COURSES CONTENT – MINIMUM TEACHING HOURS

Probability and applications using computational techniques – 24 hours
Fundamental concepts in probability, with emphasis in multivariate distributions, simulation techniques, stochastic processes. Analytic and numerical techniques. Emphasis in applications in risk management.

Statistics and applications using computational techniques – 24 hours
The course provides concise coverage of the fundamentals of inference for parametric statistical models, including both theory and practical numerical computation. The course focuses on frequentist maximum likelihood estimation while also considering alternative general methods applicable to a wide range of models and emphasizing the common questions addressed by each of the approaches. The material serves as a lively introduction to the theory and tools that a beginning graduate student needs to make the transition to serious statistical analysis: inference; modelling; computation, including optimisation; simulation methods; and the R language. The course will deepen understanding of why and when methods work and explain how they are suitably applied in practice.

Financial Markets and Corporate Finance – 24 hours
The goal of this course is twofold: First, to describe the main financial markets and instruments and, second, to analyze corporate decisions from a financial perspective. With respect to the first subject, the course focuses on money-market, capital, and debt markets. With respect to the second, the course concentrates on investment and financing decisions, valuation, and the treatment of risk. Topics to be studied are the time-value of money, exchanges and Over-The-Counter Markets, law of one price, net present value rule, capital budgeting techniques and the estimation of the cost of capital. It also studies the valuation of stocks and bonds, the risk-return trade-off, the capital structure, and its relationship with the value of the firm as well as the dividend policy of corporations.

Optimization Techniques and Portfolio Theory – 24 hours
A plethora of empirical financial problems such as portfolio construction, risk management, pricing of financial derivatives etc. require solving different optimization problems. This course will introduce and develop the relevant mathematical tools and numerical methods/techniques for analyzing and solving optimization problems in finance. The course covers linear, quadratic, and dynamic programming problems. It presents nonlinear programming, introduces the basic ideas, dual methods, Lagrange multipliers, and optimality conditions for unconstrained and constrained optimization problems. Gradient descent method, steepest descent method, Newton and quasi-newton numerical schemes are presented and developed. The basic framework of evolutionary algorithms and stochastic optimization approaches is introduced, and non-smooth and non-convex optimization problems are described. Different methods and techniques are presented such as the genetic algorithm, particle swarm optimization, simulated annealing, and stochastic gradient methods. Application of different optimization techniques in estimating the parameters of nonlinear statistical and econometric models is presented. Illustration of the proposed methods and techniques is given using empirical financial applications including construction of mean-variance optimal portfolios, estimation of the efficient frontier, optimization of Value-at-Risk and conditional Value-at-Risk, asset-liability management, and risk management.

Linear models and Time Series Analysis – 24 hours
This course serves as an introduction to the analysis of cross-sectional and time series data. It presents the basic principles, the properties, statistical inference procedures, model selection and the construction and evaluation of forecasts for these two classes of statistical models. The

empirical part of the course consists of applying the above topics using the computational environment R.

Stochastic Processes and Derivative Markets – 24 hours
The course covers the basic derivative securities, derivative markets and their functions, the pricing of derivative securities via stochastic processes and the risk management of financial positions via derivatives. Computational techniques of pricing derivatives are also covered.

Financial Econometrics – 24 hours
This course provides a broad introduction to the theory and empirical analysis of advanced econometric models in financial applications such as construction of optimal portfolios, evaluating managers' performance, and forecasting financial returns. Multi-factor models are introduced, which can be used to estimate the expected returns of financial assets, and univariate and multivariate heteroscedasticity models (ARCH/GARCH), which can be used to model the variations and covariances/correlations of financial returns. Indicative examples of the application of these advanced statistical and econometric models and techniques are (a) the construction of optimal portfolios, (b) the evaluation of the performance of the various mutual fund or hedge fund investment managers, (c) forecasts of financial series, e.g. stock returns.

Financial Mathematics with Computational Applications – 24 hours
This course focuses on the computational part of financial mathematics and is organized in three thematic sections. The first one is about Monte Carlo methods for scenario generation and their applications in pricing financial derivatives under static/dynamic approaches and variance reduction methods for improving accuracy in pricing estimates. In the second part, parametric and nonparametric approaches for the risk quantification and dependence modeling are presented, with special emphasis in the calculation of insurance and financial risk. In the third section modern statistical learning techniques for the study of data from financial and insurance markets are presented.

Life Insurance – General Insurance – 24 hours
Survival function, Simple mortality table and related functions, force of mortality, laws Classics mortality, actuarial tables and commutation functions, Stochastic approach to Life Insurance. Life annuities with one or more payments annually, Relationship between annuities, life insurance of various kinds, Relationship annuities and insurance, interest rate movements and mortality. Net premiums and gross premiums, concept, and process of calculating reserves, Relationship between successive stock prices. Tables and Actuarial functions for two or more persons, Contingent actuarial functions. Pricing and profit-testing.
Uncertainty, Risk, Insurance, Insurance Companies, Actuaries, Insurance Concepts, Products, Actuarial base. Frequency, severity and pricing methodology premium adjustments, Projections, and trends for the final payments by using linear and other models. Reserving methods, Analysis of Insurance Data, Triangular methods and olistic methods of reserving, Discounting reserves, and Confidence Intervals. Reinsurance schemes, «Bonus-Malus» and Markov Chains.

Insurance Risk Management - Solvency II– 24 hours

- Enterprise Risk Management frameworks in the context of insurance undertakings, basic principles, the role of risk culture
- Taxonomy and classification of risks that insurance undertakings are facing
- Valuation of future cash flows, calculation of the best estimate of technical provisions in the framework of Solvency II

- Risk quantification methodologies of insurance undertakings (1-year MTM approach, Liability Run-off approach), economic capital, standard approach of Solvency II
- Asset Liability Management principles and methodologies (cash flow matching, cash flow testing, key rate durations, asset-liability adequacy tests)
- The framework and processes of holistic risk management (stakeholders, risk control, strategic risk management, emergent risk management, risk management culture)
- Scenario analysis and stress tests in an ERM framework, Own Risk and Solvency Assessment in the framework of Solvency II.

Credit and Financial Risk Management – 24 hours

The course studies risk management, with a focus on financial institutions. Among the topics covered are: Interest rate risk. Volatility and value at risk (VaR). Regulatory framework for capital adequacy. Basel Accords I, II, and III. Credit risk models and calibration. Credit ratings. Estimation of default probabilities. Credit exposure on derivatives. Operating risk. Liquidity risk. Using derivatives contracts in risk management.

Topics in Insurance and Finance– 24 hours

Review of Basic issues in Probability Theory and Stochastic Processes, Poisson Process, Brownian motion, Lévy Processes, Applications in Financial Mathematics, Interest Rate Models, Applications in Actuarial Sciences (Risk/Ruin Theory).

Dissertation Thesis

In the dissertation thesis, the student writes a research assignment, in which the existing literature is reviewed, research hypotheses are proposed and basic results from the literature are reproduced. The aim is to introduce the student to (a) the existing research literature, (b) analytic/numeric methodologies, (c) data collection methods, (d) result reporting and conclusions drawing. The dissertation can involve analytic or computational data analysis techniques, in topics revolving around quantitative risk management. The outline of the dissertation will usually contain the following: Abstract/Summary, Introduction, Literature Review, Research Hypotheses Development, Research Methodology, Empirical Results, Sensitivity Analysis and Discussion, Synopsis and Conclusions, References, Appendices (e.g. Programming Code). The dissertation is organized in Chapters and the outline is agreed upon by the student and the supervisor in common.