

Financial Calculus in R

instructor: Paweł Kawa
lectures: 2h/week in a computer room
with a big blackboard

Course Goals. The course has two objectives. The first one is to get familiar with the main facilities of the R system such as a functional programming thinking style, comprehensive graphics producing possibilities, embedded data analysis tools as well as a vast collection of its free additional packages. The second goal is to get accustomed to some basic financial calculus notions and be able to implement them in R.

Prerequisites. Participants must have completed basic courses in Analysis I-III, Linear Algebra I-II, Probability Theory I and be familiar with standard programming language constructions such as variables, conditionals (if...then...else), loops (for ...), functions etc. The material covered during the summer semester on *Rynek finansowy i ubezpieczeniowy*, such as a concept of Financial Market, Indices, Securities, Markowitz Portfolio Model, CAPM, should be considered as a desired but not indispensable requirement.

Description. This course is designed mainly for students of the last year of Application of Mathematics. It begins with an introduction of necessary vocabulary concerning data structures. We get used to vectors, matrices, arrays, lists, data frames and learn how to work with them. We also deal with importing data from files, Excel worksheets, Internet and databases, generate lots of more-or-less random samples, use sequences and some functional programming concepts as vectorized arithmetical operations.

The next part of the course covers simple data analysis. We investigate heads, tails, summaries, histograms, stem-and-leaf plots, qqplots etc. More sophisticated methods are also mentioned here. Thus we learn how to modify data using mapping lists, manage missing values, query tables and finally cross-tabulate data with the `reshape` package.

In fact all the time we deal with a flock of graphical packages (`lattice`, `gplots`, `vioplot`, `plotrix`, `ggplot2`, ...) and learn how to visualize results of our data investigation.

By the end of this course we apply all these techniques to object-oriented programming and cook up some useful classes. Should we have more time, we can create a simple package. We also try to cooperate with external environments as PostgreSQL, C or Python.

While dealing with aspects of R we simultaneously acquire a financial calculus background. The scope of the this part of the course follows topics listed below:

- accumulation function, discounting;
- varying interest, force of interest;
- annuities, perpetuities, their rainbow versions;
- cash flow analysis, yield rates;
- amortization schedules, sinking funds;
- more complex loan constructions;
- bonds pricing;
- polish T-bills (*obligacje skarbowe*);
- duration and immunization;
- Markowitz model and efficient frontier;
- CAPM and market portfolio;
- arbitrage and simple option pricing models;
- binomial-tree models.

Having enough time we take a gander at a bundle of `rMetrics` packages, which can be considered as an educational software for financial engineering and computational finance.

Grading. The course grade will be based on bi-weekly homework and, if desired, announced short-quizes.

Bibliography.

- *The Theory of Interest*, Stephen Kellison;
- (small chops of) *Investment Analysis And Portfolio Management*, Reilly Brown;
- online R documentation <http://cran.r-project.org/doc/manuals/R-intro.pdf>;
- lots of online tutorials and packages descriptions, to be mentioned during the lecture.