Statistics for Financial Engineering
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2010 Syllabus

This course aims to prepare students for the statistics demands of the MFE program and to give finance professionals basic statistical tools for analyzing and modeling financial data and problems. The course will be centered on risk management and valuation issues in finance. This is an intensive course with significant weekly assignments.

Session 1

- Histograms and frequency distributions
- Events and sampling spaces
- Random variables
- Tchebysheff's theorem
- Discrete and continuous probability distributions
  - Binomial, Poisson, normal, log-normal and exponential distributions and their financial applications
- Probability transforms
- Homework project
  - Does your vote count? Practical issues with computing extremely small probabilities
  - Modeling attrition in bond portfolios due to default contagion

Session 2

- Gamma, chi-squared, t- and F distributions
- Pricing as expectations
- Order statistics
- Probability plots
- Sampling distributions
- Point estimators and estimator accuracy
  - Mean and variance estimators – t-tests and F tests
- Maximum likelihood estimation
- Small sample estimation
- Homework project
  - Estimating accuracy of mean and variance in Monte Carlo simulation
  - Comparing two time series – how are they different?

Session 3

- Maximum likelihood estimation – Bayes postulate
- Moment generating functions and applications
- Hypothesis testing
  - Mean and variance of two populations
  - The Kolmogorov-Sminov test
- Correlation and association analysis
  - Measures of association
  - Joint distributions
  - Pearson and rank correlation – estimation accuracy issues
  - The covariance matrix – eigenvalues, estimation implications and positive definitness
- Homework project
  - Bond portfolio correlation structure
  - Mean and variance comparison of time series using HT

Session 4

- Kolmogorov-Smiornov test of distributions
- Time series modeling and analysis
  - Asset price modeling – efficient markets representation
  - Conditional and unconditional moments
- Autoregressive processes

Correlograms and the Yule-Walker equations
Moving average processes
ARMA processes
Identification issues

- Homework project
  Using the KS test to test the null hypothesis of normality in a time series
  Simulate and compute the correlogram of AR(2) and MA(2) processes

Session 5

- Heteroskedasticity modeling
  ARCH and GARCH modeling
  Option pricing under GARCH and its extensions
- One-dimensional linear regression
  Prediction
  Confidence intervals – extension to small samples
  Extensions to categorical variables
- Homework project
  Devising a two-stock investment strategy using linear regression

Session 6

- Introduction to ANOVA
  Coefficient of determination and correlation
  t-test and F-test equivalence
- Linear regression in multiple dimensions
  Least squares estimation
  The issue of linearity and basis functions
  Partial correlations and partial regressions
  Multidimensional ANOVA
  Importance of predictive variables
- Beyond linear correlation
  Correlation versus dependency
  Copula functions – the Gaussian copula
- Homework project
  Using copulas to model joint exposure to co-dependent defaultable obligors

Session 7

- Multicolineary issues
- Dimensionality in Finance
  Principal component analysis
  Factor analysis
- Time series co-integration
- Framing your statistical problem

In-class case critique of the uses and misuses of statistics:
The case of spending on public education

Rererence materials

Comprehensive notes will be provided, but the following references will be useful:

1. Mathematical Statistics and Data Analysis by John A. Rice (Duxbury Press)
2. Time Series Models by Andrew C. Harvey (MIT Press)
3. Numerical Recipes in C/C++ by William H. Press et al. (Cambridge University Press)

Requirements

Linear algebra and calculus.
Programming knowledge in a high level language (C,C++,VB) desirable but not essential
Working knowledge of Excel and its basic capabilties is essential

Grading criterion

Participants will be give a letter grade based on homework projets - there is no final exam