



## Lecture 1 – 09/11/06: introduction

### Contents

- Course overview
- Introduction to MATLAB
  - Set path and work from command window
  - Generate scripts
  - Generate functions
  - Debug
  - Plot 2D (lines, scatter plots, histograms)
  - Plot 3D (surfaces, histograms)
- Representations of univariate distributions
  - Probability density function
  - Cumulative distribution function
  - Quantile
  - Characteristic function
- Monte Carlo simulations
  - Dirac delta and generalized functions
  - Empirical distribution
  - Histograms and pdf
  - Empirical cdf
  - Empirical quantile by interpolation
- Distribution of transformations of random variables
  - Invertible transformations
  - Positive affine transformations
- Summary statistics:
  - Location
  - Dispersion
  - Higher moments
- Taxonomy of univariate distributions
  - Uniform distribution
  - Normal/Cauchy/ Student t distributions
  - Gamma distribution
  - Lognormal distribution

### References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:
  - (!): Preface, 1.1->1.3, 4.2 p.178-179, B.1, B.2
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:
  - (!): 1.1->1.4, 1.6; (?) : 1.5
- (!): Support material for Lecture 1 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 2 – 09/18/06: multivariate statistics I

### Contents

- Representations of multivariate distributions
  - Probability density function
  - Cumulative distribution function
  - Characteristic function
  - Simulations and empirical distribution
- Conditional distribution and independence
- Copula-marginal factorization
  - Marginals as histograms
  - Grades
  - Copula representation via pdf and cdf
  - Co-monotonic random variables
  - Copula simulation
- Dependence and concordance summary statistics
  - Special copulas
  - Schweizer-Wolff measure
  - Kendall tau
  - Spearman rho
- Simulation of generic distributions via copula and quantile

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:
  - (!): 2.1->2.3, 2.5
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:
  - (!): wherever cited above; (?) : otherwise
- (!): Support material for Lecture 2 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 3 – 09/25/06: multivariate statistics II

### Contents

- 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
  - Uniform distribution
  - Wishart distribution

### References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!): 2.4, 2.6, A.4, A.5; (?): A.1-> A.3
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 3 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 4 – 10/02/06: market modeling I

### Contents

- Special classes of multivariate distributions
  - Order statistics
  - Elliptical distributions
  - Stable distributions
  - Infinitely divisible distributions
- The quest for invariance
  - Equities: log-returns
  - Fixed-income: changes in yield to maturity
  - Derivatives: changes in at-the-money implied volatility

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!): 2.6.8->2.7; 3.1
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 4 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 5 – 10/16/06: market modeling II

### Contents

- Projection of invariants to the investment horizon
  - Convolution
  - Fourier transform
  - Analytical projection: characteristic function
  - Numerical projection: FFT
- Pricing of invariants at the investment horizon
  - Analytical: log-distributions for raw securities
  - Numerical: Monte Carlo
  - Approximate: theta-delta/vega-gamma
  - Approximate: carry-duration-convexity

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!): B3, B4, 3.2, 3.3
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 5 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 6 – 10/23/06: market modeling III

### Contents

- Dimension reduction, theory:
  - Multivariate market betas
  - Principal component analysis
- Dimension reduction, notable examples
  - Capital Asset Pricing Model
  - Arbitrage Pricing Theory
  - Fama-French factors
- Principal component analysis of the swap market
  - Level-slope-butterfly interpretation of the components
  - Continuum limit: Fourier basis and main frequencies

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:
  - (!): A.1->A.5, 3.4, 3.5
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:
  - (!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 6 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 7 – 10/30/06: estimation I

### Contents

- Estimators
  - general definitions
  - evaluation: bias, inefficiency, error
- Non-parametric estimators
  - Sample quantile and order statistics.
  - Sample mean/covariance and best-fitting ellipsoid
  - Sample factor loadings (betas) and OLS

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:
  - (!): 4.1, 4.2
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:
  - (!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 7 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 8 – 11/06/06: estimation II

### Contents

- Maximum-likelihood estimators
  - Normal hypothesis: sample estimators
  - Non-normal hypothesis: outlier rejection
- Shrinkage estimators
  - Stein mean
  - Ledoit-Wolf covariance

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!); 4.3, 4.4
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 8 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 9 – 11/13/06: estimation III

### Contents

- 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: the EM algorithm

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!): 4.5, 4.6
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 9 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 10 – 11/20/06: portfolio evaluation I

### Contents

- Multivariate Bayesian estimation
  - Theoretical background
  - Analytical solutions: Normal-Inverse Wishart model
- Investor's objectives
  - Total return
  - Benchmark allocation
  - Net profits

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!): 7.1->7.4, 5.1
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 10 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 11 – 11/22/06: portfolio evaluation II

### Contents

- Global evaluation of a portfolio: stochastic dominance
- Summary evaluation of a portfolio: indices of satisfaction
  - Money-equivalence
  - Estimability
  - Sensibility
  - Consistence with stochastic dominance
  - Constancy
  - Positive homogeneity
  - Translation invariance
  - Sub- and super-additivity
  - Co-monotonic additivity
  - Concavity and convexity
  - Risk aversion, risk propensity and risk neutrality
- Expected utility and certainty-equivalent

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!): 5.2->5.4
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 11 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 12 – 11/27/06: portfolio evaluation III

### Contents

- Quantiles and value at risk (VaR)
  - Main properties
  - Analytical computation
  - Numerical computation
  - Marginal contributions to VaR
- Coherent measures of performance
  - Expected shortfall (ES) and conditional value at risk (CVaR)
  - Spectral measures of performance
  - Main properties
  - Analytical computation
  - Numerical computation
  - Marginal contributions to ES
- Extreme value theory (EVT)
- Cornish Fisher expansion

### References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:
  - (!): 5.5, 5.6
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:
  - (!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 12 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 13 – 12/04/06: portfolio optimization I

### Contents

- Portfolio optimization theory
  - Investor's inputs: market, investment horizon, objectives and satisfaction
  - Market inputs: distribution of prices at the horizon, transaction costs
- Constrained optimization: computationally tractable problems
  - Linear and quadratic programming
  - Second order and semi-definite cone programming
- Two-step optimization
  - Analytical solutions
  - Numerical solutions
- Benchmark vs. total-return portfolio management
  - Mean-variance approximation
  - Analytical solutions in total-return coordinates
  - Analytical solutions in relative-return coordinates:  
expected outperformance, tracking error, information ratio
- Pitfalls of the mean-variance approach

### References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:  
(!):, 6.1->6.4, 6.7 6.5, 6.6
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:  
(!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 13 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com

## Lecture 14 – 12/11/06: portfolio optimization II

### Contents

- Allocations as decisions
  - Opportunity cost
  - Allocation decisions evaluated as estimators
- Prior allocation
- Sample-based allocation
  - Error in satisfaction and constraint assessment
  - Leverage of estimation risk
- Bayesian allocation
  - Predictive return allocation
  - Classical-equivalent allocation
- Black-Litterman allocation
  - Views on market parameters
  - Views on the market realizations
- Copula-opinion pooling allocation
- Resampled allocation
- Robust allocation
  - Second-order cone programming problems
  - Semi-definite programming problems
- Robust Bayesian allocation

References: (!) = required, (?) = optional

- A. Meucci, *Risk and Asset Allocation* – Springer:
  - (!): 8.1 -> 9.5
- A. Meucci, *Risk and Asset Allocation, Technical Appendices* – symmys.com:
  - (!): wherever cited above; (?): otherwise
- (!): Support material for Lecture 14 – symmys.com
- (?): A. Meucci, *Risk and Asset Allocation, Exercise Book* – symmys.com