Module manual

of the M. Sc. degree programme in

Mathematical Finance

Christian-Albrechts-Universität zu Kiel
Mathematisch-Naturwissenschaftliche Fakultät

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A. Overview of the Degree Programme M.Sc. Mathematical Finance

1. Programme Schedule

1st Sem	**Mathematical Finance**		**Advanced Mathematics**	**Financial Economics**	**Econo-metrics/ Statistics**	
2nd Sem	**Computational Finance**		**Mathematical Finance and Stochastic Integration**	**Financial Economics**	**Internship**	**Semi-nar**
3rd Sem	**Advanced Math. Finance**	**Advanced Math. Finance**	**Advanced Mathematics**	**Financial Economics**	**Econo-metrics/ Statistics**	**Semi-nar**
4th Sem	**Master Thesis**					**Research Seminar**

2. Structure of Curriculum

Section	Module	Type of examination	SWS	CP Module	CP Section
Compulsory Section in Mathematical Finance	Mathematical Finance	O or W	4L +2T	9	27
	Computational Finance	O or W	4L + 2T	9	
	Mathematical Finance and Stochastic Integration	O or W	4L + 2T	9	
Advanced Mathematical Finance	Module I	O or W	2L + 1T	5	10
	Module II	O or W	2L + 1T	5	
Advanced Mathematics	Module I (Mathematics)	O or W	4L + 2T	9	18
	Module II (Applied Mathematics)	O or W	4L + 2T	9	
Financial Economics	Financial Economics I	W	2L + 1T	5	15
	Financial Economics II	W	2L + 1T	5	
	Financial Economics III	W	2L + 1T	5	
Econometrics and Statistics	Econometrics I / Advanced Statistics II	O or W	2L + 1T	5	9
	Econometrics for Financial Markets/ Statistics for Financial Markets/ Multivariate Time Series Analysis and Forecasting/ Univariate Time Series Analysis	O or W	2L + 1T	4	
Seminars	Seminar I	P	2	4	11
	Seminar II (Mathematical Finance)	P	2	4	
	Research Seminar on Master Thesis	P	2	3	
Internship		R	Not specified	4	4
Master Thesis					26
$\sum$					120

Explanations:
W: written examination, O: oral examination, P: presentation, R: Report
SWS: "Semesterwochenstunden" = weekly 45-minute teaching hours during the semester.
Types: L = lecture, T = tutorial, S = seminar
CP: ECTS credit points

3. Detailed Curriculum

	Module	Type[1]	Hours[2]	Exam[3]	CP[4]	CP / Year
Semester 1	Mathematical Finance	L/T	4/2	o or w	9	
	Advanced Mathematics[5 6]	L/T	4/2	o or w	9	
	Financial Economics I[7]	L/T	2(/1)	w	5	
	Econometrics I or Advanced Statistics II	L/T	2/2 or 2/1	w	5	
			∑ 17 - 19		**∑ 28**	
Semester 2	Computational Finance	L/T	4/2	o or w	9	
	Mathematical Finance and Stochastic Integration	L/T	4/2	o or w	9	
	Financial Economics II[7]	L/T	2(/1)	w	5	
	(Econometrics for Financial Markets or Multivariate Time Series Analysis and Forecasting or Univariate Time Series Analysis)[8]	(L/T)	(2(/1))	(w)	(4)	
	Seminar[9]	S	2	p	4	
	Internship[10]	I		ru	4	
			∑ 16 - 20		**∑ 31**	**∑ 59**
Semester 3	Advanced Mathematics[5 6]	L/T	4/2	o or w	9	
	Advanced Mathematical Finance[11]	L/T	2 x 2/1	o or w	10	
	Financial Economics III[7]	L/T	2/1	w	5	
	Statistics for Financial Markets[8]	L/T	2(/1)	w	4	
	Seminar[9]	S	2	p	4	
			∑ 16 – 20		**∑ 32**	
Semester 4	Research Seminar[12]	S	2	pu	3	
	Master Thesis[13]	T	x	t	26	
			∑ 2+x		**∑ 29**	**∑ 61**

Explanation:

[1] L=lecture, T=tutorial, S=seminar, I=internship, T=thesis

[2] weakly hours (=45 minutes each) during the semester

[3] o=oral, w=written, p=presentation, r=report, t=thesis, u=unmarked

[4] credit points

[5] Can be split into 1-3 modules of altogether 6 hours (L+T)

[6] Can be chosen from the modules in applied and pure mathematics. At least one of the modules is to be chosen from applied (rather than pure) mathematics. Modules are typically taught in English upon request. Suggested courses are Mathematical Statistics (Mathematische Statistik) and Numerics of Differential Equations (Numerik von Differentialgleichungen).

[7] Financial Economics I-III can be chosen from "Economics of Risk and Uncertainty" and from the lectures in the group Financial Economics (1060300).

[8] One can choose either Econometrics for Financial Markets/Multivariate Time Series Analysis and Forecasting/Univariate Time Series Analysis in Semester 2 or Statistics for Financial Markets in Semester 3

[9] Seminar in applied mathematics. At least one seminar must be in the area of Mathematical Finance. One of the seminars can be chosen from the seminars in the group of modules Financial Economics (1060300), subject to admission by the examination board and the organizer.

[10] Can be moved to Semester 3 (depending e.g. on the choice Econometrics vs. Statistics for Financial Markets)[8], typically in the term break

[11] Advanced Courses in Mathematical Finance as e.g. Risk Management, Interest Rate Theory, Optimization in Mathematical Finance, Actuarial Mathematics and Risk Theory.

[12] Research seminar in the area of the Master thesis

[13] The master thesis is supposed to be closely connected to Mathematical Finance. It may be supervised by a professor involved in the Master's programme Quantitative Finance from the faculty of Business, Economics and Social Sciences.

B. Modules

1. Compulsory Section Mathematical Finance

module name	Mathematical Finance			
module code	MNF-math-finmath1			
term / duration	1 / 1 semester			
responsible person for this module	Prof. Dr. Sören Christensen, Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Compulsory Section in Mathematical Finance		
	M.Sc. Mathematik	Optional module		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Mathematical Finance Prof. Dr. Jan Kallsen	9 ECTS winter	compulsory	l: 4 SWS (60 hrs.) t: 2 SWS (30 hrs.)
credit points and grade	9 ECTS		German Scale, ECTS-System	
workload entire module	270 hours			
language	English			
requirements for performance assessment	Oral or written exam			
educational objectives / competencies	Basic knowledge of mathematical finance			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Introduction to pricing theory 2. Stochastic foundation of discrete markets 3. Derivative pricing in discrete markets 4. Risk neutral measures and the fundamental theorem of asset pricing 5. Cox-Ross-Rubinstein model 6. American claims and optimal stopping 7. Black Scholes model and Black Scholes formula			
References	• Irle, Albrecht: Mathematical Finance, Teubner. • More references are given in the course.			

module name	Computational Finance			
module code	MNF-math-compfin			
term / duration	2 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Compulsory Section in Mathematical Finance		
	M.Sc. Mathematik	Optional module		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Computational Finance Prof. Dr. Jan Kallsen	9 ECTS summer	compulsory	l: 4 SWS (60 hrs.) t: 2 SWS (30 hrs.)
credit points and grade	9 ECTS		German Scale, ECTS-System	
workload entire module	270 hours			
language	English			
requirements for performance assessment	Oral or written exam			
educational objectives / competencies	Basic knowledge of computational finance			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents **References**	1. Derivative pricing 2. Numerical integration 3. Tree based methods 4. Finite difference method 5. Finite element method 6. Monte-Carlo method 7. Integral transform method • References are given in the course.			

module name	Mathematical Finance and Stochastic Integration			
module code	MNF-math-compfin			
term / duration	2 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Compulsory Section in Mathematical Finance		
	M.Sc. Mathematik	Optional module		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Mathematical Finance and Stochastic Integration Prof. Dr. Jan Kallsen	9 ECTS summer	compulsory	l: 4 SWS (60 hrs.) t: 2 SWS (30 hrs.)
credit points and grade	9 ECTS		German Scale, ECTS-System	
workload entire module	270 hours			
language	English or German			
requirements for performance assessment	Oral or written exam			
educational objectives / competencies	Basic knowledge of computational finance			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Stochastic integration 2. Stochastic differntial equations 3. Equivalent martingale measures 4. Hedging of Derivatives in continuous time markets 5. Black-Scholes model and other models for continuous time markets			
References	• References are given in the course.			

2. Advanced Mathematical Finance

module name	**Risk Management**			
module number	MNF-math-riskman			
term / duration	3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematical Finance		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Risk Management Prof. Dr. Jan Kallsen	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	Active and regular participation Written exam (max. 180 min.) or oral exam (max. 30 min.)			
educational objectives / competencies	Knowledge of models for quantifying financial risks			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents **References**	1. Loss operators 2. Risk measures 3. Value at risk 4. Expected shortfall 5. Variance covariance method 6. Historical simulation 7. Maximum likelihood estimation 8. Monte Carlo Methods 9. Extreme value theory in Risk Management 10. Multiviriate Distributions 11. Elliptical Distributions 12. Copulas • Mc Neil, Frey, Embrechts: Quantitative Risk Management.			

module name	Interest Rate Theory (Zinsmodelle)			
module number	MNF-math-zimo			
term / duration	3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**Degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematical Finance		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Zinsmodelle Prof. Dr. Jan Kallsen	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Written exam (max. 180 min.) or oral exam (max. 30 min.)			
educational objectives / competencies	Acquisition of ability to deal with model from interest rate theory.			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents **References**	1. Basics 2. Interest rate derivatives 3. Short rate models 4. Change of numeraire 5. Affine term structure 6. Factor models 7. Heath-Jarrow-Morton 8. Libor market models			
Contents References	Varying, specialized and advanced literature from mathematical finance.			

module name	Optimization in Mathematical Finance (Optimierungsprobleme in der Finanzmathematik)			
module number	MNF-math-optpro			
term / duration	3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematical Finance		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Optimierungsprobleme in der Mathematical Finance Prof. Dr. Jan Kallsen	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Written exam (max. 180 min.) or oral exam (max. 30 min.)			
educational objectives / competencies	Acquisition of ability to deal with optimization problems from mathematical finance.			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Optimal stopping 2. Portfolio optimization 3. Hedging problems 4. Stochastic control 5. Martingale methods			
References	• References are given in the course			

module name	Actuarial Mathematics and Risk Theory (Versicherungsmathematik und Risikotheorie)			
module number	MNF-math-veri			
term / duration	3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematical Finance		
courses	**title** **credits** **teachers** **term**		**status**	**time of attendance**
	lecture + tutorial: Actuarial Mathematics and Risk Theory Prof. Dr. Jan Kallsen	5 ECTS Summer	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Written exam (max. 180 min.) or oral exam (max. 30 min.)			
educational objectives / competencies	Acquisition of basic knowledge of risk theory with focus on non-life insurance.			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Models for the claim number process 2. Fitting the claim size distribution 3. Collective risk model 4. Ruin theory 5. Insurance premium principles			
References	• References are given in the course			

module name	Special Chapters from Mathematical Finance (Ausgewählte Kapitel der Finanzmathematik)			
module number	MNF-mathAKdF-01a			
term / duration	3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematical Finance		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: rent Issues in Mathematical Finance Prof. Dr. Jan Kallsen	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Written exam (max. 180 min.) or oral exam (max. 30 min.)			
educational objectives / competencies	Acquisition of ability to deal with advanced topics from the field of mathematical finance.			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents **References**	Advanced topics in the field of mathematical finance. • A detailed outline and references will be announced in the course.			

module name	Special Chapters from Finance (Ausgewählte Kapitel aus Numerik und Finanzmathematik)			
module number	MNF-mathAKaNuF-01a			
term / duration	3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematical Finance		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Aktuelle Probleme aus Numerik und Finanzmathematik Prof. Dr. Jan Kallsen	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Written exam (max. 180 min.) or oral exam (max. 30 min.)			
educational objectives / competencies	Acquisition of ability to deal with advanced topics from the field of mathematical finance.			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents **References**	Advanced topics in the field of mathematical finance. • A detailed outline and references will be announced in the course.			

3. Advanced Mathematics

module name	**Probability and Statistics II**			
module code	MNF-math-stat.1			
term / duration	1 or 3 / 1 semester			
responsible person for this module	Prof. Dr. Matthias Vetter, Prof. Dr. Sören Christensen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematics		
	M.Sc. Mathematik	Optional module		
courses	**title** **credits** **teachers** **term**		**status**	**time of attendance**
	lecture + tutorial: Mathematical Statistics 9 ECTS Prof. Dr. Jan Kallsen winter		compulsory	l: 4 SWS (60 hrs.) t: 2 SWS (30 hrs.)
credit points and grade	9 ECTS		German Scale, ECTS-System	
workload entire module	270 hours			
language	English or German			
requirements for performance assessment	Oral or written exam			
educational objectives / competencies	Basic knowledge of mathematical statistics			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Martingales 2. Martingale convergence theorems 3. Foundations of point estimation 4. Bayes and minimax estimation 5. Maximum likehood estimation 6. Asymptotic properties of point estimators 7. Foundations of hypothetis testing 8. Asymptotic properties of tests 9. Linear models			
References	• References are given in the course.			

module name	Stochastic Processes in Discrete Time			
module code	MNF-mathStoProDiskret-01a			
term / duration	1 or 3 / 1 semester			
responsible person for this module	Prof. Dr. Matthias Vetter, Prof. Dr. Sören Christensen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematics		
	M.Sc. Mathematik	Optional module		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Stochastic processes Prof. Dr. Uwe Rösler	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Oral or written exam			
educational objectives / competencies	Basic knowledge of stochastic processes			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Markov chains 2. Recurrence and transience 3. Asymptotic behavior of Markov chains 4. Renewal theory 5. Applications			
References	• References are given in the course.			

module name	Stochastic Processes in Continuous Time			
module code	MNF-mathStoProStetig-01a			
term / duration	1 or 3 / 1 semester			
responsible person for this module	Prof. Dr. Matthias Vetter, Prof. Dr. Sören Christensen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematics		
	M.Sc. Mathematik	Optional module		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Stochastic processes Prof. Dr. Uwe Rösler	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Oral or written exam			
educational objectives / competencies	Basic knowledge of stochastic processes			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Existence of stochastic processes 2. Brownian motion and its properties 3. Donsker's invariance principle 4. Poisson process 5. Lévy processes			
References	• References are given in the course.			

module name	Numerical Methods for Differential Equations			
module code	MNF-math-numdglmsc			
term / duration	1 or 3 / 1 semester			
responsible person for this module	Prof. Dr. Malte Braack			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Advanced Mathematics		
	M.Sc. Mathematik	Optional module		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Prof. Dr. Steffen Börm Prof. Dr. Malte Braack Prof. Dr. Thomas Slawig	9 ECTS summer	compulsory	l: 4 SWS (60 hrs.) t: 2 SWS (30 hrs.)
credit points and grade	9 ECTS		German Scale, ECTS-System	
workload entire module	270 hours			
language	German or English			
requirements for performance assessment	Oral or written exam			
educational objectives / competencies	Basic knowledge of numerical methods for solving differential equations			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	• Analytic properties for ordinary differential equations • One-step methods (in particular Runge-Kutta, convergence results, error estimates, step size control) • Numerical stability • Linear multistep methods • Discontinuous Galerkin methods, boundary value problems			
References	• References are given in the course.			

Further modules are to be found in the Module Manual Mathematics. They are typically taught in English upon request.

4. Financial Economics

module name	**Economics of Risk and Uncertainty**			
module number	VWL-PuEc-EcRU			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Ulrich Schmidt			
attribution to curriculum	**degree programme**	**status**		
	M. Sc. Mathematik	Nebenfach in Economics		
	M.Sc. Mathematical Finance	Financial Economics		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Economics of Risk and Uncertainty Prof. Dr. Ulrich Schmidt	5 ECTS summer	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	Students should become familiar with modern concepts and theories of decision-making under risk as well as possible applications in finance and insurance economics. They should be enabled to analyze decision problems under risk independently.			
knowledge transfer by lectures + tutorials	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Introduction 2. Expected Utility 3. Non-expected Utility 4. Applications to insurance economics 5. Applications to financial markets			
References	• Schmidt, U., Alternatives to Expected Utility: Some Formal Theories, in: S. Barberà, P.J. Hammond and C. Seidl (eds.), *Handbook of Utility Theory, Vol. II*, Kluwer, Boston, 2004. • Bleichrodt, H. And U. Schmidt, Applications of Non-Expected Utility, in: P. Anand and C. Puppe (eds.), Handbook of Rational and Social Choice, Oxford University Press, 2009.			

module name	International Financial Markets			
module code	VWL-FinEc-IFM			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Thomas Lux			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Mathematical Finance	Financial Economics		
	M.Sc. Mathematik	Nebenfach in Economics		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: International Financial Markets Prof. Dr. Thomas Lux	5 ECTS summer	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	The lecture covers modern theories that view foreign exchange markets and exchange rate determination from a finance perspective. Relevant topics include the importance of investors' expectations and speculative behavior in the foreign exchange market and its explanatory power for the observation of excessive volatility of foreign exchange rates compared to macroeconomic fundamentals. We also discuss the effects of political interventions to curb speculative activity and the determinants of major historical currency crises.			
knowledge	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Trading Volume and Organization of International Financial Markets 2. Foreign Exchange Markets and Macroeconomic Theory 2.1. The Lack of Explanatory Power of Traditional Macroeconimic Models of the Exchange Rate 2.2. Speculative Efficienca of the Foreign Exchange Market ? 3. Speculation, Excess Volatility and Stabilization of the Exchange Rate 3.1. Rational Speculative Bubbles in Foreign Exchange Markets 3.2. « Peso-Problems » and Noise Traders 3.3. Interaction of Chartists and Fundamentalists 3.4. The Tobin Tax and other Regulatory Interventions 4. Exchange Rate Target Zones and « Dirty Floating » 4.1. Endogeneous Stabilization through Target Zones 4.2. The Credibility of Target Zones 5. Exchange Rate Crisis and Speculative Attacks 5.1. The Collaps of Unsustainable Fixed Exchange Rates 5.2. Crisis and Multiple Equilibria 5.3. The Crises in South-East Asia and « Third Generation » Models of Exchange Rate Crisis 5.4. Contagion Effects and the Role of the IMF 6. The Great Financial Crisis of 2008 -			
References	• Cuthbertson, K. : « Quantitative Financial Economics : Stocks, Bonds and Foreign Exchange ». 2nd ed., Chistester 2004. • Hallwood, C./McDonald, R. : « International Money and Finance », 3rd. Ed. Exford 2000 • Gärtner, M. : « Macroeconomics under Flexible Exchange Rates », New York 1993, (German version : Gärtner, M. (2004), Makroökonomik flexibler und fester Wechselkurse, 3., vollständig überarbeitete und erweiterte Auflage, Berlin [u. a.]) • Nelsen, M. : « International Macroeconimics and Finance : Theory and Econometric Methods », Blackwell Publishers, 2001			

module name	Theory of Financial Markets			
module code	VWL-FinEc-TFM			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Thomas Lux			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Mathematical Finance	Financial Economics		
	M.Sc. Mathematik	Nebenfach in Economics		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Theory of Financial Markets Prof. Dr. Thomas Lux	5 ECTS winter	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	After an introduction to the empirical stylized facts of financial markets, the lecture discusses the theoretical foundations and the empirical validity of the seminal 'efficient market hypothesis'. We continue with models of price formation in accordance with rational information revelation through transactions and also review approaches in the recent 'behavioral finance' literature that emphasize the role of speculative activity and bounded rational behavior of investors.			
knowledge	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. "Stylized facts" of financial market data a. The random walk property of prices b. The distributional properties of returns c. The dynamics of volatility 2. Financial market efficiency and the problem of information transmission a. Equilibrium prices and the "efficient market hypothesis" (EMH) b. The Grossman/Stiglitz-paradoxon of the impossibility of informational efficiency markets c. The revelation of information through transactions d. Information transmission under strategic behavior 3. Pricing on incomplete markets a. Speculation: Stabilizing or destabilizing? i. Keynes vs. Friedman: A survey of older approaches ii. The theory of rational speculative bubbles iii. "Bounded rational" speculation: models with chartists and fundamentalists b. "Noise trading": Survival with wrong information c. Imitation and development of speculative bubbles d. Explanation of stylized facts in "artificial" financial market models 4. Bank panics, financial crises and the hypothesis of the fragility of the financial sector			
References	• Aschinger, G.: Börsenkrach und Spekulation: Eine ökonomische Analyse. München 1995 • Barucci, E.: Financ. Markets Theory: Equilibrium, Efficiency and Information. London 2003 • Brunnermeiner, M.K.: Asset Pricing under Asymmetric Information. Oxford 2001 • Campell, J./ Lo, A./ MacKinlay, A.: The Econometrics of Financial Markets. Princeton 1997. • Cuthbertson, K.: Quantitative Financial Economics: Stocks, Bonds and Foreign Exchange. New York 1996 • Dacorogna, M.M. / Gencay, R. / Müller, U.A./ Olsen, R.B./ Pictet, O.V.: An Introduction to High-Frequency Finance. New York, London 2001. • O´Hara, M.: Market Microstructure Theory. Oxford 1995			

	Pricing in Derivative Markets			
module code	VWL-FinEc-PDM			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Thomas Lux			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Mathematical Finance	Financial Economics		
	M.Sc. Mathematik	Nebenfach in Economics		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Pricing in Derivative Markets Prof. Dr. Thomas Lux	5 ECTS winter	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	The course provides an introduction to the pricing of financial derivatives and is logically split into two parts. The first part deals with the mechanics of derivative markets and instruments. The second part focuses on the mathematical concepts that are used to price these derivatives, often summarized under the catch-all phrase of financial engineering.			
knowledge	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. An Introduction to Derivative Markets Forwards and futures, interest rate derivatives, swaps, options 2. Microeconomic Foundations Complete markets, arbitrage, contingent claims, Arrow securities 3. Basic option Pricing Theory Binomial model, Wieder Processes and Ito's Lemma, Black-Scholes model, Greek letters 4. Numerical Methods in Option Pricing Finite difference methods for standard options, finite difference methods for American options 5. Credit Risk and Credit Derivatives Credit risk assessment, credit derivatives 6. Interest Rate Derivatives			
References	• Hull, J. "Options, Futures and Other Derivatives", 6. ed., Prentice Hall, 2006 • J. Eichberger and I. Harper, Financial Economics. Oxford Univ. Press, 1997 • John C. Hull, "Options, Futures and Other Derivatives", 8. ed., Prentice Hall, 2011 • R. Seydel, "Tools for Computational Finance", 4th ed., Berlin Springer, 2009 • P. Willmott, S. Howson and J. Dewynne "The Mathematics of Financial Derivatives: A Student Introduction", Cambriidge Univ. Press, 1995			

module name	Foreign Exchange Markets - Theory and Empirics			
module code	VWL-FinEc-FEM			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Stefan Reitz			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Mathematical Finance	Financial Economics		
	M.Sc. Mathematik	Nebenfach in Economics		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture: Foreign Exchange Markets-Theory and Empirics Prof. Dr. Stefan Reitz	5 ECTS winter	compulsory elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	The lecture provides an introduction to market microstructure of foreign exchange trading. The role of order flow and inventory risk management is analyzed in a theoretical and an empirical framework. In addition, the trading perspectives of importers/exporters, international investors are discussed by deriving and empirically testing equilibrium relationships in foreign exchange markets. Finally, recent approaches in FX research are covered.			
knowledge	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Description of Foreign Exchange Trading 1.1. FX Instruments 1.2. FX Market Segments 1.3. FX Market Participants 2. The Dealers' Perspective 2.1. The Single Dealer Approach 2.2. Dealer Trading in Segmented Markets 2.3. The Multiple Dealer Approach 3. The Customers' Perspective 3.1. Importers / Exporters 3.2. International Investors 4. Recent approaches in FX research			
References	• Lyons, R.: The Microstructure Approach to Exchange Rates, MIT Press Cambridge, MA., 2001 • Sarno, L./ Taylor, M.: "The Economics of Exchange Rates". Cambridge University Press, Cambridge 2002.			

module name	Applied Econometrics of Foreign Exchange Markets			
module code	VWL-FinEc-AEFE			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Reitz			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Mathematical Finance	Financial Economics		
	M.Sc. Mathematik	Nebenfach Volkswirtschaftslehre		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture: Applied Econometrics of Foreign Exchange Markets Prof. Dr. Reitz	5 ECTS Summer	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	The course introduces into empirical analysis of modern exchange rate economics. After providing an introduction to R programming important concepts of exchange rate economics such as purchasing power parity, uncovered interest parity, ARCH effect in FX returns are econometrically tested using data from various sources. In addition, a variety of nonlinear models are introduced. At the end of this practitioners' course participants will be able to derive empirical results from their ohn econometric programs.			
knowledge	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Introduction to R programming 2. The linear regression model 3. ARCH/GARCH in FX returns 4. The Markov switching model 5. The Threshold autoregression model 6. The smooth transition regression model			
References	• Sarno, L.; Taylor, M; The Economics of Exchange Rates, Cambridge University Press, 2002			

module name	Agent Based Models in Economics and Finance			
module code	VWL-FinEc-ABM			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Thomas Lux			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Finanzmathematik	Financial Economics		
	M.Sc. Mathematik	Nebenfach Volkswirtschaftslehre		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture: Agent Based Models in Economics and Finance Prof. Dr. Thomas Lux	5 ECTS SS(occasionally)	elective	l: 2 SWS (30 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	The course will provide a rigorous, but accessible and self-contained introduction to recent stochastic models of interacting autonomous agents with a particular emphasis on financial applications and their empirical motivation. While many traditional classroom models use a representative agent approach in order to derive choice-theoretic micro-foundations for the market behavior of firms or households, an increasing number of recent contributions in economics and finance have tried to overcome the limitation of the representative agent approach. In these models, markets are distributed dynamical systems, whose macroscopic properties are derived from their microscopic structure in a non-trivial way. The analytic apparatus that has been developed to derive macroscopic approximations for mean values and higher moments of the aggregate dynamics of distributed systems of agents will be sketched, and we will illustrate how simple ABMs can be rigorously estimated on the base of such analytical solutions. The lecture concludes with an introduction into methods artificial intelligence and machine learning that have been used to model the active adaption of economic agents to changing environments.			
knowledge	Interactive lecture, lecture notes, literature studies, exercises			
1. Contents	**1. Social Interactions and Opinion Formation of Agents** 1.1. Interaciton and Emergence of Macroscopic Order: An Example of Involuntary Racial Segregation 1.2. Strategic Choice and Historical Path Dependence 1.3. Discrete Choice with Social Interaction **2. Stochastic Models of Interaction Agents: Structure and Quantitative Modeling Concepts** 2.1. The Master Equation Fomalism: Stationary Solutions and Transient Bahaviour 2.2. Dynamics of Menas and Higher Moments 2.3. Heterogeneous Beliefs and Asset Price Dynamics 2.4. Artificial Markets with Herding and Strategy Choice 2.5. Estimation of Agent-Based Models **3. Agents with Artificial Intelligence** 3.1. Genetic Algorithms: Principles and Economic Applications 3.2. Genetic Algorithms as Explanations of Humal Behaviour			
References	**Nice introductory examples can be found in:** Schelling, T., Micromotives and Macrobehaviour, New York, 2006 Arthur, B., Competing Technologies, Increasing Returns and Lock-in by Historical Events, Economic Journal, 99, 106-131, 1989			

	Excellent introductions to stochastic modeling principles for systems of interacting agents and more interesting applications can be found in: Weidlich, W. and G. Haag, Concepts and Models of an Quantitative Sociology: The Dynamics of Interacting Polulations, Springer: Berlin 1983 Weidlich, W., Sociodynamics: A Systematic Approach to Mathematical Modelling in the Social Sciences. Amsterdam, Harwood Academic, 2000 Aoki, M., Modeling Aggregate Behaviour and Fluctuations in Economics: Stochastic Views of Interacting Agents. Cambridge: University Press 2002 Aoki, M. and H. Yoshikawa, Reconstructing Macroeconomics: A Perspective from Statistical Physics and Combinatorial Stochastic Processes. Cambridge University Press, 2007 **Part 2 of the lecture draws on material from the following papers:** Lux, T., Rational Forecasts or Social Opinion Dynamics: Identification Effects in an Business Climate Index, in: Journal of Economic Behaviour and Organization 72, 2009, 638 – 655 Lux, T., Stochastic Behavioural Asset Pricing Models and the Stylized Facts, chapter 3 in T. Hens and K. Schenk-Hoppé, eds., handbook of Financial Markets: Dynamics and Evolution. Amsterdam, 2009, 161 – 215 (North-Holland)

module name	Research in International Finance			
module code	VWL-FinEc-RestInFin			
Exam number	3903210			
term / duration	2-3/ 1 semester			
responsible person for this module	Prof. Dr. Christoph Trebesch			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Finanzmathematik	Financial Economics		
	M.Sc. Mathematik	Nebenfach Volkswirtschaftslehre		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture:+ tutorial: Research in Internation Finance Prof. Dr. Christoph Trebesch	5 ECTS winter	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam (take home)			
educational objectives / competencies	Upon the successful completion of this course, students should have a deeper understanding of current policy issues and research in the field of internation finance. Methodologically the course aims to train students to critically assess advanced empirical work in international finance and to learn about good research design. Specifically, students will train: - How data is used to analyze important issues in internation finance and international macroeconomics - how to identify flaws and limitations of the papers discussed - How to set up an applied research project that builds on existing work			
knowledge	Interactive lecture and tutorial, lecture notes, literature studies and extensive reading (including recent research on cutting edge work), writing a referee report and developing a research proposal, discussing research with peers an lecturer			
2. Contents	The course focuses on three main topics 1. Sovereign risk, international lending, and debt crises 2. Cross-border capital flows, the current account, and sudden stops 3. Exchange rate regimes and the international financial architecture In the first part of each session we will discuss current research contributions and how the relate to the fundamental questions in international finance and international macroeconomics (lecture). The second part will be more interactive with more inputs from students (tutorial). We will jointly discuss the required readings for each week on which students are supposed to write a referee report.			
References	The course will not follow a textbook but build on much cited papers in the field, mostly empirical contributions.			

module name	Advanced Topics in Financial Economics			
module code	VWL-FinEc-Adv			
term / duration	1-3/ 1 semester			
responsible person for this module	Prof. Dr. Thomas Lux			
attribution to curriculum	**degree programme**	**Status**		
	M.Sc. Mathematical Finance	Financial Economics		
	M.Sc. Mathematik	Nebenfach in Economics		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture: Advanced Topics in Financial Economics N.N.	5 ECTS n.s.	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	t.b.a.			
knowledge	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents References	Varying topics in the field of financial economics. This course only takes place occasionally.			

5. Econometrics and Statistics

module name	**Advanced Statistics II**			
module code	VWL-AdvStatII			
term / duration	2-3/ 1 semesters			
responsible person for this module	Prof. Dr. Matei Demetrescu			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Econometrics and Statistics		
	M.Sc. Mathematik	Nebenfach Statistics and Econometrics		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Advanced Statistics II Prof. Dr. Matei Demetrescu	5 ECTS summer	compulsory elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	The course allows the students to become familiar with, to understand and to apply the concepts of mathematical statistics underlying the procedures of statistical inference on which the statistical and econometric analysis of economic data are based. The focus in the second part is on parametric inferential theory.			
knowledge transfer by lectures + tutorials	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Statistics and Sampling Distributions 2. Elements of Point Estimation 3. Point Estimation Methods 4. Hypothesis Testing 5. Model Selection			
References	• Mittelhammer, R.C.(1996), Mathematical Statistics for Economics and Business. Springer-Verlag, New-York. • Mood, A.M., Graybill, F.A.and D.C. Boes (1974), Introduction to the Theory of Statistics. McGraw Hill, Boston. • Casella, G.and R.Berger (2002). Statistical Inference. Pacific Grove: Duxbury.			

module name	Econometrics I			
module code	VWL-EcoI			
term / duration	1 / 1 semester			
responsible person for this module	Prof. Dr. Carstensen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Econometrics and Statistics		
	M.Sc. Mathematik	Minor Subject Statistics and Econometrics		
courses	**title** / **teachers**	**credits** / **term**	**status**	**time of attendance**
	lecture +tutorial: Econometrics I Prof. Dr. Carstensen	5 ECTS winter	compulsory	l: 2 SWS (30 hrs.) t: 2 SWS (30 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	written exam			
educational objectives / competencies	The lecture covers important estimation and inference techniques for cross-sectional data and introduces into the use of the econometric software packages Gretl and Stata.			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents References	1. Review (conditional expectations, linear projections, OLS basics) 2. Basic asymptomics theory (convergende in probability, convergence in distribution, limit theorems for random samples) 3. Linear Models a. The Single-Equation Model and OLS Estimation b. Instrumental Variables Estimation of Single-Equation Models c. Additional Single-Equation Topics d. The SUR model e. The Simultaneous Equations Model 4. Nonlinear Models: M-Estimation Textbook: Jeffrey M Wooldridge (2010), Econometric Analysis of Cross Section and Panel Data, 2nd edition, MIT Press.			

module name	Econometrics for Financial Markets			
module code	VWL-AEM-EcFin			
term / duration	2-3 / 1 semester			
responsible person for this module	Prof. Dr. Markus Haas			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Econmetrics and Statistics for Financial Markets		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Econometrics for Financial Markets Prof. Dr. Markus Haas	5 ECTS summer	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	Written exam			
educational objectives / competencies	This course offers the possibility for the students to become familiar with special econometric techniques required to work with financial market data. Main topics include a thorough analysis and discussion of approaches for modelling conditional volatilities and corelations of financial assets. Applications to risk management and portfolio optimization are considered, among others.			
knowledge transfer by lectures + tutorials	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Introduction 2. The stable hypothesis 3. Time series concepts 4. Univariate volatility modelling and forecasting - GARCH - stochastic volatility - dynamic score models - realized volatility - evaluating volatility forecasts 5. Multivariate volatility models			
References	• Alexander, C. (2008). Practical Financial Econometrics. Wiley, Chichester. • Harvey, A. C. (2013). Dynamic Models for Volatility and Heavy Tails. Cambridge University Press, Cambridge • Linton, O. (2019). Financial Econometrics: Models and Methods. Cambridge University Press, Cambridge. • Taylor, S. (2005): Asset Price Dynamics, Volatility and Prediction. Princeton University Press, Princeton. • Paolella, M. S. (2007). Intermediate Probability: A Computational Approach. Wiley, Chichester. • Paolella, M. S. (2018). Fundamental Statistical Inference: A Computational Approach. Wiley, Chichester			

module name	**Multivariate Time Series Analysis and Forecasting**			
module code	VWL-AEM-MTSA			
term / duration	2-3 / 1 semester			
responsible person for this module	Prof. Dr. Kai Carstensen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematik	Minor Subject Statistics and Econometrics		
	M.Sc. Mathematical Finance	Econmetrics and Statistics for Financial Markets		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Multivariate Time Series Analysis and Forecasting Prof. Dr. Kai Carstensen	5 ECTS summer	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	Take-away exams, written exam at the end of the semester			
educational objectives / competencies	The lecture offers an introduction to the vector autoregressive (VAR) model, the workhorse model for multivariate time series analysis. This includes aspects of specification, estimation, forecasting, and (structural) interpretation. In addition, selected topics in forecasting and forecast evaluation are presented. In the tutorial, students solve methodological and applied problem sets, and use the scientific software Matlab.			
knowledge transfer by lectures + tutorials	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents **References**	• Stable Vector Autoregressive Processes • Estimation of Vector Autoregressive Processes • Forecasting with VAR models • VAR Order Selection and Checking the Model Adequacy • Topics in forecasting Textbook: Helmut Lütkepohl (2007), New Introduction to Multiple Time Series Analysis, Springer, Berlin.			

module name	**Statistics for Financial Markets**			
module code	VWL-AEM-StatFin			
term / duration	2-3 / 1 semester			
responsible person for this module	Prof. Dr. Markus Haas			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematik	Nebenfach Statistics and Econometrics		
	M.Sc. Mathematical Finance	Econmetrics and Statistics for Financial Markets		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Statistics for Financial Markets Prof. Dr. Markus Haas	5 ECTS winter	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	Written exam			
educational objectives / competencies	This course offers the possibility for the students to become familiar with important statistical techniques requiredto work with financial market data. Main topics include tests for predictability, a thorough discussion of estimating and backtesting risk measures such as Value-at-Risk and Expected Shortfall, and regime-switching models.			
knowledge transfer by lectures + tutorials	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Introduction: Asset Returns and Their Properties 2. The random walk hypothetis 3. GARCH models with application to Value-at-Risk and Expected Shortfall estimation and backtesting 4. Regime-switching models			
References	• Christoffersen, P. (2012). Elements of Financial Risk Management. Academic Press, Amsterdam (2e) • Guidolin, M. and M. Pedio (2018). Essentials of Time Series for Financial Applications. Academic Press, London. • Linton, O. (2019). Financial Econometrics: Models and Methods. Cambridge University Press, Cambridge. • Taylor, S. (2005): Asset Price Dynamics, Volatility, and Prediction. Princeton University Press, Princeton			

module name	Univariate Time Series Analysis			
module code	VWL-AEM-UTSA			
term / duration	2-3 / 1 semester			
responsible person for this module	Prof. Dr. Matei Demetrescu			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematik	Minor Subject Statistics and Econometrics		
	M.Sc. Mathematical Finance	Econmetrics and Statistics for Financial Markets		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	lecture + tutorial: Univariate Time Series Analysis Prof. Dr. Matei Demetrescu	5 ECTS summer	elective	l: 2 SWS (30 hrs.) t: 1 SWS (15 hrs.)
credit points and grade	5 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English			
requirements for performance assessment	Written exam			
educational objectives / competencies	The aim of the course is to provide students with the theoretical basis for working with time series models. It starts with an overview of basic notions of time series analysis, and continues with the simple component model distinguishing between deterministic and random components. For the random components, we introduce linear models for the conditional mean (in particular ARMA) and justify them by the Wold decomposition theorem. Estimation and model selection is discussed in detail for the autoregressive process. We also examine briefly GARCH models for the conditional variance and integrated models for stochastically trending variables.			
knowledge transfer by lectures + tutorials	Interactive lecture and tutorial, lecture notes, literature studies, exercises			
Contents	1. Filters 2. The World decomposition and linear models 3. ARMA models 4. Forecasting 5. Nonlinear and nonstationary models			
References	• Brockwell, P.J. and R.A. Davis (2002), Introduction to Time Series and Forecasting, 2nd ed., Springer • Hamilton, J. (1994), Time Series Analysis, Princeton University Press • Hassler, U. (2018), Time Series Analysis with Long Memory in View, Wiley • Brockwell, P. J. and R. A. Davis (1991), Time Series: Theory and Methods, 2nd ed., Springer			

6. Seminars

module name	**Seminar on Stochastics and Mathematical Finance (Seminar Stochastik und Finanzmathematik)**			
module number	MNF-math-sem_fma_m			
term / duration	2 or 3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	degree programme	status		
	M.Sc. Mathematical Finance	Seminar in Mathematical Finance		
courses	title teachers	credits term	status	time of attendance
	seminar: Seminar Stochastik und Mathematical Finance Prof. Dr. Jan Kallsen	4 ECTS n.s.	elective	2 SWS (30 hrs.)
credit points and grade	4 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Oral presentation at an advanced stage (90 min.)			
educational objectives / competencies	Acquisition of research and communication competencies by self-dependent elaboration and presentation of an advanced topic from mathematical finance based on mathematical research papers.			
knowledge transfer	presentations, literature studies			

module name	**Seminar on Computational Finance and Mathematical Finance (Seminar Numerik und Finanzmathematik)**			
module number	MNF-math-sem_cfi_m			
term / duration	2 or 3 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	degree programme	status		
	M.Sc. Mathematical Finance	Seminar in Mathematical Finance		
courses	title teachers	credits term	status	time of attendance
	seminar: Seminar on Computational Finance and Mathematical Finance Prof. Dr. Jan Kallsen	4 ECTS winter	elective	2 SWS (30 hrs.)
credit points and grade	4 ECTS		German Scale, ECTS-System	
workload entire module	150 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Oral presentation at an advanced stage (90 min.)			
educational objectives / competencies	Acquisition of research and communication competencies by self-dependent elaboration and presentation of an advanced topic from mathematical finance based on mathematical research papers.			
knowledge transfer	Interactive lecture and tutorial, lecture notes, literature studies, exercises			

module name	Higher Seminar Mathematical Finance			
module number	MNF-math-osem_fima			
term / duration	4 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	degree programme	status		
	M.Sc. Mathematical Finance	Research Seminar		
courses	title teachers	credits term	status	time of attendance
	seminar: Research Seminar Prof. Dr. Jan Kallsen	3 ECTS n.s.	elective	2 SWS (30 hrs.)
credit points and grade	3 ECTS		German Scale, ECTS-System	
workload entire module	90 hours			
language	English or German			
requirements for performance assessment	Active and regular participation Oral presentation at an advanced stage (90 min.)			
educational objectives / competencies	Acquisition of research and communication competencies by self-dependent elaboration and presentation of topics concerning the own master thesis			
knowledge transfer	presentations, literature studies			

7. Master Thesis

module name	**Master Thesis (Mathematical Finance)**			
module number	Not specified			
term / duration	4 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	**degree programme**	**status**		
	M.Sc. Mathematical Finance	Master Thesis		
courses	**title** **teachers**	**credits** **term**	**status**	**time of attendance**
	Thesis:	26 ECTS	compulsory	none
credit points and grade	26 ECTS		German Scale, ECTS-System	
workload entire module	780 hours			
language	German or English			
requirements for performance assessment	Writing a Master Thesis, Oral presentation in the research seminar			
educational objectives / competencies	Acquisition of research and communication competencies by self-dependent elaboration and presentation of an advanced topic from mathematical finance based on mathematical research papers.			
knowledge transfer	Writing scientific texts, literature studies			

8. Internship

module name	**Internship**			
module number	MNF-math-prakt_fin			
term / duration	2 / 1 semester			
responsible person for this module	Prof. Dr. Jan Kallsen			
attribution to curriculum	degree programme	status		
	M.Sc. Mathematical Finance	Internship		
courses	title teachers	credits term	status	time of attendance
	seminar: Seminar Stochastik und Mathematical Finance Prof. Dr. Jan Kallsen	4 ECTS n.s.	compulsory	Not specified
credit points and grade	4 ECTS		German Scale, ECTS-System	
workload entire module	120 hours			
language	Not specified			
requirements for performance assessment	Report on the tasks during the internship (ungraded)			
educational objectives / competencies	Insights for possible applications of Mathematical Finance/ Mathematics in research, development and economy			
knowledge transfer	Application and implementation of mathematical methods in professional practice			