Statistics for Financial Engineering
Refresher Seminar

Baruch College Financial Engineering Program

Times and location: August 4 – August 12, 2014
August 4, 5, 6, 7, 11, 12 (6 sessions), 6–9 pm.

Instructor: Radoš Radoičić
Coordinates: Office 6-254. Phone: 646-312-4169. email: rados.radoicic@baruch.cuny.edu

Location: Room 6-140, 6th floor of the Vertical Campus building at Lexington Avenue and 24th Street.

Textbooks:

(1) Ruppert, D., Statistics and Data Analysis for Financial Engineering, *Springer*, 2010.

Other reference books (in no particular order):

(1) DeGroot, M. H. and Schervish, M. J., Probability and Statistics, *Addison-Wesley*, 3rd edition, 2002.
(2) Kutner, M., Nachtsheim, C., and Neter, J., Applied Regression Models, *McGraw Hill/Irwin*, 4th edition, 2004.
(3) Hayashi, F., Econometrics, *Princeton University Press*, 2000.
(4) Tze Leung Lai and Haipeng Xing, Statistical Models and Methods for Financial Markets, *Springer*, 2008.
(5) Tsay, R. S., Analysis of Financial Time Series, *Wiley-Interscience*, 2nd edition, 2005.

Teaching Assistants: Ivan Matić will answer questions on QuantNet and grade your assignments. Email contact: *ivan.matic@baruch.cuny.edu*

Course Policy: Homework will be assigned every lecture and due the following lecture. You are encouraged to work on the homework with your colleagues, but everyone will submit individual homeworks. No late homeworks are accepted. An in–class **Final Test** will be given on Wednesday, August 13. The final exam will have two parts:
• R programming;
• pencil and paper.

Grading: The course is graded on a Pass/Fail basis. Sixty percent is needed to Pass the course.

Homeworks	60%
Final Exam	40%

Content: The seminar is a graduate-level introduction to statistical methods and models of importance to quantitative finance. It will provide basic background in statistics/econometrics, which includes multivariate regression, maximum likelihood estimation, statistical inference, re-sampling, principal component analysis (PCA), and the basic time series analysis. We will also describe applications of these methods to portfolio theory and dynamic models of asset returns and their volatilities. A useful by-product of this course is a thorough preparation for potential statistics interview questions, as well as for the MFE courses, such as MTH 9875, MTH 9891, MTH 9893, MTH 9894, and MTH 9895.

Detailed Syllabus

Lecture 1:

- Modeling important probability distributions: chi-squared, student t-, Fisher, heavy-tailed (Laplace, Pareto, mixture models), multivariate normal, Wishart distribution; skewness, kurtosis.
- Maximum likelihood estimators, Fisher information, asymptotic inference.
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Financial Applications:

- Exploratory analysis of returns data (histograms, kernel density estimation, order statistics, QQ-plots and box-plots, normality tests, data transformation).

Textbook Sections: Chapters 4, 5, 7, instructor's notes.

Lecture 2:

- Confidence intervals, hypothesis testing (t-, F-, likelihood ratio, Goodness-of-fit, independence tests, Kolmogorov-Smirnov tests).
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Financial Applications:

- Fitting univariate and multivariate distributions to financial data, analysis of the fit.

Textbook Sections: Chapters 4, 5, 7, instructor's notes.

Lecture 3:

- Linear regression: ordinary least squares (OLS).
- B(L)UE (Gauss-Markov).
- Joint distribution of estimators, confidence/prediction intervals, hypothesis testing.
- Cramer-Rao inequality.

Financial Applications:

- Regression with interest rate data: ANOVA, model selection, residual diagnostics, data collinearity, VIF, leverages, Cook's D, checking model assumptions.

Textbook Sections: Chapters 12, 13, instructor's notes.

Lecture 4:

- (Univariate) time series modeling: stationarity, (AR)(MA) models.
- Parameter estimation, forecasting, model selection.
- Non-stationarity (de-trending, differencing, unit-root tests, ARIMA).
- (P)ACF plots, seasonality, Box-Cox transformation.
- Multivariate time series.

Financial Applications:

- Systematic study of CPI, inflation, and log return data.

- Estimating default probabilities.

Textbook Sections: Chapters 9, 10, instructor's notes.

Lecture 5:

- Resampling/bootstrapping.
- Principal component analysis (PCA).
- Markowitz portfolio theory.
- Capital asset pricing model (CAPM).
- Factor models.

Financial Applications:

- Bootstrapping in regression models.
- PCA on yield curves.
- Global asset allocation problem.
- Efficient frontier, tangency portfolio and minimum variance portfolio using quadratic programming.
- Estimation of Beta, testing the CAPM model.
- Fitting the Fama-French model on equity return data.
- Estimation of the covariance matrix of asset returns.

Textbook Sections: Chapters 6, 11, 16, 17.

Lecture 6:

- Copulas: Gaussian, t-, Archimedean, Frank, Clayton, Gumbel; rank correlation; calibrating copulas.
- (E)(G)ARCH, ARMA-(E)GARCH, forecasting future returns and volatilities.

Financial Applications:

- Fitting copulas to returns data.
- Risk management: estimation of VaR and ES.

Textbook Sections: Chapters 8, 18, 19.