Prerequisites (no class)

References

- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Prerequisites

Lecture 1 – Statistics I

Contents

- Announcements and course overview
- Introduction to MATLAB
- Representations of distributions
  - Á Probability density function
  - Á Cumulative distribution function
  - Á Quantile
  - Á Characteristic function
- Monte Carlo simulations
  - Á Dirac delta and generalized functions
  - Á Glivenko-Cantelli theorem
  - Á Empirical distribution
  - Á Histograms and pdf
  - Á Empirical cdf
  - Á Empirical quantile by interpolation
- Distribution of transformations of random variables
  - Á Invertible transformations
  - Á Positive affine transformations
- Copula-marginal factorization
  - Á Marginal distributions
  - Á Grades
  - Á Copula representation via pdf and cdf
  - Á Copula representation via simulations
  - Á Co-monotonic random variables
  - Á Simulation of generic distributions via copula and quantile

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 1, 2.1, 2.2
- www.symmys.com Ą Book Ą Downloads Ą Technical Appendices
- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 1

Lecture 1' – MATLAB overview (taught by teaching assistant)

References

- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 1'

Lecture 2 – Statistics II

Contents

- Conditional distribution
  - Pdf representation
  - Bayes'rule
- Dependence and concordance summary statistics
  - Special copulas
  - Schweizer-Wolff measure
  - Kendall tau
  - Spearman rho
- Shape summary statistics
  - Affine equivariance of shape statistics
  - Expected value – covariance
  - Mode – modal dispersion
- Location-dispersion ellipsoid
  - Spectral theorem
  - Statistical interpretation
- Pearson correlation: theory, practice and pitfalls
- Taxonomy of multivariate distributions
  - Normal distribution
  - Cauchy distribution
  - Student t distribution
  - Log-distributions
  - Beta/uniform distribution
  - Wishart distribution
- Special classes of multivariate distributions
  - Order statistics
  - Elliptical distributions
  - Stable distributions
  - Infinitely divisible distributions
  - Discrete distributions (Bernoulli, Poisson)

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 2.3, 2.4, 2.5, 2.6, 2.7
- www.symmys.com → Book → Downloads → Technical Appendices
- www.symmys.com → Teaching → Courses → Support materials for Lecture 2

Lecture 3 – Market modeling I

Contents

- The quest for invariance: the random walk
  - Equities: log-returns
  - Fixed-income: changes in yield to maturity
  - Derivatives: changes in at-the-money implied volatility
- The quest for invariance: advanced dynamics in discrete time
  - Autocorrelation and AR(1) processes
  - ARMA processes and Wold's theorem
  - Long memory: fractional integration
  - Volatility clustering: GARCH
- The quest for invariance: advanced dynamics in continuous time
  - Random walk and Levy processes
  - Autocorrelation and Ornstein-Uhlenbeck process
  - Long memory: fractional Brownian motion
  - Volatility clustering: stochastic volatility models
  - Volatility clustering: autocorrelated subordination

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 3.1
- www.symmys.com Book Downloads Technical Appendices
- www.symmys.com Teaching Courses Support materials for Lecture 3

Lecture 4 – Market modeling II

Contents

- The quest for invariance: the multivariate case
  - Multivariate Ornstein-Uhlenbeck process
  - Multivariate dynamics and cointegration
  - Foundations of statistical arbitrage
- Dimension reduction, theory:
  - Generalized r-square
  - Explicit factors models
  - Implicit factors models: principal component analysis
  - Implicit factors models: diagonal residuals
  - Implicit factors models: constrained loadings
- Dimension reduction, explicit factors examples
  - Capital Asset Pricing Model
  - Arbitrage Pricing Theory
  - Fama-French factors
- Dimension reduction, implicit factors examples
  - Principal component analysis of the swap market
  - Level-slope-butterfly interpretation of the components
  - Continuum limit: Fourier basis and main frequencies

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 3.4 3.5
- www.symmys.com Book Downloads Technical Appendices
- www.symmys.com Teaching Courses Support materials for Lecture 4

Lecture 5 – Estimation I

Contents

- Estimators
  - General definitions
  - Evaluation: bias, inefficiency, error
  - Stress-testing
  - Generalized p-values, generalized t-statistics
- Multivariate non-parametric estimators
  - Sample quantile and order statistics.
  - Sample mean/covariance and best-fitting ellipsoid
  - Sample factor loadings (betas) and OLS
- Multivariate maximum-likelihood estimators
  - Normal hypothesis: sample estimators
  - Non-normal hypothesis: outlier rejection
  - Non-normal hypothesis: generalized p-values and t-statistics

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 4.1, 4.2, 4.3
- www.symmys.com → Book → Downloads → Technical Appendices
- www.symmys.com → Teaching → Courses → Support materials for Lecture 5

Lecture 6 – Estimation II

Contents

- Shrinkage estimators
  - Stein mean
  - Ledoit-Wolf covariance
- Robust estimators
  - Assessing robustness: the influence function
  - Huber's "M" robust estimators: location, scatter and betas
  - Outlier detection and high-breakdown estimators
  - Minimum-volume ellipsoid and minimum-covariance determinant
- Missing data

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 4.4, 4.5, 4.6
- www.symmys.com → Book → Downloads → Technical Appendices
- www.symmys.com → Teaching → Courses → Support materials for Lecture 6

Lecture 7 – Risk management I

Contents

- Projection of invariants to the investment horizon
  - Random walk analytical projection: convolution
  - Random walk numerical projection: FFT
  - General projection: simulations
- Pricing of invariants at the investment horizon
  - Exact analytical: log-distributions for raw securities
  - Exact numerical: scenario pricing (Monte Carlo/historical)
  - Taylor approximation: theta-delta/vega-gamma
  - Taylor approximation: carry-duration-convexity

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch.3.2, 3.3
- www.symmys.com → Book → Downloads → Technical Appendices
- www.symmys.com → Teaching → Courses → Support materials for Lecture 7

Lecture 8 – Risk management II

Contents

- Investor's objectives
  - Total return
  - Benchmark allocation
  - Net profits
- Global evaluation of a portfolio: stochastic dominance
- Summary evaluation of a portfolio: indices of satisfaction
  - Consistence with stochastic dominance
  - Positive homogeneity and Euler's identity
  - Risk aversion, risk propensity and risk neutrality
  - Concavity, convexity and sub-/super-additivity
  - Co-monotonic additivity
  - Other properties
- Non-dimensional indices
  - Sharpe ratio
  - Omega
  - Sortino ratio
  - Kappa
- Expected utility and certainty-equivalent
  - Properties
  - Analytical solutions: mean-variance as satisfaction
  - Numerical solutions

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 5.1, 5.2, 5.3, 5.4
- www.symmys.com → Book → Downloads → Technical Appendices
- www.symmys.com → Teaching → Courses → Support materials for Lecture 8

Lecture 9 – Risk management III

Contents

- Quantiles and value at risk (VaR)
  - Á Properties
  - Á Semi-analytical solutions in elliptical markets
  - Á Cornish-Fisher approximation
  - Á Extreme value theory (EVT)
  - Á Numerical solutions
  - Á Contribution to VaR from securities/factors
- Coherent measures of performance
  - Á Expected shortfall (ES) and conditional value at risk (CVaR)
  - Á Contribution to ES from securities/factors
  - Á Spectral measures of performance

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 5.5, 5.6
- www.symmys.com Ą Book Ą Downloads Ą Technical Appendices
- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 9

Lecture 10 – Portfolio management I

Contents

- Constrained optimization: computationally tractable problems
  - Á Linear and quadratic programming
  - Á Second order and semi-definite cone programming
- Two-step heuristics
  - Á Analytical mean-variance: two-fund theorem
  - Á Numerical mean-variance: quadratic programming
  - Á Mean-CVaR and alternative trade-offs

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 6.1, 6.2, 6.3, 6.4
- www.symmys.com Ą Book Ą Downloads Ą Technical Appendices
- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 10

Lecture 11 – Portfolio management II

Contents

- Benchmark vs. total-return portfolio management
  - Á Expected outperformance, tracking error, information ratio
  - Á Analytical mean-variance solutions in total-return coordinates
  - Á Analytical mean-variance solutions in relative-return coordinates
- Pitfalls of the mean-variance approach

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 6.5, 6.6, 6.7
- www.symmys.com Ą Book Ą Downloads Ą Technical Appendices
- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 11

Lecture 12 – Portfolio management III

Contents

- Estimation risk: allocation as a decision
  - Á Opportunity cost as loss of an estimator
  - Á Stress testing
- Simple allocation techniques
  - Á Prior allocation and high efficiency
  - Á Sample-based allocation: unbiasedness and leverage of estimation error
- Robust allocation
  - Á Box uncertainty sets
  - Á Elliptical uncertainty sets (second-order cone programming)

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 8.1, 8.2, 8.3, 9.4
- www.symmys.com Ą Book Ą Downloads Ą Technical Appendices
- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 12

Lecture 13 – Portfolio management IV

Contents

- Multivariate Bayesian estimation
  - Á Theoretical background
  - Á Analytical solutions: Normal-Inverse Wishart model
  - Á Numerical solutions: Monte Carlo Markov Chains
- Bayesian allocation
  - Á Predictive return allocation
  - Á Classical-equivalent allocation

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 7, 9.1
- www.symmys.com Ą Book Ą Downloads Ą Technical Appendices
- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 13

Lecture 14 – Portfolio management V

Contents

- Black-Litterman allocation
  - Views on market parameters
  - Views on the market realizations
  - Black-Litterman for derivatives
- Beyond Black-Litterman
  - Non-normal markets
  - Non-linear views
  - Generalized stress-testing
  - Ranking allocation

References

- A. Meucci, *Risk and Asset Allocation* – Springer: Ch. 9.2
- www.symmys.com Ą Book Ą Downloads Ą Technical Appendices
- www.symmys.com Ą Teaching Ą Courses Ą Support materials for Lecture 14
- www.symmys.com Ą Research Ą Working Papers Ą
  - *The Black-Litterman Approach: Original Model and Extensions*
  - *Enhancing the Black-Litterman and Related Approaches: Views and Stress-Test on Risk Factors*
  - *Fully Flexible Views: Theory and Practice*