














Program: MASTER OF SCIENCE IN FINANCE AND BANKING

Course: Advanced Topics in Finance and Insurance



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Year: 2024




Week 1

Macro topics	Theory	Video lectures
Introduction	About the ARPM Lab	
Introduction	Notation	
Linear algebra primer	Vector spaces	 (theory)
Linear algebra primer	Linear transformations	 (theory)
Linear algebra primer	Spectral decomposition	 (theory)
Linear algebra primer	Metric and normed spaces	 (theory)
Linear algebra primer	Inner product spaces	 (theory)
Linear algebra primer	Matrix transpose-square-root	 (theory)
Linear algebra primer	Matrix operations	 (theory)
Calculus	Differentiation	 (theory)
Calculus	Discrete derivatives	 (theory)
Calculus	Taylor expansion	 (theory)
Calculus	Integration	 (theory)
Calculus	Monotone functions	 (theory)
Calculus	Convexity	 (theory)
Functional analysis	Function spaces	
Functional analysis	L2 spaces	
Functional analysis	Spectral theorem	
Selected homework	Determinant, eigenvalues, and inverse matrix	
	Length, distance and angle	
	Concavity and Hessian matrix	
	Matrix calculus	



Week 2

Macro topics	Theory	Video lectures
Introduction	P versus Q	
Introduction	Summary: “Quantitative Finance checklist”	 (theory)
The Checklist: Step 1 - Risk drivers identification	Risk drivers identification	
The Checklist: Step 1 - Risk drivers identification	Equities	
The Checklist: Step 1 - Risk drivers identification	Currencies	
The Checklist: Step 1 - Risk drivers identification	Fixed-income	
The Checklist: Step 1 - Risk drivers identification	Derivatives	
The Checklist: Step 1 - Risk drivers identification	Credit	
The Checklist: Step 1 - Risk drivers identification	Strategies	
Applications	Quantitative finance: the “Checklist”	
Applications	Step 1. Risk drivers identification - Historical	
Applications	Step 1. Risk drivers identification - Monte Carlo	 (practice)
Selected homework	The Checklist: executive summary overview 2	
	Fixed-income risk drivers: value vs yield	
	Fixed-income risk drivers: alternative representations	
	Call option risk drivers	


Week 3

Macro topics	Theory	Video lectures
Dynamic models	Linear state space models	
The Checklist: Step 2 - Quest for invariance	Quest for invariance	 (theory)
The Checklist: Step 2 - Quest for invariance	Simple tests	
The Checklist: Step 2 - Quest for invariance	Efficiency	
The Checklist: Step 2 - Quest for invariance	Mean-reversion - fast decaying autocorrelation	
The Checklist: Step 2 - Quest for invariance	Discrete state transitions	
The Checklist: Step 2 - Quest for invariance	Volatility clustering	
Applications	Step 2. Quest for invariance - Historical	
Applications	Step 2. Quest for invariance - Monte Carlo	 (practice)
Distributions	Distributions	 (theory)
Distributions	Normal	
Distributions	Lognormal	
Distributions	Quadratic normal	
Distributions	Elliptical distributions	
Distributions	Scenario-probability	
Distributions	Exponential family	
Distributions	Mixtures	
Selected homework	Efficiency: random walk	
	Yield to maturity and autocorrelation	
	Volatility clustering	
	Scenario-probability distributions	



Week 4

Macro topics	Theory	Video lectures
Location and dispersion	Expectation and variance	 (theory)
Location and dispersion	Environment: mean-covariance	
Location and dispersion	L2 spaces of random variables	
Location and dispersion	Affine equivariance	
Location and dispersion	Variational principles	
Copulas	Grades and inverse sampling	
Copulas	Definition of copulas	
Copulas	Properties of copulas	
Copulas	Elliptical copulas	
Copulas	Implementation	
The Checklist: Step 2 - Quest for invariance	Multivariate quest	 (theory)
The Checklist: Step 2 - Quest for invariance	Vector autoregression of order one	
The Checklist: Step 2 - Quest for invariance	Cointegration	
Selected homework	Mean-covariance: visualization	
	Definition and properties of copulas	
	Copula-marginal implementation	
	Cointegration	








Week 5

Macro topics	Theory	Video lectures
The Checklist: Step 3 - Estimation	Estimation	 (practice)
The Checklist: Step 3 - Estimation	Flexible probabilities	
The Checklist: Step 3 - Estimation	Historical estimation	
The Checklist: Step 3 - Estimation	Maximum likelihood estimation	
The Checklist: Step 3 - Estimation	Robustness	
The Checklist: Step 3 - Estimation	(Dynamic) copula-marginal	
The Checklist: Step 3 - Estimation	Missing data	
The Checklist: Step 3 - Estimation	Shrinkage	
Applications	Step 3. Estimation - Historical	
Applications	Step 3. Estimation - Monte Carlo	
Selected homework	Historical estimation with flexible probabilities	
	Step 3: Estimation	
	(Dynamic) copula-marginal	
	Maximum likelihood with flexible probabilities	





Week 6

Macro topics	Theory	Video lectures
Linear factor models	Definitions	 (theory)
Linear factor models	Linear least squares regression	
Linear factor models	Principal component models	
Linear factor models	Factor-analysis models	
Linear factor models	Cross-sectional models	
Linear factor models	Finite set of times to maturity	
Linear factor models	Capital asset pricing framework	 (theory)
Selected homework	Linear factor models: theory Regression linear factor model for stock returns Cross-sectional linear factor models: systematic-idiosyncratic assumption Factor analysis linear factor models: loadings and factors	






Week 7

Macro topics	Theory	Video lectures
Machine learning foundations	Approaches to machine learning	 (theory)
Machine learning foundations	Prediction	
Machine learning foundations	Learning and inference	
Supervised learning: regression	Point least squares regression	
Supervised learning: regression	Point non-least squares regression	 (theory)
Supervised learning: classification	Point binary classification	 (theory)
Unsupervised learning	Least squares autoencoders	
Unsupervised learning	Unsupervised learning: graphical models	 (theory)
Applications	Machine learning for hedging	 (practice)
Applications	Least squares regression	 (practice)
Applications	Least absolute distance regression	 (practice)
Selected homework	Discriminative versus generative prediction Supervised point prediction: mean regression Unsupervised autoencoders: k-means clustering Receiver operating characteristic (ROC)	







Week 8

Macro topics	Theory	Video lectures
Estimation and assessment	Estimators as decisions	 (theory)
Estimation and assessment	Regularization: factors selection	
Estimation and assessment	Bayesian	
Estimation and assessment	Ensemble learning	
Estimation and assessment	Credit default classification	
Dynamic models	Spectral representation	 (theory)
Dynamic models	Linear state-space models	 (theory)
The Checklist: Step 4 - Projection	Step 4: Projection	 (theory)
The Checklist: Step 4 - Projection	One-step historical projection	
The Checklist: Step 4 - Projection	Lévy processes	
The Checklist: Step 4 - Projection	Markov chains	
The Checklist: Step 4 - Projection	Multivariate analytical projection	
The Checklist: Step 4 - Projection	Monte Carlo	
The Checklist: Step 4 - Projection	Application to credit risk	
The Checklist: Step 4 - Projection	Historical	
Selected homework	Probabilistic regression: Bayesian estimation	
	Linear state-space models	
	One-step historical projection	
	Monte Carlo projection and historical bootstrapping	






Week 9

Macro topics	Theory	Video lectures
The Checklist: Step 5 - Pricing at the horizon	Step 5: Repricing	 (theory)
The Checklist: Step 5 - Pricing at the horizon	Exact repricing	
The Checklist: Step 5 - Pricing at the horizon	Taylor approximations	
Applications	Step 4: Projection	
Applications	Step 4: Projection	 (practice)
Applications	Step 5: Repricing	
Applications	Step 5: Repricing	 (practice)
The Checklist: Step 6 - Aggregation	Step 6: Aggregation	 (theory)
The Checklist: Step 6 - Aggregation	Portfolio exposure	
The Checklist: Step 6 - Aggregation	Holding P&L of a portfolio	
The Checklist: Step 6 - Aggregation	Returns	
The Checklist: Step 6 - Aggregation	Static market/credit risk	 (theory)
The Checklist: Step 6 - Aggregation	Dynamic market/credit risk	
The Checklist: Step 6 - Aggregation	Stress-testing	
The Checklist: Step 6 - Aggregation	Enterprise risk management	
Selected homework	Exact repricing: derivatives	
	Taylor repricing: fixed income	
	Aggregation: overview	
	Aggregation: scenario-probability distribution	



Week 10

Macro topics	Theory	Video lectures
The Checklist: Step 7 - Ex-ante evaluation	Step 7: Ex-ante evaluation	 (theory)
The Checklist: Step 7 - Ex-ante evaluation	Stochastic dominance	
The Checklist: Step 7 - Ex-ante evaluation	Satisfaction/risk measures	
The Checklist: Step 7 - Ex-ante evaluation	Mean-variance trade-off	
The Checklist: Step 7 - Ex-ante evaluation	Expected utility and certainty-equivalent	
The Checklist: Step 7 - Ex-ante evaluation	Value at Risk and quantile	 (theory)
The Checklist: Step 7 - Ex-ante evaluation	Spectral/distortion satisfaction measures	
The Checklist: Step 7 - Ex-ante evaluation	Coherent satisfaction measures	
The Checklist: Step 7 - Ex-ante evaluation	Non-dimensional ratios	
Applications	Step 6: Aggregation	 (practice)
Applications	Step 6: Aggregation	
Applications	Step 7: Ex-ante evaluation	 (practice)
Applications	Step 7: Ex-ante evaluation	
The Checklist: Ex-ante attribution: performance	Step 8a: Ex-ante performance attribution	 (theory)
The Checklist: Ex-ante attribution: performance	Bottom-up exposures	
The Checklist: Ex-ante attribution: performance	Top-down exposures: factors on demand	
The Checklist: Ex-ante attribution: performance	Application: hedging	
The Checklist: Step 8b - Ex-ante attribution: risk	Step 8b: Ex-ante risk attribution	 (theory)
The Checklist: Step 8b - Ex-ante attribution: risk	General criteria	
The Checklist: Step 8b - Ex-ante attribution: risk	Euler decomposition	
Selected homework	Properties of satisfaction measures	
	Quantile satisfaction (VaR) computation: elliptical distribution	
	Hedging: factors on demand versus	
	Black-Scholes-Merton	
	Euler decomposition: marginal risk contributions	




Week 11

Macro topics	Theory	Video lectures
The Checklist: Step 9a - Portfolio optimization	Step 9a: Portfolio optimization	
The Checklist: Step 9a - Portfolio optimization	Fundamental concepts	 (theory)
The Checklist: Step 9a - Portfolio optimization	Smooth programming	
The Checklist: Step 9a - Portfolio optimization	Convex programming	
The Checklist: Step 9a - Portfolio optimization	Mean-variance principles	 (theory)
The Checklist: Step 9a - Portfolio optimization	Analytical mean-variance	
The Checklist: Step 9a - Portfolio optimization	Selection problems	
The Checklist: Step 9a - Portfolio optimization	Mean-variance pitfalls	
The Checklist: Step 9b - Estimation and model risk	Step 9b: Estimation and model risk	 (theory)
The Checklist: Step 9b - Estimation and model risk	Allocation (=output) uncertainty: Robust allocation	
The Checklist: Step 9b - Estimation and model risk	Minimum-torsion bets attribution of variance	
Applications	Step 8: Ex-ante attribution	 (practice)
Applications	Step 8: Ex-ante attribution	
Applications	Step 9: Construction	 (practice)
Applications	Step 9: Construction	
Selected homework	Convex programming	
	Portfolio optimization framework	
	Analytical mean-variance optimization	
	Optimization: general concepts	

Week 12

Macro topics	Theory	Video lectures
Black-Litterman	Prior distribution	 (theory)
Black-Litterman	Active views	
Black-Litterman	Posterior predictive distribution	 (theory)
Black-Litterman	Limit cases and generalizations	
Generalized probabilistic inference	Generalized probabilistic inference	
Generalized probabilistic inference	Views processing: minimum relative entropy	
Generalized probabilistic inference	Analytical implementation	
Signals	Signals	
Signals	Value signals	
Signals	Technical signals	
Signals	Signal processing	
The Checklist: Step 9c - Cross-sectional strategies	Step 9c: Cross-sectional strategies	
The Checklist: Step 9c - Cross-sectional strategies	Step 9c: Cross-sectional strategies	
The Checklist: Step 9c - Cross-sectional strategies	Advanced portfolio construction	
The Checklist: Step 9c - Cross-sectional strategies	Relationship with FLAM and APT	
The Checklist: Step 9c - Cross-sectional strategies	Multiple portfolios	
The Checklist: Step 9c - Cross-sectional strategies	Points of interest, pitfalls, practical tips	
Selected homework	Black-Litterman: views on return of two stocks	
	Views processing: views on standard deviations	
	Factor portfolios: general concepts	
	Factor portfolios: characteristic portfolio variance	

Week 13

Macro topics	Theory	Video lectures
The Checklist: Step 9d - Times series strategies	Step 9d: Times series strategies	 (theory)
The Checklist: Step 9d - Times series strategies	The market	
The Checklist: Step 9d - Times series strategies	Expected utility maximization	
The Checklist: Step 9d - Times series strategies	Option based portfolio insurance	
The Checklist: Step 9d - Times series strategies	Rolling horizon heuristics	
The Checklist: Step 9d - Times series strategies	Signal induced strategy	
The Checklist: Step 10 - Execution	Execution	 (theory)
The Checklist: Step 10 - Execution	High frequency risk drivers	
The Checklist: Step 10 - Execution	Market impact modeling	 (practice)
The Checklist: Step 10 - Execution	Order scheduling	
Applications	Step 10. Execution - Historical	
Applications	Step 10. Execution - Monte Carlo	
Selected homework	The market: strategy dynamics	
	Option based portfolio insurance: partial differential equation	
	Market impact modeling	
	Order scheduling: permanent market impact model	