Introduction to Financial Engineering (W1)

Module Handbook

1 Module Handbook

Module covers an Introduction to Finance and the statistical/mathematical methods used in Computational Finance. The syllabus is a mixture of:

1. Computation (mainly in R) and Numerical Algorithms
2. Finance
3. Applied Maths and Stats

The content is spread between Lectures and Computer Lab:

- Lectures are approximately 2 hours per week (they will be organized like seminars aiming to start and finish one topic per week).
- Computer Lab is approximately 1 hours per week, aiming to solve a problem sheet. There will be one problem sheet per week. Based on the number of students, assignments will required to be submitted per groups (this is to be announce at the beginning of the semester).
  - It is also recommended that you bring your own laptops to the Lab sessions.

In case the course is set in a way that lab working sheets are to be submitted in groups, each group will appoint a speaker which will be in charge to submit the homework via Campus Virtual (the rest of the group will not need to submit it). Any communication related to the homework activity to the professor will need to be send by the speaker of the group copying the rest of the team. You will not be able to modify team members after the first submission of the coursework.

: Evaluation

$$\max\left\{\underbrace{(0.7x+0.3y)\mathbb{1}_{\{x\geq 4, y\geq 3\}}}_{:=w}, (0.7x+0.3z)\mathbb{1}_{\{w<5\}}\right\}$$

where x is the qualification of the assignments, y is the qualification of the Final Exam and z is the qualification of the Recovery Exam.

2 Key Topics Covered

The main goal of the course is to show different applications of mathematical and statistics concepts in financial engineering. Therefore we will not redefine or prove known tools, but rather explore the application of those tools within a financial institution. Banks, Credit Entities, Insurance Companies or Investment offices are constantly looking for the specialized and highly quantitative profiles such as the ones from math and stats graduates.

From that point of view, the course will be organized as a walk through different departments and divisions in a credit entity which demand those profiles and we will show some examples of the techniques used and applied

in each case.

The syllabus is divided into 6 sections:

1. **Introduction to Math Finance**: A brief introduction to some financial concepts, markets and products. Basic definitions of interest rates together with capitalization and discounting laws. Derivation of the computation for a mortgage payment with French amortization.

    - *Key terms*: Interest rate, Capitalization, Discount Factor, Bond Price, Mortgage Payments

2. **Time Series**: Financial entities have the need to forecast and estimate macroeconomic data such as GDP, unemployment rate, house pricing, inflation rate, ... Medium to large companies have Macroeconomic Departments to develop inhouse models. In this section we will explore some of this macroeconomic series, specifically those that are stationary (or nearly) and review the construction of ARMA, ARCH and GARCH models to calibrate those data.

    - *Key terms*: Stationary Time Series, ARMA, ARCH, GARCH, Random Walk

3. **Stochastic Calculus**: Some entities are active players on financial markets and have extensive front offices that trade various financial products continuously as part of the hedging strategy or as part of a speculative activity. Therefore the knowledge of the price of those products are of key importance. In this section we will focus on building up a model to price vanilla options on equity.

    - *Key terms*: Vanila Options, Calls and Puts, Binomial Model, Brownian Motion, Monte Carlo methods

4. **Mathematical Optimization**: Some of the main activities of Financial Institutions are fiduciary management, as for example fund management. In this situation financial experts are asked to optimize a portfolio investment to minimize risk for a given expected return. Asset Management departments are in charge of this activity.

    - *Key terms*: Markowitz model, Optimization, Lagrange Multipliers, CAPM

5. **Probability**: Financial Institutions are ones of the most regulated industries and central banks supervise their activity in great detail. Over the last decades the different financial crises have result in an increase of regulation rules which ended up with the need to reinforce compliance and risk departments. Risk departments encapsulate most of this activity together with the mandate to monitor that the risk incurred by the activities of the entity are within the limits and appetite of the Board of Directors.

    - *Key terms*: Risk Estimation, VaR

6. **Financial Disasters**: Financial crisis seem to be inevitable and they appear cyclical, the aim of this section is to briefly dissect one of the largest and latest financial crisis linking some of the aspects which triggered it to concepts viewed during the course.

    - *Key terms*: Subprime financial crisis

3 Module Workflow

Reading book references will be given during the lecture sessions. A set of non comprehensive Lecture notes will be available, but it is expected that you will need to consult the given reference as well as other sources of information to fully complete coursework.

4 Assignments: Rules and Submission

- You may work in cooperation, but the solutions you submit must be entirely your own group (in case team work apply for coursework, this rule must be understood with respect to other groups).
- You must give citations for all sources that you use.
- All programs must be written in R (if not otherwise stated in the problem sheet).
- It is not acceptable to copy, modified or adapt someone else code and submit it as your own.
- Submissions must be via Campus Virtual.
- Submission files are specified in each problem sheet, but in general you will be asked to submit a source code (.r) and a answer sheet (.pdf).
- It is not acceptable to submit files in other extensions or zip format.
- You should keep a copy of everything you submit.
- It is not acceptable to submit assignments after the deadline.
- Fail in any of the above rules may lower your assignment score.

5 Final Remarks

Your code should compile without errors and should be properly commented. The accompanying write-up should be written as a report and should demonstrate that you understand the underlying theory. The aim of the write-up is to be a report answering the questions raised in the problem sheet using the output of your code (do not paste code in the write-up unless necessary). When using any of the build-in functions, tests or any other resource from R, specify in the write-up the hypothesis used and conclusion extracted contextualized with the problem setup.

As an example, you may be asked to check whether a certain distribution has zero mean or not. One possible answer is to use a t-test, in which case you will need to specify in the write-up that you are using a t-test, what are the null and alternative hypothesis and the result of the p-value together with the conclusion applied to the specific problem in hand.