MASTERS IN ACTUARIAL SCIENCE

Programme specification for 2017/18:

1st SEMESTER

Curricular Unit	ECTS	Type	Contact Hours
Computation Tools for Actuaries	4	Obligatory	39
Financial Markets and Investments	6	Obligatory	39
Financial Mathematics	6	Obligatory	45.5
Probability and Stochastic Processes	8	Obligatory	58.5
Risk Models	6	Obligatory	45.5

2nd SEMESTER

Curricular Unit	ECTS	Type	Contact Hours
Generalized Linear Models	4	Obligatory	19.5
Loss Reserving	4	Obligatory	26
Risk Theory	8	Obligatory	52
Survival Models and Life Contingencies	8	Obligatory	52
Time Series	6	Obligatory	39

3rd SEMESTER

Curricular Unit	ECTS	Type	Contact Hours
Actuarial Topics	6	Elective 1	39
Asset-Liability Management	4	Elective 2	19.5
Finance and Financial Reporting	6	Elective 2	39
Models in Finance	8	Obligatory	39
Pension Funds	4	Elective 1	26
Ratemaking and Experience Rating	4	Elective 1	26
Solvency Models	4	Obligatory	26

4th SEMESTER

Internship	30	Elective
Dissertation	30	Elective
Project	30	Elective

Elective 1 - The student must choose at least 8 ECTS of those subjects
Elective 2 - The student must choose at least 4 ECTS of those subjects

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	CTA	Course name:	Computational Tool for Actuaries			ECTS credits:	4
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	1st	Semester	1st	X	Type	Obligatory	X
			2nd			Elective	
Lecturer:	Daniela Pateiro						

Contact hours	Total workload
39	112

Aims and scope

Information systems are important tools for actuaries, as they make it possible to automatically perform complex calculations on large data sets. In this context, an essential skill lies in the ability to express solutions to actuarial problems using appropriate computational tools. This course aims providing actuaries with a set of conceptual and practical computational tools, ranging from simple formulas computed in a spreadsheet (typically Excel) to programs written in R.

Summary

- EXCEL ESSENTIALS
- STATISTICAL ANALYSIS WITH EXCEL
- USING THE EXCEL SOLVER
- WORKING WITH LARGE DATA
- INTRODUCTION TO VBA
- INTRODUCTION TO R

Main bibliography

- Akaiwa, F., Nordquist, K. and Gross,D. (2013) Succeeding in Business with Microsoft Excel 2013: A Problem-Solving Approach (New Perspectives) 1st Edition, Cengae Learning
- Maindonald, J. and Braum, W.J. (2011) Data Analysis and Graphics Using R – an example-based approach, 3rd edition, Cambridge University Press.
- Seref, M.M.H., Ahuja, R.K. and Winston W.L. (2007) Developing Spreadsheet-based Decision Support Systems using Excel and VBA for Excel Dynamic Ideas, Belmont, Massachusetts.
- Venables, W.N., Smith, D.M. and the R Core Team (2012) An Introduction to R Notes on R: A Programming Environment for Data Analysis and Graphics Version 2.15.2.

Teaching and assessment methodologies

The curricular unit will be taught by means of theoretical-practical lectures using slides to underline the main points. An intensive use of the computer by all students will be required.
The final grade, on a 0-20 scale, is assigned on the basis of an exam to be answered using the computer.

PROGRAMME

1. EXCEL ESSENTIALS
2. STATISTICAL ANALYSIS WITH EXCEL
   2.1 Introduction
   2.2 Understanding data
   2.3 Distributions
   2.4 Data analysis module
3. USING THE EXCEL SOLVER
   3.1 Introduction
   3.2 The Excel Solver
   3.3 Applications
4. WORKING WITH LARGE DATA
   4.1 Importing data
   4.2 Exporting data
   4.3 Creating Pivot Tables from external data
5. INTRODUCTION TO VBA
   5.1 Introduction - The VBA editor
   5.2 Macros
   5.3 Referencing and names in VBA
   5.4 Formulas in VBA
   5.5 Variables
   5.6 VBA math functions
   5.7 Sub Procedures and Function Procedure
   5.8 Programming Structures
   5.9 Arrays
   5.10 User Interface
   5.11 Working with large Data using VBA
6. INTRODUCTION TO R
   6.1 Introduction (The R language and Environment)
   6.2 Getting started
   6.3 Expressions and assignments
   6.4 Built-in functions
   6.5 Logical operators
   6.6 One dimensional arrays – vectors
   6.7 Two dimensional arrays – matrices. Matrix operators
   6.8 Using libraries
   6.9 Reading data
   6.10 Lists and data frames
   6.11 Loops and conditional execution
   6.12 Simple graphs
   6.13 User written functions

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MIF-FI	Course name:	Financial Markets and Investments		ECTS credits:	6	
Scientific field:	Finance			Department:	Management		
Curricular year:	1st	Semester	1st	X	Type	Obligatory	X
			2nd			Elective	

Lecturer: Raquel Maria Medeiros Gaspar

Contact hours	Total workload
39	168

Aims and scope

This course starts with an overview on financial markets and their instruments, and then goes towards combinations of alternative investments and portfolio theory. On what concerns portfolio theory, it covers the standard Modern Portfolio Theory (MPT), at a relatively high mathematical level, in accordance with objectives (i)-(vi) of the CT8 module from the Faculty and Institute of Actuaries.

Investor profiling and choice of optimal portfolios are analysed under the classical expected utility theory (EUT) setup. Stochastic dominance and alternative risk measures are presented. The role of factor models is discussed and the two main types of equilibrium models – CAPM and APT – are derived and analysed.

The course finishes discussing the limitations of the classical EUT setup and with a brief introduction into behavioural issues and prospect theory.

Summary

- Financial markets and their instruments
- Definitions of risk and return
- Two asset portfolios
- The notion of efficient portfolios
- Various market conditions: existence (or not) of a risk-free asset, possibility (or not) of (un)constrained short selling
- Finding the efficient frontier
- Factor models: single and multi-factor models
- Utility theory and deriving investor's utility function
- Expected utility theory (EUT) and optimal portfolios
- Stochastic Dominance
- Risk Measures
- Equilibrium models: capital asset pricing model (CAPM), arbitrage pricing theory (APT)
- Market efficiency and rationality
- Behavioural issues and alternatives to EUT

Main bibliography

- Elton, E. J., Gruber, M. J., Brown, S. J., & Goetzmann, W. N. (2014). Modern portfolio theory and investment analysis. John Wiley & Sons, 9th edition
- Joshi, M. S. and Paterson, J. M., (2013) Introduction to Mathematical Portfolio Theory, International Series on Actuarial Science, Cambridge University Press.

Teaching and assessment methodologies

The UC is taught in sessions of 3h each. The first 2h are usually used to present the theoretical concepts and derive the main results, while the remaining 1h after the break is used to solve exercises or analyse real life cases.

Students are assessed by a final exam.

PROGRAMME

PART I – INTRODUCTION TO FINANCIAL MARKETS AND INVESTMENTS

1 Basic Concepts on Financial Markets
- 1.1 Securities: Stocks, bonds, fund units, securitized credit units, warrants, etc.
- 1.2 Public Offers
  - 1.2.1 Types of Offers
  - 1.2.2 Particularities of Public offers
  - 1.2.3 Announcement and Prospectus
  - 1.2.4 Allocation Criteria
- 1.3 Elements of Financial Markets
  - 1.3.1 Market Classification
  - 1.3.2 Types of (exchange) orders
  - 1.3.3 The role of information
- 1.4 Agents in Financial Markets
  - 1.4.1 Supervision Authorities
  - 1.4.2 Financial Intermediaries
  - 1.4.3 Pooled Investments
  - 1.4.4 Investment Clients
- 1.5 Experiencing Financial Markets

2 A Portfolio Perspective on Investing
- 2.1 Portfolio diversification
- 2.2 The Risk-return trade-off
- 2.3 The Emergence of Modern Portfolio Theory

PART II– PORTFOLIO THEORY

1 Introduction

2 Risk and Returns
- 2.1 Basics on Return
- 2.2 Other Measures of Returns
- 2.3 Variance and Covariance of Returns
- 2.4 Other Measures of Risk

3 Mean-Variance Portfolio Theory
- 3.1 Combinations of two Assets
- 3.2 Including a risk free asset
- 3.3 Three or more assets
  - 3.3.1 The investment opportunity set
  - 3.3.2 The Efficient Frontier
- 3.4 Safety Criteria
  - 3.4.1 Roy
  - 3.4.2 Kataoka
  - 3.4.3 Telser
- 3.5 Widening the Selection Universe
  - 3.5.1 International diversification and the world portfolio
  - 3.5.2 The role of exchange rate risk

4 Portfolio Selection Models
- 4.1 Constant Correlation Model
  - 4.1.1 Motivation
  - 4.1.2 Choosing the Efficient Portfolios

- 4.2 Single index Model
  - 4.2.1 Underlying Ideas
  - 4.2.2 Model Assumptions
  - 4.2.3 Characteristics of Single-index models
  - 4.2.4 Using the Model
  - 4.2.5 A measure of non-diversifiable risk
  - 4.2.6 Beta Estimations
  - 4.2.7 Choosing Efficient Portfolios
- 4.3 Multi-Index Models
  - 4.3.1 Characteristics of multi-index models
  - 4.3.2 Using Multi-index models
  - 4.3.3 Equivalent Models

5 Selecting the Optimal Investor Portfolio
- 5.1 Recap on Utility Theory under certainty
- 5. 2 Utility Theory under uncertainty
- 5.3 Risk tolerance functions
- 5.4 The Choice of the optimal portfolio
- 5.5 Alternative Selection Criteria
  - 5.5.1 Maximizing long-term growth
  - 5.5.2 Stochastic Dominance
  - 5.5.3 Risk Measures

PART III – MODELS OF EQUILIBRIUM IN CAPITAL MARKETS

1 The CAPM- Capital Asset Pricing Model
- 1.1 Assumptions of standard CAPM
- 1.2 The Standard Capital Asset Pricing Model
  - 1.2.1 The “market portfolio”
  - 1.2.2 The Capital Market Line (CLM)
  - 1.2.3 The Security Market Line (SML)
  - 1.2.4 Performance Evaluation under CAPM
- 1.3 Limitations of CAPM
- 1.4 Nonstandard forms of CAPM
- 1.5 Empirically testing CAPM

2 The APT- Arbitrage Pricing Model
- 2.1 Assumptions of APT
- 2.2 Estimating and Testing APT
- 2.3 APT versus CAPM

3 Efficiency in Financial Markets
- 3.1 Forms of efficiency
- 3.2 Testing market’s efficiency
- 3.3 Week and strong arbitrage and markets efficiency
- 3.4 “Anomalies” existent in financial markets

4 Behavioural Issues and introduction to Prospect Theory

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MAFI-CA	Course name:	Financial Mathematics			ECTS credits:	6
Scientific field:	Mathematical Analysis and Mathematical Finance			Department:	Mathematics		
Curricular year:	1st	Semester	1st	X	Type	Obligatory	X
			2nd			Elective	
Lecturer:	Onofre Alves Simões						

Contact hours	Total workload
45.5	168

Aims and scope

- To provide a grounding in Financial Mathematics, including an introduction to equity and fixed income investments and to financial derivatives.
- To instil the ability to take into account the time value of money, and to understand the term structure of interest rates and simple stochastic interest rate models.
- To learn how to solve paradigmatic problems in the insurance business.

Summary

- Introduction to interest rates
- Present values
- Annuities certain and loan schedules
- Cash flow techniques
- Investments
- Term structure of interest rates
- Stochastic interest rate models

Main bibliography

- Broverman, S. A. (2015), *Mathematics of investment and credit*, 6th ed., Actex Publications, Winstead.
- McCutcheon & W. Scott (1986), *An Introduction to the Mathematics of Finance*, Heinemann, London.
- Matias, R. (2004), *Cálculo Financeiro – Teoria e Prática*, Escolar Editora, Lisboa.

Teaching and assessment methodologies

Lectures will be theoretical and practical, focused on the models used to carry out financial assessments in various situations. As these situations replicate very often real life problems, of which students are in some way aware, it is possible to use a mix of verbal, active, and even intuitive methods.

The final note, on the scale of 0 to 20, is assigned on the basis of a written exam.

PROGRAMME

1 INTEREST RATE MEASUREMENT

- 1.1 Financial transactions. Time, money and interest
- 1.2 Simple and compound interest
- 1.3 Present value and equations of value
- 1.4 Effective and nominal rates of interest
- 1.5 Simple and compound discount
- 1.6 The force of interest
- 1.7 Inflation and the “real” rate of interest

2 VALUATION OF ANNUITIES

- 2.1 Annuities: definition and types of annuities
- 2.2 Level payment annuities in discrete and continuous time
- 2.3 Annuities with non-constant payments in discrete and continuous time

3 LOAN REPAYMENT

- 3.1 Loan repayment methods
- 3.2 Deferral periods; variable interest rates; sinking funds; Makeham’s formula
- 3.3 Bond valuation: determination of bond prices; amortization of a bond; callable bonds; serial bonds

4 MEASURING THE RATE OF RETURN OF AN INVESTMENT

- 4.1 Internal rate of return and net present value
- 4.2 Profitability index; payback period; discounted payback period; modified internal rate of return
- 4.3 Money weighted and time weighted rates of return
- 4.4 Interest preference rates for borrowing and lending
- 4.5 Yield in continuous time

5 THE TERM STRUCTURE OF INTEREST RATES

- 5.1 Spot rates of interest
- 5.2 Forward rates of interest
- 5.3 At-par yield
- 5.4 Interest rate swaps

6 INVESTMENTS

- 6.1 Forward and futures contracts
- 6.2 Stocks, short sale and options
- 6.3 Fixed Income Investments. Inflation protected securities; bond default and risk premium

7 STOCHASTIC INTEREST RATE MODELS

- 7.1 Introduction.
- 7.2 Probability distribution and moments of the accumulated amount of a series of annual investments (exact or generated by simulation methods)
  - 7.2.1 Independent annual rates of return (discrete or continuous random variables)
  - 7.2.2 Dependent annual rates of return (discrete or continuous random variables)
  - 7.2.3 Log-normal distribution of yields

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	PPE	Course name:	Probability and Stochastic Processes		ECTS credits:	8	

Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	1st	Semester	1st	X	Type	Obligatory	X
			2nd			Elective	

Lecturer:	Maria de Lourdes Caraças Centeno

Contact hours	Total workload
58.5	224

Aims and scope

- It is our aim with this Curricular Unit that students acquire the necessary background to precede to the study of other more advanced stochastic phenomena that arise in insurance business, in more advanced Curricular Units.
- The first part of the Curricular Unit is intended to introduce important concepts of probability distributions and their characteristics. In addition to a more advanced study of topics already taught in the first cycle, new concepts are introduced, with actuarial science applications, as is the case of measures for evaluating the tails of the distributions.
- In the second part some of the most relevant stochastic processes used for modelling actuarial phenomena are introduced.

Summary

- Principles of actuarial modelling
- Overview of some concepts
- Distributions and basic distributional quantities: random variable, distribution and survival functions, moments, quantiles, generating functions, sums of random variables, residual life, censored random variables, limited random variables, tails of distributions
- Characteristics of actuarial models: the role of the parameters, the exponential and the linear exponential family
- Continuous models: creating new distributions, identification of some distributions
- General notions of stochastic processes and their classification
- Discrete time Markov chains
- Introduction to counting processes: the homogeneous Poisson process, the non-homogeneous Poisson process and the mixed Poisson process
- Continuous time homogeneous Markov chains
- Time Inhomogeneous Markov Chains
- Actuarial Applications

Main bibliography

- Klugman, S.A.; Panjer, H.H. & Willmot, G.E. (2008), *Loss Models, From Data to Decisions*, (3rd edition), John Wiley & Sons.
- Core Reading 2011, CT4 Models, The Actuarial Profession.
- Dickson, D., Hardy, M., and Waters, H., (2009) Actuarial Mathematics for Life Contingent Risks, Cambridge University Press.
- Ross. S. M. (2010), *Introduction to Probability Models*, (Tenth Edition), Academic Press, New York.
- Ross. S. M. (1996), *Stochastic Processes*, 2nd ed. John Wiley & Sons, New York.
- Taylor, H. M. & Karlin, S. (1998), *An Introduction to Stochastic Modelling*, (3rd edition), Academic Press, New York.

Teaching and assessment methodologies

Sessions are of a theoretical-practical nature, based on oral presentations, accompanied by the projection of slides containing the main results, which will be derived, explained and exemplified.

Students must solve the recommended exercises, as assigned homework, so that proposed solutions may be discussed in the class.

The final note, on the scale of 0 to 20, is assigned on the basis of a written exam.

PROGRAMME

1. PRINCIPLES OF ACTUARIAL MODELLING
   - 1.1. The model–based approach: why and how models are used
   - 1.2. Benefits and limitations of modelling
   - 1.3. Stochastic versus deterministic models; static random phenomena versus stochastic processes
   - 1.4. Suitability of a model; analysing the output of a model; sensitivity testing
   - 1.5. Communicating the results of a model

2. DISTRIBUTIONS AND BASIC DISTRIBUTIONAL QUANTITIES
   - 2.1. Overview of some concepts: experiment, outcome, sample space, event, event space, □□algebra of events, probability function, probability space, conditional probability, theorem of total probability, Bayes' formula, multiplication rule, independent events
   - 2.2. Random variable; distribution function; continuous, discrete and mixed random variables; hazard rate
   - 2.3. Multivariate random variables; independent random variables
   - 2.4. Moments and related quantities
   - 2.5. Some well-known discrete and continuous random variables
   - 2.6. Residual life; left censored and shifted random variable; limit loss variable
   - 2.7. Quantiles
   - 2.8. Moment generating function, probability generating function and cumulant generating function
   - 2.9. Sum of independent random variables; central limit theorem
   - 2.10. Tails of distributions: comparison of the tail based on moments, on the limiting tail behaviour, on the hazard rate function and on the mean excess loss function; The equilibrium distribution and the tail behaviour

3. CHARACTERISTICS OF ACTUARIAL MODELS
   - 3.1. Parametric and scale distributions: scale distribution and scale parameter; location and shape parameters; the exponential family and the linear exponential family
   - 3.2. Mixed distributions: discrete and continuous mixtures

4. SEVERITY MODELS (CONTINUOUS MODELS)
   - 4.1. Creating new distributions: sums of distributions; transformation of random variables; mixing of distributions
   - 4.2. Recognition of families of distributions and their relations

5. GENERAL NOTIONS OF STOCHASTIC PROCESSES
   - 5.1. Some definitions
   - 5.2. Specification of a stochastic process
   - 5.3. Classification of a stochastic process

6. DISCRETE TIME MARKOV CHAINS
   - 6.1. Definitions
   - 6.2. Transition probability matrices
   - 6.3. First step analysis
   - 6.4. Classification of states
   - 6.5. Limit Behaviour
   - 6.6. Applications to no claim discount and *bonus-malus* systems

7. INTRODUCTION TO COUNTING PROCESSES
   - 7.1. Some definitions: counting process, Markov counting process, birth process – the homogeneous and the non-homogeneous processes
   - 7.2. The homogeneous Poisson process: its genesis, discussion of the postulates, some related distributions –the exponential, the gamma, the binomial and the uniform
   - 7.3. The non-homogeneous Poisson process
   - 7.4. The mixed Poisson process; the Polya process

8. CONTINUOUS TIME HOMOGENEOUS MARKOV CHAINS
   - 8.1. Introduction: time homogeneous Markov process; Chapman-Kolmogorov equations
   - 8.2. The transition probability matrix
   - 8.3. The forward and backward differential equations
   - 8.4. The embedded Markov chain
   - 8.5. Stationary and limiting distributions

9. TIME INHOMOGENEOUS MARKOV CHAINS
   - 9.1. Introduction; Chapman-Kolmogorov equations
   - 9.2. Kolmogorov's forward differential equations
   - 9.3. Probabilities of remaining in states for given time periods
   - 9.4. Kolmogorov's backward differential equations
   - 9.5. Applications in insurance

Degree:	2nd	Field of Study:	Actuarial Science

Code:	MR-CA	Course name:	Risk Models	ECTS credits:	6

Scientific field:	Statistics and Actuarial Science	Department:	Mathematics

Curricular year:	1st	Semester	1st	X	Type	Obligatory	X
			2nd			Elective	

Lecturer:	João Manuel de Sousa Andrade e Silva

Contact hours	Total workload
45.5	168

Aims and scope

The student is expected

- To use statistical methods to estimate survival, severity, frequency and aggregate models given sample data.
- To understand the assumptions implicit in each statistical technique.
- To recognize which assumptions and statistical technique are appropriate to solve a given problem.

Summary

- Review of Basic statistical concepts
- Construction of empirical models
  - Estimation for complete data
  - Estimation for modified data
- Parametric statistical methods
  - Frequentist estimation
  - Introduction to Bayesian estimation
  - Model selection
- Simulation and Bootstrap
  - Simulation
  - Bootstrap

Main bibliography

- Klugman, S.A., Panjer, H.H. and Willmot, G.E. (2012), *Loss Models – From data to decisions*, 4th Edition, John Wiley & Sons, Inc., New-Jersey.
- Hesterberg, T., Monaghan, S., Moore, D.S., Clipson, A., Epstein, R. (2003), *Bootstrap Methods and Permutation Tests* (http://bcs.whfreeman.com/pbs/cat_160/PBS18.pdf), companion chapter 18 to The practice of Business Statistics by David S. Moore, MCCabe, Duckworth and Sclove.
- Casella, G. and Berger, R. (2002), *Statistical Inference* (Second Edition). Duxbury Press.
- Efron, B. and Tibshirami, R.J. (1993), *An Introduction to the Bootstrap*, Chapman & Hall, New-York.
- Ross, S.M. (2002) *Simulation*, 3rd Edition, Academic Press.
- Seila, A., Ceric,V. and Tadikamalla,P. (2003), *Applied Simulation Modeling,* Duxbury Applied Series.
- Wasserman, L. (2004), *All of Statistics: A Concise Course in Statistical Inference*, New York, Springer.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points and using computer to solve some examples.

Student's autonomous work is a main point of teaching methodologies. Students must also solve a set of exercises.

The final note, on the scale of 0 to 20, is assigned on the basis of a written exam.

PROGRAMME

1. REVIEW OF BASIC STATISTICAL CONCEPTS
   - 1.1. Introduction
   - 1.2. Point estimation with emphasis on measures of quality
   - 1.3. Interval estimation
   - 1.4. Tests of hypothesis
2. CONSTRUCTION OF EMPIRICAL MODELS
   - 2.1. Estimation for complete data
     - 2.1.1. The empirical distribution for complete individual data
     - 2.1.2. The empirical distribution for grouped data
   - 2.2. Estimation for modified data
     - 2.2.1. Introduction. The Kaplan-Meier estimator
     - 2.2.2. Means, variance and interval estimation
     - 2.2.3. Kernel density models
     - 2.2.4. Approximations for large data sets
3. PARAMETRIC STATISTICAL METHODS
   - 3.1. Frequentist estimation
     - 3.1.1. Methods of moments and percentile matching
     - 3.1.2. Maximum likelihood estimation (individual, grouped, censored and truncated data)
     - 3.1.3. Variance and interval estimation
     - 3.1.4. Non-normal confidence intervals
     - 3.1.5. Estimation for discrete distribution
     - 3.1.6. An introduction to Bayesian estimation
   - 3.2. Introduction to Bayesian estimation
     - 3.2.1. Introduction. Bayes theorem
     - 3.2.2. Inference and prediction
     - 3.2.3. Conjugate priors distribution
   - 3.3. Model selection
     - 3.3.1. Introduction
     - 3.3.2. Representation of the data and model and graphical comparison of the density and distribution functions
     - 3.3.3. Goodness of fit testing
     - 3.3.4. Likelihood ratio test
     - 3.3.5. Selecting a model
4. SIMULATION AND BOOTSTRAP
   - 4.1. Simulation
     - 4.1.1. Basics of simulation
     - 4.1.2. Examples of simulation in actuarial modelling and finance
   - 4.2. Bootstrap
     - 4.2.1. Introduction to bootstrapping
     - 4.2.2. Bootstrap distributions and standards errors
     - 4.2.3. Bootstrap confidence intervals

Degree:	2nd	Field of Study:	Actuarial Science

Code:	MLG	Course name:	Generalized Linear Models	ECTS credits:	4

Scientific field:	Statistics and Actuarial Science	Department:	Mathematics

Curricular year:	1st	Semester	1st			Type	Obligatory	X
			2nd	X			Elective	

Lecturer: Rui Paulo

Contact hours	Total workload
19.5	112

Aims and scope

To review regression models in general, and the simple and multiple linear models. To introduce the fundamental theory of Generalized Linear Models (GLM) and present applications to actuarial problems. Provide skills for real-data estimation of GLM.

Summary

- Review of Normal Linear Model
- General overview of Generalized Linear Models
- Statistical inference
- Continuous response models
- Discrete response models
- Quasi-likelihood and overdispersion

Teaching and assessment methodologies

Lectures will alternate theoretical presentations of statistical models with data analysis performed with suitable software.

The final grade, on a 0-20 scale, is awarded on the basis of a written exam.

Main bibliography

- McCullagh P. And Nelder, J.A. *, Generalized Linear Models* , 2nd Edition, Chapman and Hall, London., 1989
- Azzalini A., *Statistical Inference – Based on the Likelihood*, Chapman and Hall, 1996.
- Venables W. N. and Ripley B. D., *Modern Applied Statistics with S*, 4th Edition, Spinger, 2002.

PROGRAMME

1. Review of linear regression model
   - 1.1 Introduction.
   - 1.2 Definition of the linear regression model.
   - 1.3 Basic hypotheses of the model.
   - 1.4 Coefficient estimation through the least squares method.
   - 1.5 Coefficient of determination.
   - 1.6 The normal linear regression model.
   - 1.7 Inference in the linear regression model.
2. Introduction to generalised linear models
   - 2.1 Data types.
   - 2.2 Exponential family of distributions: introduction.
   - 2.3 Natural and scale parameters. Mean and variance. Variance function.
   - 2.4 Introduction to Generalized Linear Models: link functions, canonical link function, linear predictor.
   - 2.5 Variables, factors, interactions. Parametrisation.
   - 2.6 Deviance and scaled deviance.
   - 2.7 Pearson and deviance residuals.
3. Statistical inference in the GLM
   - 3.1 Review of Maximum Likelihood theory.
   - 3.2 Point and interval estimation.
   - 3.3 Test of hypotheses on individual parameters.
   - 3.4 Test of linear restrictions - nested models.
   - 3.5 Model fit and model comparison.
   - 3.6 Estimation of dispersion parameter.
4. Continuous response models
   - 4.1 The Normal model.
   - 4.2 The Exponential and Gamma models.
5. Discrete response models
   - 5.1 The Binomial model.
   - 5.2 The Poisson model.
   - 5.3 Modelling of proportions.
   - 5.4 Poisson modelling of rates. Offset.
6. Quasi-likelihood and overdispersion
   - 6.1 Introduction to quasi-likelihood estimation.
   - 6.2 Likelihood equations for the general and regression models.
   - 6.3 Choice of mean value and variance functions.
   - 6.4 Estimation of the dispersion parameter.

Degree:	2nd	Field of Study:	Actuarial Science

Code:	PRVS	Course name:	Loss Reserving	ECTS credits:	4

Scientific field:	Statistics and Actuarial Science	Department:	Mathematics

Curricular year:	1st	Semester	1st		Type	Compulsory	X
			2nd	X		Optional	

Lecturer:	Walther Adolf Hermann Neuhaus

Contact hours	Total workload
26	112

Aims and scope

To give students:
- A good understanding of outstanding claims in general insurance
- Models and methods for estimating the cost of outstanding claims
- Practical exercise with the analysis of several realistic data sets

Summary

1. Introduction
2. Current practice
3. Modelling claim counts
4. Tail extension
5. Modelling claim amounts
6. Credibility theory
7. GLM
8. Diagnostics and data
9. Reinsurance recoveries
10. Accounting for outstanding claims
11. Towards better estimates

Main bibliography

- Neuhaus, Walther (2009-2016). Lecture notes.
- Taylor, G.C. (2000). Loss reserving: an actuarial perspective, Kluwer Academic, Boston.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points and using computer to solve some examples.
The assessment is based on an examination.

PROGRAMME

1. Introduction
   - General insurance contracts: lines on insurance, claim attachment
   - Stages in the life of a claim: notification, assessment, handling, payment, settlement, reopening, recoveries
   - Purpose of valuation: accounting, pricing, portfolio transfer, commutation
   - Case estimates
   - Time dimensions (events): underwriting, loss event, claim reporting, payments, settlement
   - Four-letter words: CBNI, IBNR, RBNS

2. Current practice
   - Development triangles
   - Chain ladder method
   - Bornhuetter-Ferguson's method
   - Benktander method
   - Generalised linear models

3. Modelling claim counts
   - Fixed parameter models
   - MLE derivation of Bornhuetter-Ferguson and chain ladder method

4. Tail extension

5. Modelling claim amounts
   - The basic methods (Bornhuetter-Ferguson, chain ladder)
   - Bühlmann-Straub model
   - Hesselager-Witting model
   - Mack model
   - All with expressions of MSEP

6. Credibility theory
   - Bayes estimator, linear Bayes estimator, regression model with random coefficients
   - Variations on Bühlmann-Straub model: modelling à priori uncertainty, modelling time series

7. Generalised linear models
   - Link functions, covariates and probability distributions
   - Modelling examples
   - Estimation and prediction
   - Bootstrapping

8. Diagnostics and data

9. Reinsurance recoveries
   - Contract types
   - Form of recovery
   - Duration of contracts (clean-cut vs run-off)
   - Limitations
   - Accounting considerations

10. Accounting for outstanding claims
    - Balance sheet items
    - Premium provision
    - Claim provision
    - Risk margin
    - Recoveries

11. Towards better estimates
    - Stages in the life of a claim: CBNI, IBNR, RBNS
    - Making the most of scarce information
    - Separating the analysis of RBNS, IBNR and CBNI
    - Modelling in continuous time (briefly)

Degree:	2nd	Field of Study:	Actuarial Science		
Code:	TR	Course name:	Risk Theory	ECTS credits:	8
Scientific field:	Statistics and Actuarial Science	Department:	Mathematics		

Curricular year:	1st	Semester	1st		Type	Obligatory	X
			2nd	X		Elective	

Lecturer:	Maria de Lourdes Caraças Centeno		
Contact hours		Total workload	
52		224	

Aims and scope

Students that have successfully completed this course should be able of understanding how:
- stochastic models are used in insurance, namely in general insurance
- calculating the aggregate claim distribution
- calculating the ruin probability or an approximation
- analysing the effect of reinsurance on the retained claim process.

Summary

- The number of claims
  - The (a,b,0) class of distributions
  - The class (a,b,1) of distributions: Truncation and modification at zero
  - Compound frequency models
  - Mixed frequency models
  - Effect of exposure on frequency
- Impact of coverage modifications in the frequency and severity, including deductible, inflation effects, policy limits
- Aggregate models
  - Collective risk model versus individual risk model
  - The compound model
  - Special cases
  - The aggregate claim distribution
  - The impact of individual policy modifications on the aggregate claim distribution
  - The individual model
  - Approximated methods
- Premium principles; Risk Measures
- Reinsurance: Quota-share, Surplus, Excess of Loss and Stop Loss
- Ruin Theory
  - Continuous time model
  - Discrete time model
  - The impact of reinsurance on the ruin probability

Main bibliography

- Klugman, S., Panjer, H. and Willmot, G. (2008) *Loss Models, Third Edition*. John Wiley & Sons.
- Kaas, R., Goovaerts, M., Dhaene, J. and Denuit, M. (2008), *Modern Actuarial Risk Theory*, Using R. , Kluwer Academic Publishers, Boston.
- Centeno, M.L. (2003), *Teoria do Risco na Actividade Seguradora*, Celta Editora, Oeiras, Portugal.

Teaching and assessment methodologies

Sessions are of a theoretical-practical nature, based on oral presentations, accompanied by the projection of slides containing the main results, which will be derived, explained and exemplified.

Students must solve the recommended exercises, as assigned homework, so that proposed solutions may be discussed in the class.

The final note, on the scale of 0 to 20, is assigned on the basis of a written exam.

PROGRAMME

1. INTRODUCTION

2. THE NUMBER OF CLAIMS

- 2.1 The (a,b,0) class of distributions
- 2.2 The class (a,b,1) of distributions: Truncation and modification at zero
- 2.3 Compound frequency models
- 2.4 Mixed frequency distributions
- 2.5 Effect of exposure on frequency

3. IMPACT OF COVERAGE MODIFICATIONS IN THE FREQUENCY AND SEVERITY

- 3.1 Deductible
- 3.2 Inflation effects
- 3.3 Policy limits
- 3.4 Coinsurance, deductibles and limits
- 3.5 The impact of deductibles on the claim frequency

4. AGGREGATE LOSS MODELS

- 4.1 Collective risk model *versus* individual risk model
- 4.2 Assumptions and characteristics of the compound model
- 4.3 Special cases
- 4.4 The aggregate claim distribution
  - 4.4.1 Introduction
  - 4.4.2 Recursive method
  - 4.4.3 Constructing arithmetic distributions
- 4.5 The impact of individual policy modifications on the aggregate claim distribution
- 4.6 The individual model
- 4.7 Approximated methods
  - 4.7.1 The Normal Power approximation
  - 4.7.2 The translated Gamma approximation

5. PREMIUM PRINCIPLES

- 5.1 Some premium calculation principles
- 5.2 Properties

6. RISK MEASURES

- 6.1 Coherent risk measures
- 6.2 Value at Risk (VaR)
- 6.3 Tail Value at Risk (TVaR)
- 6.4 Conditional Tail Expectation (CTE)
- 6.5 Expected Shortfall (ES)

7. REINSURANCE

- 7.1 Introduction
- 7.2 Quota share reinsurance
- 7.3 Surplus reinsurance
- 7.4 Excess of loss reinsurance, per risk and per event covers, working and clash covers
- 7.5 Stop loss reinsurance

8. RUIN THEORY

- 8.1 Continuous time model *versus* discrete time model
- 8.2 Continuous time model
  - 8.2.1 The adjustment coefficient
  - 8.2.2 Some functional equations for the ultimate probability of ruin
  - 8.2.3 Lundberg's inequality
  - 8.2.4 The maximum aggregate loss
  - 8.2.5 Beekman's formula
  - 8.2.6 The exact ruin probability in some simple cases
- 8.3 Discrete time model
  - 8.3.1 The adjustment coefficient
  - 8.3.2 The impact of reinsurance on the adjustment coefficient

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MASV	Course name:	Survival Models and Life Contingencies	ECTS credits:	8		
Scientific field:	Statistics and Actuarial Science	Department:	Mathematics				
Curricular year:	1st	Semester	1st		Type	Obligatory	X
			2nd	X		Elective	
Lecturer:	Onofre Simões						

Contact hours	Total workload
52	224

Aims and scope

The aim of this subject is to provide students with the skills necessary to apply and develop actuarial mathematics concepts and techniques, in the area of life contingent risks. In a particular way, those skills must be used to model and evaluate cash-flows dependent on death, survival, disability and other risks present in life insurance and pensions.

Summary

- Life Insurance Products
- Mortality and Life Tables
- The Evaluation of Assurances and Annuities
- Premiums and Reserves Calculation
- Multi-state Policies
- Discounted Emerging Cost Techniques
- Single Figure Indices to Summarise and Compare Mortality Levels

Main bibliography

- Dickson, D., Hardy, M. and Waters, H. (2013), *Actuarial Mathematics for Life Contingent Risks*, 2nd ed., Cambridge University Press.
- Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997), *Actuarial Mathematics* , 2nd ed, The Society of Actuaries, Schaumburg, IL.
- The Actuarial Profession, Subject CT5 - Contingencies - Core Reading for the 2017 exams (2016), The Actuarial Profession.

Teaching and assessment methodologies

The sessions of theoretical and practical content will consist of oral presentations accompanied by the projection of slides containing the main formulae and results, which will be explained, demonstrated and exemplified using suitable techniques. A significant part of the sessions will be devoted to drafting exercises and practical applications.

The final grade, on a 0-20 scale, is awarded on the basis of a written exam lasting three hours.

PROGRAMME

1. LIFE INSURANCE PRODUCTS
   - 1.1. Life Insurance contracts
   - 1.2. Annuity contracts
   - 1.3. Pension benefits

2. MORTALITY AND LIFE TABLES
   - 2.1. Survival functions and force of mortality
   - 2.2. The future life time and curtate future lifetime
   - 2.3. Life tables
   - 2.4. Select survival models
   - 2.5. Select life tables

3. THE EVALUATION OF ASSURANCES AND ANNUITIES
   - 3.1. Valuation of insurance benefits (level and variable, in continuous and discrete time)
   - 3.2. Valuation of life annuities (level and variable, in continuous and discrete time)

4. CALCULATION OF PREMIUMS AND RESERVES
   - 4.1. Net and gross premiums
   - 4.2. The principle of equivalence
   - 4.3. The portfolio percentile principle
   - 4.4. Extra mortality risk
   - 4.5. Reserving for a policy with discrete cash flows (annual and other)
   - 4.6. Reserving for a policy with continuous cash flows
   - 4.7. Policy alterations

5. MULTI-STATE POLICIES
   - 5.1. Multiple state models
   - 5.2. Assumptions and notation
   - 5.3. Transition intensities and probabilities
   - 5.4. Numerical evaluation of probabilities
   - 5.5. Premiums
   - 5.6. Thiele's differential equation generalisations
   - 5.7. Multiple decrement models (competing risks)
   - 5.8. Joint life status and last survivor status
   - 5.9. Multiple decrement models (competing risks) revisited

6. DISCOUNTED EMERGING COST TECHNIQUES
   - 6.1 Evaluating expected cash flows
   - 6.2 Deterministic profit testing for traditional life insurance
   - 6.3 Deterministic profit testing for equity-linked insurance
   - 6.4. Stochastic profit testing

7. SINGLE FIGURE INDICES TO SUMMARISE AND COMPARE MORTALITY LEVELS

7.1. Mortality, selection and standardisation

7.2. Crude mortality rate

7.3. Directly standardised mortality rate

7.4. Indirectly standardised mortality rate and area comparability factor

7.5. Standardised mortality ratio

Degree:	2nd	Field of Study:	Actuarial Science

Code:	MP-CA	Course name:	Time Series	ECTS credits:	6

Scientific field:	Econometrics	Department:	Mathematics

Curricular year:	1st	Semester	1st		Type	Obligatory	X
			2nd	X		Elective	

Lecturer:	Nuno Sobreira

Contact hours	Total workload
39	168

Aims and scope

The student is expected:

- To be familiar with the basic ideas, concepts and tools required for the description, modelling, and forecasting of time series data
- To know to select a forecasting method for a time series
- To know how to build and fit a model to a time series
- To be familiar with specificities of financial time series modelling.

Summary

- Introduction, description, and classical decomposition
- Stationary and integrated processes
- Stationary models: autoregressive (AR), moving average (MA) and mixed (ARMA)ARIMA and seasonal ARIMA
- ARIMA and seasonal ARIMA models
- Model building
- Forecasting
- Conditional heteroskedasticity
- Multivariate time series models

Main bibliography

- Enders, W. (2009). *Applied Econometric Time Series*, Wiley.
- Hamilton, J. (1994). *Time Series Analysis*, Princeton University Press.
- Tsay, R. S. (2005). *Analysis of Financial Time Series*, Wiley.
- Morettin P. A., e C. M. C. Toloi (2004). *Análise de Séries Temporais*, Editora Edgard Blücher.
- Wooldridge, J.M. (2011). *Introductory Econometrics: A Modern Approach*, Cengage Learning.

Teaching and assessment methodologies

Lectures will be theoretical and practical, starting on main empirical patterns found in time series as a basis to present statistical methods and models used to represent it. Core mathematical models for time series will be presented in a constructive way, but practical relevance of different models in terms of time series behavioural patterns and on the nature of implied forecast functions will also be strengthened. Using available software, models and modelling strategies will be applied on real time series data with emphasis in critical analysis as a function of purposes.

Students will be assessed based on a final exam.

PROGRAMME

1. INTRODUCTION, DESCRIPTION, AND CLASSICAL DECOMPOSITION
   - 1.1. Examples of time series patterns; objectives of time series analysis
   - 1.2. Component models: additive and multiplicative
   - 1.3. Moving averages filtering: estimating trends and seasonality
   - 1.4. Sample autocorrelation function and serial dependence
2. STATIONARY AND INTEGRATED PROCESSES
   - 2.1. Definition of second-order stationarity: autocovariance and autocorrelation functions.
   - 2.2. White noise process and the general linear process
   - 2.3. Integrated processes: the random walk
   - 2.4. A note on spurious time series regression and cointegration
3. STATIONARY MODELS: AUTOREGRESSIVE (AR), MOVING AVERAGE (MA) AND MIXED (ARMA)
   - 3.1. Autoregressive models: stationarity conditions, autocorrelation function (ACF) and partial autocorrelation function (PACF). AR(1) and AR(2) processes.
   - 3.2. Moving average models: stationarity and invertibility; ACF and PACF. MA(1) and MA(2) processes.
   - 3.3. ARMA models: stationarity and invertibility; ACF and PACF. ARMA(1,1) process.
4. ARIMA AND SEASONAL ARIMA MODELS
   - 4.1. Models for non stationary time series: ARIMA(p,d,q) models
   - 4.2. Modelling seasonality: ARIMA(p,d,q)$(P,D,Q)_s$ models
5. MODEL BUILDING
   - 5.1. Model identification: producing stationarity; using sample ACF and PACF to choose a model
   - 5.2. Model estimation: notes on estimation methods; parameter evaluation
   - 5.3. Model diagnostics: tests on residuals
   - 5.4. Model selection criteria and the principle of parsimony.
6. FORECASTING
   - 6.1. Minimum MSE forecasts for ARIMA models and forecast error variance
   - 6.2. Eventual forecast function profiles of ARIMA models
   - 6.3. Exponential smoothing forecasting methods
   - 6.4. Forecasting accuracy measures. Combination of forecasts
7. CONDITIONAL HETEROSKEDASTICITY
   - 7.1. Financial time series patterns
   - 7.2. ARCH and GARCH volatility models
8. MULTIVARIATE TIME SERIES MODELS
   - 8.1. Vector autoregressions (VAR)
   - 8.2. Cointegration and Vector Error Correction model (VEC)

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	TOA-CA	Course name:	Actuarial Topics			ECTS credits:	6
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	2nd	Semester	1st	X	Type	Obligatory	
			2nd			Elective	X
Lecturer:	Agnieszka Bergel						

Contact hours	Total workload
39	166

Aims and scope

The aim of this unit is to provide an understanding in survival models and their applications.

Summary

- Estimating lifetime distributions – The Kaplan-Meier, Nelson-Aalen and Cox estimates.
- Maximum likelihood estimators for transition intensities in models of transfers between states.
- The binomial mortality model.
- Transition intensities based on age.
- Testing crude estimate for consistency based on different methods. The graduation process.

Main bibliography

- Bowers, Newton, Hans Gerber, James Hickman, Donald Jones e Cecil Nesbit; *Actuarial Mathematics,* The Society of Actuaries, Illinois, 2nd edition, 1997.
- Dickson, D., Hardy, M., and Waters, H. *Actuarial Mathematics for Life Contingent Risks*, Cambridge University Press, 2009.
- Wolthuis, H.; *Life Insurance Mathematics*, Caire Education Series 2, Brussels, 1994.
- Core Reading 2013, CT4 Models, The Actuarial Profession.
- A.S. Macdonald, An actuarial survey of statistical models for decrement and transition data, British Actuarial Journal 2, 1996.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points.

The assessment is based on an examination.

PROGRAMME

1. ESTIMATING LIFETIME DISTRIBUTIONS

   1.1. Estimating the survival function in the absence of censoring
   1.2. Life time data censoring and its consequences in the estimation process
   1.3. The Kaplan- Meier estimate
   1.4. The Nelson-Aalen estimate
   1.5. The Cox model for proportional hazards, partial likelihood estimate in the absence of ties and its asymptotic distribution

2. MAXIMUM LIKELIHOOD ESTIMATORS FOR TRANSITION INTENSITIES IN MODELS OF TRANSFERS BETWEEN STATES

   2.1. Define an observational plan and derive the resulting statistics, including waiting times
   2.2. Likelihood function for constant intensities in a Markov model, using the results of 2.1.
   2.3. Maximum likelihood estimators for transition intensities in 2.2. and their asymptotic joint distribution
   2.4. Poisson approximation to the estimator in 2.3.

3. THE BINOMIAL MORTALITY MODEL

   3.1. The Binomial model of the mortality of a group of identical individuals subject to no other decrements between two given ages
   3.2. Maximum likelihood estimator for the rate of mortality, its mean and variance
   3.3. Advantages and disadvantages of the multiple state model and the Binomial model

4. TRANSITION INTENSITIES BASED ON AGE

   4.1. Importance of dividing data into homogeneous classes
   4.2. The importance of the principle of correspondence
   4.3. Data requirements for an exact calculation of a central exposed to risk depending on age and sex
   4.4. Calculate a central exposed to risk given data in 4.3
   4.5. Estimates of transition probabilities
   4.6. Assumptions underlying census approximation of waiting times
   4.7. Rate interval
   4.8. Census formulae given age at birthday
   4.9. Age to which estimates of transition intensities or probabilities in 4.8

5. TESTING CRUDE ESTIMATE FOR CONSITENCY BASED ON DIFFERENT METHODS. THE GRADUATION PROCESS

   5.1. Statistical tests of crude estimates, for comparison with a standard table
      5.1.1.chi-square test
      5.1.2.standardised deviations test
      5.1.3.sign test
      5.1.4.cumulative deviation test
      5.1.5.grouping of signs test
      5.1.6.serial correlations test
      5.1.7.for comparison with a standard table
   5.2. Reasons for graduating crude estimates of transition intensities or probabilities
   5.3. Test for smoothness of a set of graduated estimates
   5.4. Graduation by the following methods:
      5.4.1.parametric formula
      5.4.2.standard table
      5.4.3.graphical
   5.5. Amend tests in 5.1. to compare crude and graduates sets of estimates and to allow for the presence of duplicate policies
   5.6. Comparison of crude estimates and a standard table, or between crude estimates and graduates estimates

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	GAP-CA	Course name:	Asset-Liability Management			ECTS credits:	4
Scientific field:	Finance			Department:	Mathematics		
Curricular year:	1st	Semester	1st	X	Type	Obligatory	
			2nd			Elective	X
Lecturer:	Walther Adolf Hermann Neuhaus						

Contact hours	Total workload
19.5	112

Aims and scope

To give students:
- a broad understanding of the financial risks of an insurance company
- measures of riskiness and risk appetite
- models for asset risk and liability risks
- methods to analyse and manage the overall risk

Summary

- Asset classes
- Market risk
- Liability risk
- Interest rate risk
- Mean-variance asset allocation
- Risk management by reinsurance
- Measuring capital at risk
- Dynamic financial analysis

Main bibliography

- Neuhaus, Walther. Lecture notes.

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points and using computer to solve some examples.
The assessment is based on an individual project and/or an examination.

PROGRAMME

1. STAKEHOLDERS AND THEIR INTEREST
   - 1.1. Shareholders
   - 1.2. Policyholders
   - 1.3. Creditors
   - 1.4. Management
   - 1.5. Reinsurers
   - 1.6. Supervisors
   - 1.7. Rating agencies
   - 1.8. Tax authorities
2. TYPICAL ASSETS HELD BY INSURERS AND THEIR RISK CHARACTERISTICS
   - 2.1. Bills
   - 2.2. Bonds
   - 2.3. Equity
   - 2.4. Property
3. INSURANCE LIABILITIES AND THEIR RISK CHARACTERISTICS
   - 3.1. General insurance
   - 3.2. Life insurance
   - 3.3. Pension insurance
4. THE OVERALL RISK LANDSCAPE
   - 4.1. Interest rate risk
   - 4.2. Credit risk
   - 4.3. Redemption risk
   - 4.4. Reinvestment risk
   - 4.5. Market risk
   - 4.6. Default risk
   - 4.7. Premium deficiency
   - 4.8. Under-estimation of liabilities
   - 4.9. Currency risk
5. INTEREST RATE RISK
   - 5.1. Bonds
   - 5.2. Bond yield
   - 5.3. The yield curve
   - 5.4. Duration and Convexity
   - 5.5. Determining the yield curve
   - 5.6. Forward rates
   - 5.7. Matching
   - 5.8. Immunisation
6. STOCHASTIC TERM STRUCTURE MODELS
   - 6.1. Equilibrium models
   - 6.2. No-arbitrage models
   - 6.3. Simulation
7. MEAN-VARIANCE MODELLING FOR ALM
   - 7.1. Optimum asset allocation for one period
   - 7.2. Optimum asset allocation to fund a stochastic liability
   - 7.3. Discussion of the mean-variance framework
8. RISK CALIBRATION
   - 8.1. Modelling periodic returns
   - 8.2. Geometric Brownian motion
   - 8.3. Estimation of volatility
9. RISK MEASUREMENT
   - 9.1. Value at risk
   - 9.2. Tail value at risk
   - 9.3. Expected shortfall
   - 9.4. Coherent risk measures
   - 9.5. Spectral risk measures
10. DYNAMIC FINANCIAL ANALYSIS
10. MISCELLANEOUS TOPICS

Degree:	2nd	Field of Study:	Actuarial Science

Code:	MODFIN	Course name:	Models in Finance	ECTS credits:	8

Scientific field:	Mathematical Analysis and Mathematical Finance	Department:	Mathematics

Curricular year:	2nd	Semester	1st	X	Type	Obligatory	X
			2nd			Elective	

Lecturer:	João Manuel Espiguinha Guerra

Contact hours	Total workload
39	224

Aims and scope

– The aim of this course is to develop the necessary skills in order to understand and apply the mathematical methods, of analytical, stochastic and numerical type, that play an important role in financial stochastic models either in discrete or continuous time. In particular, we are interested in models for the valuation of derivative securities. These skills are also important in order to communicate with other financial professionals and to critically evaluate modern financial theories.

Summary

- Brownian motion
- The Itô integral
- Itô's Formula
- Stochastic Differential Equations
- Girsanov's Theorem
- Stochastic models of security prices
- Introduction to the valuation of derivative securities
- The Binomial model
- The Black-Scholes model
- Models for the term structure of interest rates
- Credit risk models

Teaching and assessment methodologies

In classes, we shall discuss the syllabus topics in sequential order. However, we will point the multiple connections and relations between the topics and models. In classes, the syllabus topics will be presented and we shall stimulate critical discussion about the different models and their underlying financial theories. The students should read parts of the books of the main bibliography and selected papers will be recommended for a deeper study of a particular area.

Assessment: The final grade is awarded on the basis of a written exam.

Main bibliography

- Björk, Tomas (2004), *Arbitrage Theory in Continuous Time*, second edition, Oxford University Press.
- Hull, J. (2008) *Options, futures and other derivatives*, 7th ed., Prentice Hall.
- Mikosch, T. (1998), *Elementary Stochastic Calculus with Finance in view*, World Scientific.
- Oksendal, B. (2003), *Stochastic Differential Equations: An Introduction with Applications*, 6th edition, Springer.
- The Actuarial Profession Institute and Faculty of Actuaries, *Core Reading for the 2014* examinations, Subject CT8 , Institute and Faculty of Actuaries, 2013.

PROGRAMME

1. STOCHASTIC CALCULUS
   - 1.1. The Brownian motion
     - 1.1.1. Definition
     - 1.1.2. Main properties of the Brownian motion
     - 1.1.3. The geometric Brownian motion
     - 1.1.4. Martingales in discrete and in continuous time
   - 1.2. The Itô integral
     - 1.2.1. The Itô integral for deterministic functions
     - 1.2.2. The Itô integral for simple processes
     - 1.2.3. Main properties of the Itô integral
     - 1.2.4. The Itô integral for adapted and square-integrable processes
   - 1.3. Itô's Formula
     - 1.3.1. The one dimensional Itô formula or Itô lemma. Examples of application.
     - 1.3.2. The multidimensional Itô formula
     - 1.3.3. The martingale representation theorem
   - 1.4. Stochastic Differential Equations
     - 1.4.1. Itô processes and diffusions
     - 1.4.2. The existence and uniqueness theorem
     - 1.4.3. The geometric Brownian motion and mean reverting processes
     - 1.4.4. The Ornstein-Uhlenbeck process
   - 1.5. The Girsanov Theorem
     - 1.5.1. Change of probability measures
     - 1.5.2. The Girsanov Theorem
   - 1.6. Stochastic models of security prices
     - 1.6.1. The properties of the lognormal distribution and the lognormal model
     - 1.6.2. Empirical tests of the lognormal model
     - 1.6.3. Brief introduction to Lévy processes based models and stochastic volatility models
     - 1.6.4. Time series "cross-sectional" and longitudinal properties
     - 1.6.5. Auto-regressive models
     - 1.6.6. The Wilkie model
     - 1.6.7. Some alternative models
     - 1.6.8. The parameter estimation for asset pricing models: data availability, data errors, outliers, stationarity of underlying time series and the role of economic judgement.
2. VALUATION OF DERIVATIVE SECURITIES
   - 2.1. Introduction to the valuation of derivative securities
     - 2.1.1. Derivatives
     - 2.1.2. Arbitrage
     - 2.1.3. Forward and futures contracts
     - 2.1.4. European and American options
     - 2.1.5. Bounds for options prices
     - 2.1.6. The Put-Call parity and arbitrage opportunities
     - 2.1.7. Situations where the values of European and American options are the same.

2.2. The Binomial model

2.2.1. The Binomial model with one time step

2.2.2. The Binomial model with two time steps

2.2.3. The Binomial model with n time steps.

2.2.4. The risk-neutral pricing measure for a binomial lattice and the risk-neutral pricing approach

2.2.5. The binomial trees recombination

2.2.6. How to calculate the value of European and American options using the binomial model

2.2.7. How to calibrate a binomial model

2.2.8. The state-price deflator approach to pricing

2.2.9. Complete markets

2.2.10. The martingale representation theorem in discrete time

2.2.11. The martingale method

2.3. The Black-Scholes model

2.3.1. The Black-Scholes model assumptions. Stock prices following diffusion processes.

2.3.2. The Black-Scholes PDE and the Black-Scholes formula. The Black-Scholes formula as an expected value for a lognormal distribution.

2.3.3. How to calculate the value of European options using the Black-Scholes option-pricing model.

2.3.4. The Black-Scholes model for assets with dividends

2.3.5. The implicit volatility

2.3.6. The martingale method. The risk-neutral pricing and the equivalent martingale measure.

2.3.7. How to control risk using the Delta hedging.

2.3.8. The Deflator approach and its equivalence to the risk-neutral pricing approach

2.3.9. The Greeks and their interpretation: Delta, Gamma, Vega, Rho, Lambda and Theta

2.3.10. Exotic options and their cash flow characteristics: Asian, barrier, compound, gap, and exchange.

3. TERM STRUCTURE AND CREDIT RISK MODELS

3.1. Models for the term structure of interest rate

3.1.1. Introduction

3.1.2. Desirable characteristics of term-structure models

3.1.3. The risk-neutral approach to the pricing of zero-coupon bonds and interest-rate derivatives

3.1.4. The state-price deflators approach to the pricing of zero-coupon bonds and interest-rate derivatives

3.1.5. Features of the Vasicek bond price model

3.1.6. Features of the Cox-Ingersoll-Ross (CIR) bond price model

3.1.7. The time-zero yield curve in the Vasicek and Cox-Ingersoll-Ross bond price models cannot be exogenously prescribed

3.1.8. The Hull-White model

3.1.9. A Black-Derman-Toy binomial model matching a given time-zero yield curve and a set of volatilities

3.2. Credit risk models

3.2.1. Introduction

3.2.2. Credit event and recovery rate

3.2.3. Structural models. Reduced form models and intensity based models

3.2.4. The Merton model

3.2.5. Two-state models for credit ratings with a constant transition intensity

3.2.6. The Jarrow-Lando-Turnbull model

3.2.7. Two-state models for credit ratings with stochastic transition intensity

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	FPEN-CA	Course name:	Pension Funds			ECTS credits:	4
Scientific field:	Statistics and Actuarial Science			Department:	Mathematics		
Curricular year:	2nd	Semester	1st	X	Type	Obligatory	
			2nd			Elective	X
Lecturer:	Fátima Pires de Lima						

Contact hours	Total workload
26	112

Aims and scope

The aim of this subject is to provide the master students with the skills required to apply and develop the mathematical techniques used in modelling and evaluating cash-flows dependent on retirement, disability, and other uncertain risks present in Pension Funds, group insurance and other social plans.

Summary

- Introduction to some basic concepts in pension funds.
- Evaluation of liabilities regarding age-retirement benefits.
- Individual and aggregate methods of Funding in pension funds.
- Some considerations about the best estimate for the actuarial assumptions.
- Evaluation of liabilities regarding vested rights benefits.
- Evaluation of liability for D&D, early retirement and pre-retirement benefits.
- Pensions Accounting according to IAS19-R.
- DC pension plans
- Investment policy for pension funds
- ALM for Pension Funds

Main bibliography

- Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. & Nesbitt, C.J. (1997) *Actuarial Mathematics*, 2nd ed, The Society of Actuaries, Schaumburg, IL.
- Dickson, D., Hardy, M., and Waters, H. *Actuarial Mathematics for Life Contingent Risks*, (2009), Cambridge University Press.
- Lee E M, (1986) *An Introduction to Pension Schemes*, Institute of Actuaries and Faculty of Actuaries.
- Lima, Fátima, (2013). Lecture notes.
- Mcgill, D., (1989) *Fundamentals of Private Pensions*, sixth edition, Irwin, Homewood, Illinois.

Teaching and assessment methodologies

Sessions will be of theoretical and practical content, with oral presentations, accompanied by the projection of slides containing the main formulae and results, which will be explained, derived and exemplified. A significant part of the time will be devoted to drafting exercises and practical applications.
The final grade, on a 0-20 scale, is awarded on the basis of a written exam.

PROGRAMME

1. Introduction to some basic concepts in pension funds

1.1 Definition of pension fund, pension plan and the various parties involved.

1.2 Classification of Pension Funds and Pension Plans.

1.3 Presentation of the structure division of pension systems on three pillars.

1.4 Presentation of the current formula for calculating old-age pension given by Social Security in Portugal.

1.5 Transition rules, currently in force, to calculating the Portuguese Social Security pension for old age.

1.6 Identify and interpret the common states and decrements for pension plans, and the parametric and tabular models, including Markov chain models, associate with these decrements.

1.7 Apply to calculations involving pension plans benefits approximation methods such as uniform distribution of deaths, constant force, Woolhouse and Euler.

1.8 Rules to constitute a closed pension fund, an open pension fund and a contract of collective membership of an open pension fund.

1.9 Classification of the type of benefits.

2. Individual methods of Funding in pension funds, contributions and normal funding for:

2.1 Pay -as-you –go

2.2 Initial Funding

2.3 Terminal Funding

2.4 Entry Age

2.5 Individual Level Premium

2.6 Unit Credit (Projected, Non-Projected and Corrected)

2.7 Individual Attained Age

3. Aggregate Methods of Funding in Pension Funds, contributions and normal funding for

3.1 Aggregate

3.2 Attained Age

4. Some considerations about actuarial assumptions

4.1 Factors affecting the choice of funding method.

4.2 Population data necessary to compute the liabilities value and demographic assumptions needed;

4.3. Description of the factors to consider in choosing the best estimate for the interest rate, salary scale, inflation, mortality table, disability rates, retirement age rates, turnover rates and population increments;

4.4. Distinction between economic assumptions.

5. Evaluation of liabilities regarding vested rights benefits

5.1 Classification of pension plans in accordance with the vested rights.

5.2 Some observations about the portability of acquired rights.

5.3 Formulas for calculating the actual values of the vested rights benefits and of the corresponding liabilities.

5.4 Normal contributions required to fund vested rights benefits.

5.5 Valuation of the liabilities with the participants who had already termite their services.

5.6 Value of the Minimum Fund required by the supervisory authority.

6. Evaluation of liability for D&D, early retirement and pre-retirement benefits
   - 6.1 Calculation's formula of the annual risk with disability.
   - 6.2 Methods of financing of disability liabilities.
   - 6.3 Determination of the reinsurance value in order to limit the annual risk with disability.
   - 6.4 Calculation's formula of the annual risk with death while active.
   - 6.5 Methods of financing the survival benefits.
   - 6.6 Determination of the reinsurance value in order to limit the annual risk with death.
   - 6.7 Liability with early-retirement and pre-retirement benefits and respective funding methods.
7. Pension Accounting according to IAS19R
   - 7.1 Identification of items necessary for the accounts of pension fund liabilities.
   - 7.2 Requirements in accordance with IAS19R.
   - 7.3 Special events such as Plan Terminations, Settlements, Curtailments and Termination Benefits.
   - 7.5 How to determine the financial ant the actuarial Gains and Losses.
8. DC pension plans
   - 8.1 Various types of DC Pension Plans.
   - 8.2 Expected value of the individual account, at retirement date, and the corresponding expected value.
   - 8.3 The special case of the DC Pension plan with target-benefit.
9. Investment policy for pension funds
   - 9.1 Principles for the pension's fund management.
   - 9.2 Aspects to include in the investment policy.
   - 9.3 Aspects to define the investment strategy.
   - 9.4 Measures of investment performance: IRR, TWR, Alpha, Beta, R2, Tracking Error, Sharpe Ratio and Information Ratio.
10. ALM for Pension Funds
    - 10.1 Actuarial Factors and their interrelationship in an ALM Model.
    - 10.2 Definition of Risk, Risk analysis and Risk Management.
    - 10.3 The Three main categories of ALM Models: Static Models, Dynamic Models, Stochastic Models.
    - 10.4 Macauley Duration, Convexity, stress tests and scenarios testing, and stochastic model.
    - 10.5 Model for simulate Mortality, termination, retirement and other decrements, annual salary increases, annual inflation and Investment Returns.

Degree:	2nd	Field of Study:	Actuarial Science

Code:	TARIF-CA	Course name:	Ratemaking and Experience Rating	ECTS credits:	4

Scientific field:	Statistics and Actuarial Science	Department:	Mathematics

Curricular year:	2nd	Semester	1st	X	Type	Obligatory	
			2nd			Elective	X

Lecturer:	Alfredo Duarte Egídio dos Reis

Contact hours	Total workload
26	112

Aims and scope

On completion of the subject the student should be able to build a tariff for some sorts of insurance, particularly those for big portfolio, like in the motor insurance line of business. To achieve that it is necessary to bring tools that model the past experience onto the portfolio future rating.

Thus, the student should get solid knowledge on Credibility Theory, Bonus-Malus Systems as well as be able to apply his acquired knowledge on Generalized Linear Models to ratemaking.

Summary

- Introduction and concepts
- Credibility theory
- Bonus-malus systems
- Experience rating and Generalized Linear Models. Applications

Main bibliography

- Klugman, S.A.; Panjer, H.H. & Willmot, G.E. (2008 or 2012), Loss Models, From Data to Decisions (3rd or 4th editions), John Wiley & Sons, Hoboken NJ.
- Kaas, R., Goovaerts, M., Dhaene, J. e Denuit, M. (2008), Modern Actuarial Risk Theory: Using R (2nd edition), Springer.
- Centeno, M.L. (2003), Teoria do Risco na Actividade Seguradora, Celta Editora, Oeiras, Portugal.
- Ohlsson, E. & Johansson, B. (2010). Non-Life Insurance Pricing with Generalized Linear Models, EAA series/EAA Lecture Notes, Springer.
- Pitrebois, S.; Denuit, M. & Walhin, J.F. (2003), Setting a bonus-malus scale in the presence of other rating factors: Taylor's work revisited, ASTIN Bulletin, 33(2), 419-436.

Teaching and assessment methodologies

Lectures will be of a mixed type, theoretical and practical, where there will be a presentation of the theory and explanation, followed by practical illustration. Students will be asked to solve the given problems. Evaluation will be twofold: A final exam according to ISEG's exam regulations at the end of the semester and a project. Exam is individual and the project is a tariff build and made by group of students. Project grade has a weight of 20% in the final mark.

PROGRAMME

1. Introduction and concepts
2. Credibility theory
    - 2.1 The Credibility formula
    - 2.2 Classical and Bayesian methodology
    - 2.3 Bühlmann's model
    - 2.4 Bühlmann-Straub's model
    - 2.5 Exact credibility
    - 2.6 Parameter estimation
3. Bonus-malus systems
    - 3.1 Introduction and definitions
    - 3.2 Markov analysis
    - 3.3 Evaluation measures
4. Experience rating and Generalized Linear Models. Applications

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	MSOLV	Course name:	Solvency Models			ECTS credits:	4
Scientific field:	Finance			Department:	Management		
Curricular year:	2nd	Semester	1st	X	Type	Compulsory	X
			2nd			Optional	
Lecturer:	Hugo Borginho						

Contact hours	Total workload
26	112

Aims and scope

- to introduce the objectives and specificities of the regulation of the insurance sector;
- to understand the risks associated to the insurance sector and their dynamics;
- to introduce the European supervisory architecture implemented in 2011;
- to introduce the new European regulatory regime – Solvency II;
- to gather knowledge of the Pillar I aspects of Solvency II, namely the valuation of assets and liabilities, technical provisions, own funds and capital requirements (SCR and MCR);
- to gather knowledge of the Pillar II aspects of Solvency II, namely the system of governance, ORSA, capital add-ons and supervisory review process;
- to gather knowledge of the Pillar III aspects of Solvency II, namely requirements on public disclosure and reporting to supervisors.

The main competences to be developed are:

- the ability to identify and understand the dynamics of risks underlying insurance activities;
- the ability to perceive and interpret the regulatory requirements applicable to the insurance sector.

Summary

- Insurance basics and need for regulation
- European financial supervision architecture
- Risk fundamentals
- New European regulatory regime: Solvency II

Main bibliography

- International Actuarial Association (2004), A Global Framework for Insurer Solvency Assessment;
- Directive 2009/138/EC of the European Parliament and of the Council of 25 November 2009 (on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II));
- Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC.

Teaching and assessment methodologies

Classes will combine Theory and Practice, with the presentation and discussion of slides. Students will be evaluated through a group work and respective presentation in class (weight of 30%) and an exam (weight of 70%). However, the grade of the exam should in no case be less than 8.0 (non-rounded mark).

PROGRAMME

1. Introduction to solvency models
   - 1.1. Insurance basics
   - 1.2. Overview of the European insurance market
   - 1.3. Why regulate?
   - 1.4. Banks vs. insurers
2. European financial supervision architecture
   - 2.1. Origins of the financial crisis
   - 2.2. EU answers
   - 2.3. Recent developments
3. Risk fundamentals
   - 3.1. Risk definition and categories
   - 3.2. Components of risk
   - 3.3. Purpose and design of capital requirements
4. Solvency II
   - 4.1. Introduction to the Solvency II regime
   - 4.2. Pillar I – quantitative requirements
     - 4.2.1. Overview
     - 4.2.2. Valuation of assets and liabilities
     - 4.2.3. Own funds
     - 4.2.4. Capital requirements
     - 4.2.5. SCR standard formula
     - 4.2.6. Internal models
     - 4.2.7. Minimum capital requirement (MCR)
   - 4.3. Pillar II – qualitative requirements
     - 4.3.1. System of governance
     - 4.3.2. Own risk and solvency assessment (ORSA)
     - 4.3.3. Capital add-ons
     - 4.3.4. Supervisory review process
   - 4.4. Pillar III – transparency, reporting and disclosure of information

Degree:	2nd	Field of Study:	Actuarial Science				
Code:	FFR	Course name:	Finance and Financial Reporting			ECTS credits:	6
Scientific field:	Finance			Department:	Management		
Curricular year:	2st	Semester	1st	x	Type	Obligatory	
			2nd			Elective	x
Lecturer:	Pedro Nuno Rino Vieira						
	Contact hours		Total workload				
	39		168				

Aims and scope

Introduce the student to corporate finance and the interpretation of company account, such that at the end of the course she will be able to:

- understand the economic context in which the business operates, namely the shareholder-manager relationship.
- demonstrate an understanding of accounting and financial reporting principles.
- state the importance of auditing.
- interpret an auditing report.
- construct simple balance sheets, profit and loss accounts and cash flow statements.
- interpret financial statements.
- make investment decisions that create shareholder value.
- explain the different debt and equity financial instruments.
- discuss the capital structure of a firm and its relationship with the firm's value.
- understand and explain the main impact of taxation in a firm.
- discuss the use of derivatives to manage risk.

Summary

- The role of finance in a firm
- Types of financial institutions
- Financial Accounting
- Construction of simple balance sheets, profit and loss accounts and cash flow statements
- Introduction to Financial Statement Analysis
- Auditing
- Capital Structure
- Payout Policy and its Interaction with Capital Structure
- Financial instruments and Long Term Financing
- Working Capital Management and Short-Term Financing
- Derivatives and Risk Management
- Investment Appraisal
- Cost of Capital and its relationship with the project value

Main bibliography

- Corporate Finance, Berk, J.; DeMarzo, P. 3rd ed., Pearson, 2015. 1104 pages. ISBN: 978-0273792024
- Introduction to Financial Accounting, Horngren; C. T., Sundem; G. L., Elliot, J. A.; Philbrick, D. 11th Edition. Pearson, 2014. 648 pages. ISBN: 978-0133251036
- International Financial Statement Analysis. Robinson, T. R.; Henry, E.; Pirie, W. L.; Broihahn, M. A.; Cope, A. T. 3th ed. Wiley, 2015. 1072 pages. ISBN: 978-1118999479
- A Risk Based-Approach to Conducting a Quality Audit, Johnstone, K.; Gramling. A.; Rittenberg, L. E., 10th ed., Cengage Learning, 2016. 960 pages. ISBN: 978-1305080577
- Accounting and finance for non-specialists. Atrill, P.; McLaney, E. 9th ed. Pearson, 2015. 600 pages. ISBN: 978-1292062716
- Fundamentals of financial management (concise edition). Brigham, E. F.; Houston, J. F. 8th ed. Cengage Learning, 2015. 688 pages. ISBN: 9781285065137
- How to understand the financial pages. Davidson, A. 2nd ed. Kogan Page, 2008. 384 pages. ISBN: 978-0749451448
- Interpreting company reports and accounts. Holmes, G.; Sugden, A.; Gee, P. 10th ed. 336 pages. FT Prentice Hall, 2008. ISBN: 978-0273711414

Teaching and assessment methodologies

The curricular unit will be taught by mean of theoretical-practical lectures using slides to underline the main points and using computer to solve some examples.
The assessment is based on an examination.

PROGRAMME

1. INTRODUCTION TO CORPORATE FINANCE
   - 1.1. Value Creation and the Theory of Agency
   - 1.2. The Types of Firms
   - 1.3. The Stock Market
   - 1.4. Financial Institutions
2. FINANCIAL ACCOUNTING
   - 2.1. Accounting: the Language of Business
   - 2.2. International Standards: IFRS and U.S. GAAP
   - 2.3. Accounting Mechanics
   - 2.4. Income Statement
   - 2.5. Balance Sheet
   - 2.6. Cash Flow Statement
   - 2.7. Intercorporate Investments and Consolidations
3. Financial Statement Analysis
   - 3.1. The Financial Analysis Process
   - 3.2. Analysis Tools and Techniques
   - 3.3. Common Ratios Used in Financial Analysis
   - 3.4. Equity Analysis
   - 3.5. Credit Analysis
4. Auditing
   - 4.1. Introduction
   - 4.2. The Risk of Fraud and Mechanisms to Address Fraud
   - 4.3. Professional Auditing Standards and the Audit Opinion Formulation Process
   - 4.4. Auditing Process
   - 4.5. Audit Reports on Financial Statements
5. Capital Structure
   - 5.1. In a Perfect Market
   - 5.2. Debt and Taxes (corporate and personal)
   - 5.3. Financial Distress, Managerial Incentives and Information
6. Payout Policy
   - 6.1. Dividends and Share Repurchases
   - 6.2. Dividends and Taxes
   - 6.3. Retain or Payout?
7. Financial instruments
   - 7.1. Long Term
   - 7.2. Short Term
8. Long-Term Financing
   - 8.1. Raising Equity Capital
   - 8.2. Debt Financing
   - 8.3. Leasing
9. Short-Term Financing
   - 9.1. Working Capital Management
   - 9.2. Short-Term Financial Planning
10. Derivatives and Risk Management
    - 10.1. Introduction to Options, Futures and Swaps
    - 10.2. Insurance
    - 10.3. Commodity Price Risk
    - 10.4. Exchange Rate Risk
    - 10.5. Interest Rate Risk

11. Investment Appraisal
    - 11.1. Investment Decision Rules
    - 11.2. Capital Budgeting
    - 11.3. Valuation and Leverage
12. Cost of Capital
    - 12.1. Measuring Risk and Return
    - 12.2. Portfolio Choice and CAPM
    - 12.3. Cost of Capital