
- Exercise 53: Valuation Longevity Swap in Excel
- Exercise 54: Valuation derived from Climate in Excel

VALIDATION OF INTERNAL MODELS

Module 21: Validation of Internal Models I

Objective: The validation process of internal models is explained, the most common techniques such as backtesting. The appropriate reporting to validate models is explained in general terms.

- validation process
- modeling process
- modeling tools
- Backtesting Analysis
- Stress Testing

- Results stability
- Model limitation
- reporting
- Scoring model

Module 22: Validation of Internal Models II

Objective: The validation of detailed internal models for each type of risk is explained. Advanced SCR validation techniques calculated by internal models are explained.

- Validation of Internal Models
1. Market risk
2. Credit risk
3. Operational risk
4. Underwriting risk: Non-life
5. Underwriting Risk: Life
- Validation of:
1. Model Design
2. Model Output
3. Processes, data and test of use
- Kupiec`s Test for market risk
- Loss aggregation validation
- Testing distributions using Berkowitz test
- loss distribution
- Simulation of the critical chi-square value
- Berkowitz test in subportfolios
- power assessment
- Scope and limits of the test
- Model risk due to uncertainty
- Exercise 55: implementation of the Berkowitz test in internal credit models
- Exercise 56: Simulation of losses and model risk in non-life underwriting Risk

ASSET AND LIABILITY MANAGEMENT

Module 23: Quantum Portfolio Management

- Portfolio diversification
- Allocation of financial assets in insurance companies
- Financial risk tolerance
- Asset Portfolio Optimization
- efficient frontier
- Financial portfolio simulation
- Financial portfolio simulation techniques
- Portfolio Management using Reinforcement Learning
- Portfolio Management using quantum algorithms
- Exercise 57: Portfolio optimization using quantum algorithms

Module 24: Asset and Liability Management

Objective: The management of assets and liabilities is becoming more important for insurance companies every day due to the pandemic. Optimization models are explained, from the well-known cash flow matching, to advanced models of stochastic programming of assets and liabilities. Liquidity risk is explained.

- Tools to manage assets and liabilities
1. Duration Gap analysis

2. Interest rate risk
3. Liquidity risk
4. Cash Flow Testing
5. Immunization
6. Cash Flow Matching

- Optimization of assets and liabilities

1. Dynamic Financial Analysis
2. Stochastic and dynamic scenario trees in assets and liabilities
3. dynamic programming
4. Stochastic dynamic programming
5. Maximization of the financial margin and economic value
6. Application of recent economic and financial theories
7. Conditioning factors of liquidity, capital and Solvency 2
8. Stress Testing Scenarios

- International financial reporting regulations and Solvency II
- Sensitivities in IFRS 4 Financial Statements

1. Life and Non-Life Insurance Risk
2. Financial Risks

- Exercise 58: Optimization of Cash Flow Matching in Excel with Solver
- Exercise 59: Portfolio optimization using stochastic dynamic programming in SAS
- Exercise 60: Impact on financial statements due to changes in insurance and financial risk sensitivities in Excel

Module 25: Quantum ALM

- ALM Quantum Approach
- Quantitative Methods in ALM
- Bailey and Redington approach
- Operations Research Techniques
- classic optimization
- Quantum Computing in Asset–Liability Management
- Quadratic Unconstrained Binary Optimization (QUBO)
- Number of Qubits
- Exercise 45: Optimization of assets and liabilities using quantum algorithms

STRESS TESTING

Module 26: Scenario Analysis

Objective: Explains how to build risk scenarios. Activity that is becoming more pressing by the day due to the pandemic and its serious implications for the economy.

- Definition of the scenarios
- Using the scenarios
- scenario identification
- Scenario typology
- Scenario-based risk assessment
- Scenario Analysis Process
- Governance in the scenarios
- Definition of risk appetite
- Scenario evaluation
- Economic Scenario Generator (ESG)
- Exercise 61: Economic Scenario Generator in Excel

Module 27: Forecasting Models

Objective: In order to project scenarios for the future, it is necessary to have traditional tools such as VAR and ARIMA models and other more sophisticated and precise ones such as machine learning.

- Data processing
1. Non-Stationary Series
2. Dickey-Fuller test
3. Cointegration Tests
- Econometric Models
1. ARIMA models
2. VAR Autoregressive Vector Models
3. GARCH models
- Machine Learning Models
1. Supported Vector Machine
2. LSTM Recurrent Neural Network
3. Bayesian Neural Network LSTM
4. Quantum LSTM
- Review of assumptions of econometric models
1. stationary series
2. heteroscedasticity
3. Outliers
4. serial correlation
5. Collinearity detection
- Exercise 62: Tests of non-stationary series and cointegration
- Exercise 63: VAR models in R
- Exercise 64: Forecasting Machine Learning SPV and NN in R
- Exercise 65: Forecasting LSTM

Module 28: Stress Testing for Insurance companies

Objective: Stress testing consists of generating for each scenario shocks to parameters such as the mortality rate, share price, interest rates, etc., and measuring the impact they would have on capital. ORSA's role in this matter is explained. And a global stress testing exercise for an insurance company is shown.

- Stress testing aligned with ORSA
- Stress testing analysis 2011, 2014 and 2016 in EIOPA
- Quantitative and qualitative aspects of stress testing
- Stress testing scenarios
- Interest rate risk
1. Low long-term interest rate
2. double hit
- Credit Spread Risk
- Non-life insurance risk
- Reinsurers Credit Risk
- Catastrophe Risk
- life insurance risk
1. Mortality Events
2. Longevity improvements
- Liquidity risk
- Impact on assets and liabilities
- Impact on SCR and MCR
- Correlations and copulas to model dependency
- Stress Testing as a decision-making tool
- Global Exercise 66 and 67: Stress Testing in SAS, R, Excel with VBA and Gephi, includes:
- Risk Appetite and Business Plan
- Forecasting of the Income Statement and Balance Sheet
- capital planning

- Application of Scenarios and External Shocks
- Network analysis of main macroeconomic variables
- Impact on assets and liabilities
- Impact on SCR and MCR

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