Data Science for Finance | Financial Engineering for Investment | Quantitative Risk Management | Quantitative Portfolio Management

Week 1

Lectures contents

1. Introduction

About the ARPM Lab

About quantitative finance: P and Q

Notation

Executive summary

2. The Checklist: Step 1 - Risk drivers identification

Risk drivers identification

Equities

Currencies

Fixed-income

Derivatives

Credit

Strategies

Schedule

Mon, Sep 23	Lecture 1
Tue, Sep 24	Lecture 2
Wed, Sep 25	Lecture 2
Thu, Sep 26	Homework
Fri, Sep 27	Class
Sun, Sep 29	Homework submission deadline

Week 2

Lectures contents

3. The Checklist: Step 2 - Quest for invariance (univariate)

Quest for invariance

Simple tests

Efficiency: random walk

AR(1)

Mean-reversion (continuous state): ARMA

Mean-reversion (discrete state): Markov chains

4. Distributions

Representations of a distribution

Elliptical distributions

Scenario-probability distributions

Mixture distributions

Exponential family distributions

Schedule

Mon, Sep 30	Lecture 3
Tue, Oct 1	Lecture 4
Wed, Oct 2	Lecture 4
Thu, Oct 3	Homework
Fri, Oct 4	Class
Sun, Oct 6	Homework submission deadline

Week 3

Lectures contents

5. Location and dispersion

Expectation and variance

Expectation and covariance

Generalized location-dispersion: affine equivariance

6. Copulas

Copulas

Univariate results

Definition and properties of copulas

Special classes of copulas

Implementation

7. The Checklist: Step 2 - Quest for invariance (multivariate)

VAR(1)

Multivariate quest

Cointegration

Relationships among processes

Schedule

Mon, Oct 7	Lecture 5
Tue, Oct 8	Lecture 6
Wed, Oct 9	Lecture 7
Thu, Oct 10	Homework
Fri, Oct 11	Class
Sun, Oct 13	Homework submission deadline

Week 4

Lectures contents

8a. The Checklist: Step 3 - Estimation

Estimation

Setting the flexible probabilities

Historical

Maximum likelihood

Missing data

Robustness

(Dynamic) copula-marginal

8b. The Checklist: Step 3 - Estimation / model risk

Bayesian

Shrinkage

Probabilistic prediction assessment for invariants

Schedule

Mon, Oct 14	Lecture 8a
Tue, Oct 15	Lecture 8a
Wed, Oct 16	Lecture 8b
Thu, Oct 17	Homework
Fri, Oct 18	Class
Sun, Oct 20	Homework submission deadline

Week 5

Lectures contents

9. Linear factor models: foundations

Executive summary

Overview

Regression LFM's

Principal component LFM's

Systematic-idiosyncratic LFM's

Cross-sectional LFM's

10. Linear factor models: estimation

Overview

Factor selection for regression

Truncation

11. Linear factor models: applications

Capital asset pricing model framework

Application: principal component analysis of the yield curve

Cross-sectional structure of the yield curve covariance

Finite set of times to maturity

The continuum limit

Schedule

Mon, Oct 21	Lecture 9
Tue, Oct 22	Lecture 9
Wed, Oct 23	Lecture 10, 11
Thu, Oct 24	Homework
Fri, Oct 25	Class
Sun, Oct 27	Homework submission deadline

Week 6

Lectures contents

12. Machine learning foundations

Machine learning: foundations

Key ideas from linear factor models

Key concepts for machine learning

Supervised point prediction: regression

Supervised point prediction: classification

13. Machine learning: estimation

Machine learning: estimation

Probabilistic linear state space models

Probabilistic state space models

Schedule

Mon, Oct 28	Lecture 12
Tue, Oct 29	Lecture 13
Wed, Oct 30	Homework
Thu, Oct 31	Class
Fri, Nov 1	-
Sun, Nov 3	Homework submission deadline

Week 7

Lectures contents

14. Machine learning: enhancements

Bias versus variance

Feature engineering

Gradient boosting

Regularization

Ensemble learning

15. Machine learning application: regression

From probabilistic regression to Gaussian processes

Time series models

Maximum likelihood

Bayesian

Mixed approach

16. Machine learning application: credit default classification

Application: credit default classification

Background

Fit and assessment

Logistic regression

Interactions

Encoding

Regularization

Trees

Schedule

Mon, Nov 4	Lecture 14
Tue, Nov 5	Lecture 15
Wed, Nov 6	Lecture 16
Thu, Nov 7	Homework
Fri, Nov 8	Class
Sun, Nov 10	Homework submission deadline

Week 8

Lectures contents

17. The Checklist: Step 4 - Projection

Projection

One-step historical projection

Univariate analytical projection

Efficiency: Lévy processes

Ornstein-Uhlenbeck

Mean-reversion (continuous state)

Mean-reversion (discrete state)

Volatility clustering

Multivariate analytical projection

Multivariate Ornstein-Uhlenbeck

Monte Carlo

Application: multivariate Markov chains

Historical

Square-root rule and generalizations

Schedule

Mon, Nov 11	Lecture 17
Tue, Nov 12	Lecture 17
Wed, Nov 13	Lecture 17
Thu, Nov 14	Homework
Fri, Nov 15	Class
Sun, Nov 17	Homework submission deadline

Week 9

Lectures contents

18. The Checklist: Step 5 - Pricing at the horizon

Pricing at the horizon

Exact repricing

Carry

Taylor approximations

Hybrid Taylor/repricing approximation

19. The Checklist: Step 6 - Aggregation

Aggregation

Stock variables

Holding P&L of a portfolio

Returns

Excess performance

Static market/credit risk

Dynamic market/credit risk

Stress-testing

Enterprise risk management

Schedule

Mon, Nov 18	Lecture 18
Tue, Nov 19	Lecture 18
Wed, Nov 20	Lecture 19
Thu, Nov 21	Homework
Fri, Nov 22	Class
Sun, Nov 24	Homework submission deadline

Week 10

Lectures contents

20. The Checklist: Step 7 - Ex-ante evaluation

Ex-ante evaluation

Stochastic dominance

Satisfaction/risk measures

Mean-variance trade-off

Expected utility and certainty-equivalent

Quantile (value at risk)

Spectral satisfaction measures/Distortion expectations

Coherent satisfaction measures

Non-dimensional ratios

21. The Checklist: Step 8a - Ex-ante attribution: performance

Ex-ante attribution: performance

Bottom-up exposures

Top-down exposures: factors on demand

Application: hedging

22. The Checklist: Step 8b - Ex-ante attribution: risk

Ex-ante attribution: risk

General criteria

Homogenous measures and Euler decomposition

Schedule

Mon, Nov 25	Lecture 20
Tue, Nov 26	Lecture 21
Wed, Nov 27	Lecture 22
Thu, Nov 28	Homework
Fri, Nov 29	Class
Sun, Dec 1	Homework submission deadline

Week 11

Lectures contents

23. The Checklist: Step 9a - Construction: portfolio optimization

Construction: portfolio optimization

Optimization primer

Convex programming

Integer n-choose-k selection

The general framework

A compromise: two-step mean-variance

Analytical solutions of the mean-variance problem

Allocation (=output) uncertainty: Robust allocation

Minimum-torsion bets attribution of variance

Schedule

Mon, Dec 2	Lecture 23
Tue, Dec 3	Lecture 23
Wed, Dec 4	Lecture 23
Thu, Dec 5	Homework
Fri, Dec 6	Class
Sun, Dec 8	Homework submission deadline

Week 12

Lectures contents

24. Black-Litterman

Black-Litterman

Equilibrium prior distribution

Active views

Posterior distribution

Limit cases

Generalizations

25. Views processing

Views processing

Minimum relative entropy

Analytical implementation

26. Signals

Signals

Carry signals

Value signals

Technical signals

Microstructure signals

Fundamental and other signals

Signal processing

Schedule

Mon, Dec 9	Lecture 24
Tue, Dec 10	Lecture 25
Wed, Dec 11	Lecture 26
Thu, Dec 12	Homework
Fri, Dec 13	Class
Sun, Dec 15	Homework submission deadline

Week 13

Lectures contents

27. The Checklist: Step 9b - Construction: cross-sectional strategies

Construction: cross-sectional strategies

Simplistic portfolio construction

Advanced portfolio construction

Relationship with FLAM and APT

Multiple portfolios

Points of interest, pitfalls, practical tips

28. The Checklist: Step 9c - Construction: times series strategies

Construction: time series strategies

The market

Expected utility maximization

Option based portfolio insurance

Rolling horizon heuristics

Signal induced strategy

29. The Checklist: Step 10 - Execution

Execution

High frequency

Market impact modeling

Order scheduling

Order placement

Schedule

Mon, Dec 16	Lecture 27
Tue, Dec 17	Lecture 28
Wed, Dec 18	Lecture 29
Thu, Dec 19	Homework
Fri, Dec 20	Class
Sun, Dec 22	Homework submission deadline