The Faculty of Engineering and Science
The Study Board of Mathematics, Physics and Nanotechnology

Curriculum for the Master's Programme in Mathematics-Economics

Aalborg University
September 2018

Campus Aalborg

Preface:
Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum is stipulated. The programme also follows the Joint Programme Regulations and the Examination Policies and Procedures for The Faculty of Engineering and Science, The Faculty of Medicine and The Technical Faculty of IT and Design.

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Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders

The Master's programme is organised in accordance with the Ministry of Higher Education and Science's Ministerial Order no. 1328 of November 15, 2016 on Bachelor's and Master's Programmes at Universities (the Ministerial Order of the Study Programmes) with subsequent changes and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 111 of January 30, 2017 (the Admission Order) and Ministerial Order no. 114 of February 13, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation

The Master's programme falls under The Faculty of Engineering and Science, Aalborg University.

1.3 Study Board affiliation

The Master's programme falls under the Study Board of Mathematics, Physics and Nanotechnology.

1.4 External Examiners' Corps

The Master's programme is associated with the Body of External Examiners for Mathematics (Censorkorpset for matematik).

Chapter 2: Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission

Applicants with a legal claim to admission (retskrav):
Applicants with one of the following degrees are entitled to admission:

- Bachelor of Science (BSc) in Mathematics-Economics, Aalborg University

Applicants without legal claim to admission:

- Bachelor of Science (BSc) in Mathematics-Economics, Aarhus University (AU)
- Bachelor of Science (BSc) in Mathematics-Economics, Copenhagen University (KU)
- Bachelor of Science (BSc) in Mathematics-Economics, Southern Danish University (SDU)

2.2 Degree designation in Danish and English

The Master's programme entitles the graduate to the designation cand.scient.oecon (candidatus/candidata scientiarum oeconomics). The English designation is: Master of Science (MSc) in Mathematics-Economics.

2.3 The programme's specification in ECTS credits

The Master's programme is a 2-year, research-based, full-time study programme. The programme is set to 120 ECTS credits.

2.4 Competence profile on the diploma

The following competence profile will appear on the diploma:

A Candidatus/candidata graduate has the following competency profile:

A Candidatus graduate has competencies that have been acquired via a course of study that has taken place in a research environment.

A Candidatus graduate is qualified for employment on the labour market on the basis of his or her academic discipline as well as for further research (PhD programmes). A Candidatus/candidata graduate has, compared to a Bachelor, developed his or her academic knowledge and independence so as to be able to apply scientific theory and method on an independent basis within both an academic and a professional context.

2.5 Competence profile of the programme:

Students graduating as Masters of Mathematics-Economics:

Knowledge

- are well-oriented in the foundations of key mathematical-economics disciplines including econometrics, stochastic processes, quantitative finance, operations research.

Skills

- are able to independently identify, formulate, and analyse mathematical-economics problems employing theory and methodology from the mathematical and quantitative economics sciences
- are able to independently choose relevant methods and tools from various mathematical and quantitative economics areas and to motivate this choice
- are able to disseminate scientific knowledge and to discuss applications of methods from the mathematical and quantitative economics sciences
- are able to choose relevant mathematical theories to problems that originate in, for example economics, to develop them and to make use of them in the original applied context

Competencies

- are able to ponder about central mathematical and quantitative economics insights, methods and tools and to identify problems amenable to mathematical treatment
- are able to manage complex work and development scenarios that may require new strategies in order to make progress
- are able to independently take responsibility for professional development and specialization

Chapter 3: Content and Organization of the Programme

The programme is structured in modules and organized as a problem-based study. A module is a programme element or a group of programme elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods. Examinations are defined in the curriculum.

The programme is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- lectures
- classroom instruction
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- reflection
- portfolio work

Overview of the programme:

All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only).

Semester	Project = P Course = C	Module	ECTS	Assessment	Exam
MATØK7	P	The student follows *either* project a) Empirical Financial Modelling and Applied Econometrics *or* project b): Operations Research	15	7-point scale	Internal
	C	Measure Theory and Stochastic Processes (MAT7)	5	Pass/Fail	Internal
		Elective courses (valgfag). The student selects courses equivalent to 10 ECTS			
	C	Financial Econometrics and Quantitative Methods in Finance	5	7-point scale	Internal
	C	Numerical Analysis	5	Pass/Fail	Internal
	C	Topics in Operations Research (M-tech)	5	7-point scale	Internal
	C	Advanced Operations Management (M-tech)	5	7-point scale	Internal
	C	Flexible Manufacturing (M-tech)	5	7-point scale	Internal
	C	Topics in Statistical Science I (MAT7)	5	7-point scale	Internal
	C	Topics in Statistical Science II (MAT7)	5	7-point scale	Internal
	C	Statistics for Duration Data (MAT7)	5	Pass/Fail	Internal
MATØK8	P	The student follows *either* project a) In-depth Study of Financial Engineering *or* project b): Supply Chain Operations and Analysis	15	7-point scale	External
		Elective courses (valgfag). The student selects courses equivalent to 15 ECTS			
	C	Quantitative Finance and Computational Statistics	5	Pass/Fail	Internal
	C	Continuous Time Finance	5	Pass/Fail	Internal
	C	Data Mining	5	Pass/Fail	Internal
	C	Manufacturing and Supply Chain Systems (M-tech)	5	7-point scale	Internal
	C	Business Intelligence and Analytics (M-tech)	5	7-point scale	Internal
	C	Spatial Statistics and Markov Chain Monte Carlo Methods (MATTEK6)	5	Pass/Fail	Internal
MATØK9 A	P	Advanced Topics with Applications	20	7-point scale	Internal
		Elective courses (valgfag). The student selects courses equivalent to 10 ECTS			
	C	Financial Econometrics and Quantitative Methods in Finance	5	7-point scale	Internal
	C	Numerical Analysis	5	Pass/Fail	Internal
	C	Topics in Statistical Science I (MAT7)	5	Pass/Fail	Internal
	C	Topics in Statistical Science II (MAT7)	5	Pass/Fail	Internal
	C	Statistics for Duration Data (MAT7)	5	Pass/Fail	Internal
	C	Flexible Manufacturing (M-tech)	5	7-point scale	Internal
	C	Topics in Operations Research (M-tech)	5	7-point scale	Internal
	C	Advanced Fixed Income and Their Derivatives (oecon)	10	Pass/Fail	Internal

MATØK9 Or B		Study at another university, must be approved by the Study Board	30	Transfer of credits	Transfer of credits
MATØK9 Or C	P	Long Master's Thesis[1], must be approved by the Study Board	+20	7-point scale	External
	C	Elective courses (valgfag). The student selects courses equivalent to 10 ECTS. See 3rd semester MATØK9 "A".	5+5		
MATØK9 Or D	P	Long Master's Thesis[2], must be approved by the Study Board	+30	7-point scale	External
MATØK10	P	Master's Thesis	30, possible 50 or 60	7-point scale	External
Total			120		

[1] See module description for the Master's Thesis. The long Master's Thesis, which must be of experimental character, is prepared in the 3rd and 4th semesters; the extent is 50 ECTS project + 10 ECTS courses.

[2] See module description for the Master's Thesis. The long Master's Thesis, which must be of experimental character, is prepared in the 3rd and 4th semesters; the extent is 60 ECTS project

3.1 Descriptions of modules

3.1.1 Projects on 1'st semester, MATØK7

The students chose project a or project b.

Project a

Empirical Financial Modelling and Applied Econometrics / Empirisk finansiering og anvendt økonometri

Objectives: Students who have completed the module meet the following criteria:

Knowledge:

- have understanding of relevant theories and methods within one or more of these areas: option pricing and estimation of time-varying volatility models, zero coupon term structure models, dynamic term structure models, models for stock portfolios and intertemporal asset pricing models, event studies in corporate finance, or computational finance and Monte Carlo methods applied to pricing
- are able to understand and to reflect on these subject areas' issues on a scientific basis

Skills:

- must be able to identify, formulate and analyse a scientific problem independently, systematically and critically
- must be able to relate the problem to financial econometrics or quantitative finance, including explanations of the choices that have been made
- must be able to independently perform and justify the choice of theories and methods
- must be able to communicate research-based knowledge and discuss the professional and scientific problems with other people both within mathematics and economics

Competencies:

- must be able to control work and development situations which are complex, unpredictable and that require new models within financial econometrics or other quantitative finance subject area
- must be able to initiate and complete collaborations within financial econometrics, and if relevant also interdisciplinary collaborations, as well as assume professional responsibility
- must be able to independently assume responsibility for own professional development and specialisation

Type of instruction: Project work.

Exam format: Group exam based on a written report.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Project b

Operations Research / Operationsanalyse

Objective**:** Students who complete the module are expected to:

Knowledge*:*

- have gained in-depth knowledge of the development of quantitative operations management (OM) models on real life problems. The knowledge could be gained in a development project:
  - with one or more companies or public organisations
  - in a lab environment

Skills:

- be able to develop, test and demonstrate the limitations of quantitative methods for Operations Management
- be able to compare and evaluate theoretical and experimental results
- be able to critically evaluate applied methods and their results

Competencies:

- possess the ability to identify opportunities for implementing quantitative methods from operations management
- be able to develop Operations Management techniques that can be implemented in an industrial, service or public organization
- be able to evaluate the impact of implementing the developed methods

Type of instruction: Project work.

Exam format: Group exam based on a written report.

Evaluation criteria: Are stated in the Joint Programme Regulations.

3.1.2. Courses on 1'st semester, MATØK7

The course Measure Theory and Stochastic Processes must be followed by all students (mandatory course).

Measure Theory and Stochastic Processes / Målteori og stokastiske processer

Recommended academic prerequisites: The module builds on knowledge obtained by the modules Linear Algebra with Applications, Analysis 1, Analysis 2, and Probability Theory from the BSc in Mathematics-Economics.

Objective: Students who have completed the module meet the following criteria:

Knowledge:

- know selected topics concerning general measure theory with special focus on probability theoretical. Topics as existence and uniqueness of measures, Lebesgue-integration, Expectation and condition expectation, Radon-Nikodyms theorem, and information expressed through sigma-algebras
- know about stochastic processes in discrete and continuous time
- know about Wiener processes
- know about Martingales
- know about stochastic integrals, Ito's formula and Girsanovs theorem

Skills

- are able to calculate fundamental characteristics for stochastic processes.
- are able to conduct a change of measure for a martingale

Competencies

- are able to formulate mathematical results in a correct manner by means of measure-theoretical and probabilistic argumentation.
- are able to apply and mediate basic mathematics and theory related to stochastic processes.
- able to gain additional knowledge regarding probability theoretical subjects related to stochastic processes and their application in Finance

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Financial Econometrics and Quantitative Methods in Finance / Økonometri og kvantitative metoder inden for finansiering

Recommended academic prerequisites: The module builds on knowledge obtained by the modules Analysis 2 and Probability Theory from the BSc in Mathematics-Economics.

Objective: Students who have completed the module will satisfy the following criteria:

Knowledge:

- understanding of the most common applied quantitative and empirical methods in econometrics, including in particular financial econometrics
- knowledge about option pricing and estimation of time-varying volatility models
- know about zero coupon term structure models
- know about dynamic term structure models
- know about models for stock portfolios and intertemporal asset pricing models
- know about event studies in corporate finance
- know about computational finance and Monte Carlo methods applied, e.g., to the pricing of exotic options

Skills:

- are able to argue for the importance of econometric/statistical methods in the analysis of a given financial problem
- are able to build econometric models and judge their applicability

Competencies:

- are able to demonstrate understanding of the theory of the econometric models and know how to reason within the models
- are able to communicate the results of an econometric analysis to non-specialists in the financial sector
- are able to analyse financial data using the available software

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Numerical Analysis / Numerisk analyse

Recommended academic prerequisites: The module builds on knowledge obtained by the modules Linear Algebra with Applications, Analysis 1, and Probability Theory from the BSc in Mathematics-Economics.

Objective: Students who have completed the module meet the following criteria:

Knowledge:

- have knowledge of floating point arithmetic, including the international standards for floating point arithmetic
- have knowledge of error analysis and stability of numerical algorithms
- have knowledge of polynomial interpolation and its application to the derivation of numerical algorithms
- have knowledge of basic results in approximation theory
- have knowledge of methods for finding zeroes of functions
- have knowledge of numerical linear algebra, in particular algorithms adapted to large sparse systems of linear equations
- have knowledge of methods for numerical differentiation, including spectral methods
- have knowledge of methods for numerical integration, including Gaussian quadrature
- have knowledge of numerical solution methods for ordinary differential equations, including spectral methods
- have knowledge of some probabilistic methods in numerical analysis, including Monte-Carlo methods

Skills:

- can implement basic numerical algorithms in different computer architectures
- can choose appropriate numerical methods to solve a given class of problems

Competencies:

- can evaluate the appropriateness of a given numerical method for solving a class of problems
- are aware of the limitations of numerical methods to solve a class of problems

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Oral exam. In order to participate in the exam, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Topics in Operations Research / Emner i operationsanalyse

Objective**:** Students who complete the module are expected to:

Knowledge:

- manufacturing planning and control including inventory management and material requirements planning
- optimization of discrete problems
- heuristics and meta-heuristics
- relational databases and their usage

Skills:

- formulate discrete optimization problems
- chose the appropriate solution strategy to a number of discrete optimization problems
- perform basic database operations

Competencies:

- understand the principles of inventory management
- understand differences in solutions strategies
- apply heuristics and meta-heuristic methods to solve complex problems
- understand relational data structures
- understand the limitations, advantages and disadvantages of relational data structures

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Internal oral or written examination.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Advanced Operations Management / Udvidede teknikker til planlægning og styring

(from Study Regulations: Master of Science (MSc) in Engineering (Operations and Supply Chain Management), 2015. Faculty of Engineering, Study Board of Industry and Global Business Development.

Studieordning for Civilingeniør, cand.polyt. i virksomhedssystemer, 2015 (Master of Science (MSc) in Engineering (Operations and Supply Chain Management)
http://www.ses.aau.dk/studienaevn/industri-global-forretningsudvikling/studieordninger/)

Recommended academic prerequisites: None.

Objective: Students who complete the module are expected to:

Knowledge:

- Have gained both theoretical and practical knowledge about stochastic simulation and its utilisation in improvement of planning and control systems in companies and supply chains
- Have gained knowledge of a number of numerical and mathematical methods and models for designing and improving planning and control concepts in companies and supply chains
- Have gained knowledge and understanding about numerical analysis of demand patterns

Have gained knowledge about advanced order management systems

- Have gained knowledge about stochastic discrete event simulation and simulation tools
- Have gained knowledge to identify key performance indicators relevant to evaluate stochastic simulation models.

Skills:

- Be able to analyse and develop order management systems for both industrial and service companies
- Be able to conduct a numerical analysis of a company's and supply chain's performance. This involves both choice and utilisation of statistical analysis methods on selected elements of companies and supply chains
- Show understanding the utilisation of probabilistic models in connection with design and usage of planning and control systems. This includes knowledge and insight into the opportunities and limitations of probabilistic models
- Be able to utilise stochastic discrete event simulation to assess opportunities and limitations of a production system and be able to utilise simulation as a tool for analysis and synthesis in their project work
- Be able to be model and simulate a specific company's production system and evaluate the performance of this system
- Be able to design and redesign planning and control systems in production and service management companies and supply chains adapted to a company's or supply chain's specific situation.

Competences:

- Be able to combine a number of mathematical tools in an appropriate manner to conduct an analysis of the as-is situation of a company or supply chain.

Type of instruction: See Chapter 3.
Exam format: Internal oral or written examination.
Evaluation criteria: Are stated in the Joint Programme Regulations.

Flexible Manufacturing / Fleksibel produktion

(from: Study Regulations: Master of Science (MSc) in Engineering (Operations and Supply Chain Management), 2015. Faculty of Engineering, Study Board of Industry and Global Business Development.

Studieordning for Civilingeniør, cand.polyt. i virksomhedssystemer, 2015 (Master of Science (MSc) in Engineering (Operations and Supply Chain Management)
http://www.ses.aau.dk/studienaevn/industri-global-forretningsudvikling/studieordninger/)

Recommended academic prerequisites: None.

Objective: Students who complete the module are expected to:

Knowledge:

- Have gained knowledge about mass customization systems in an operations management context
- Have gained knowledge about assessment of mass customization performance
- Have gained knowledge about product architecture, manufacturing architecture and their relations to mass customization
- Have gained knowledge about flexible manufacturing systems, reconfigurable manufacturing systems, changeable manufacturing systems, automated manufacturing systems and the differences between these
- Have gained knowledge of planning methods designed specifically for flexible manufacturing systems

Skills:

- Be able to analyze a product family in terms of variety and product architecture
- Be able to evaluate different IT solutions supporting mass customization, including product configurators and perform basic modelling
- Be able to analyze a range of manufacturing tasks and evaluate different types of manufacturing systems to determine the appropriate level of flexibility vs. automation
- Be able to model flexible manufacturing problems

Competencies:

- Have the competence to evaluate a company's product portfolio in terms of volume, variety and manufacturing tasks and identify solutions for IT system support and manufacturing system design.

Type of instruction: See Chapter 3.

Exam format: Internal oral or written examination.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Topics in Statistical Sciences I / Emner inden for statistisk videnskab I

Recommended academic prerequisites: The module builds on knowledge obtained by the modules Probability Theory and Statistical Inference for Linear Models from the BSc in Mathematics-Economics.

Objective:

Knowledge: The students completing the module will have gained knowledge about a number of topics from the statistical sciences at an advanced level.

The list may include, but is not limited to, the following topics:

- dynamical linear models, including the Kalman filter
- population methods, specifically evolutionary computing and genetic algorithms
- meta analysis
- robust statistical methods including non-parametric models
- factor analysis
- graphical models, including hierarchical models

Skills:

- can apply the relevant methodologies to one or more datasets by using appropriate software implementations, and interpret the output and modify the model parameters accordingly
- are able to state the underlying assumptions and argue about limitations and extendibility of the methodology in one or more specific settings
- can assess goodness-of-fit for the models where appropriate

Competencies:

- can acquire supplementary knowledge about the relevant methodologies
- can combine appropriate topics from the course to analyse a specific dataset.
- can in writing describe the methodologies, results and outcome from an analysis of a specific dataset

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Topics in Statistical Science II / Emner inden for statistisk videnskab II

Recommended academic prerequisites: The module builds on knowledge obtained by the module Topics in Statistical Science I.

Objective:

Knowledge: The students completing the module will have gained knowledge about a number of topics from the statistical sciences at an advanced level. The list may include, but is not limited to, the following topics:

- state space models and hidden Markov models
- expectation-maximisation (EM) algorithm and missing data
- multivariate Gaussian distribution (and related distributions, e.g. Hotelling's T^2 and Wishart distributions)
- INLA
- generalised estimating equations
- bootstrap, cross-validation and other resampling techniques

Skills:

- can apply the relevant methodologies to one or more datasets by using appropriate software implementations, and interpret the output and modify the model parameters accordingly
- are able state the underlying assumptions and argue about limitations and extendibility of the methodology in one or more specific settings
- can assess goodness-of-fit for the models where appropriate

Competencies:

- can acquire supplementary knowledge about the relevant methodologies
- can combine appropriate topics from the course to analyse a specific dataset
- can in writing describe the methodologies, results and outcome from an analysis of a specific dataset

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Statistics for Duration Data / Varighedsanalyse

Recommended academic prerequisites: The module builds on knowledge obtained by the modules Probability Theory and Statistical Inference for Linear Models from the BSc in Mathematics-Economics.

Objective: Students who have completed the module meet the following criteria:

Knowledge:

- understand the special features of duration data (e.g. censoring, non-normality)
- derive the likelihood function for right-censored data
- know basic characterisations of duration data distributions such as the survival and hazard function
- be able to derive basic non-parametric estimates such as the Kaplan-Meier and Nelson-Aalen estimates
- know parametric models for duration data
- understand the assumptions underlying the Cox partial likelihood
- derive the Cox partial likelihood
- know methods of model assessment for parametric models and the Cox proportional hazards model

Skills:

- be able to identify relevant type of censoring for a specific set of duration data
- be able to estimate and interpret survival functions or cumulative hazard functions for a specific set of duration data
- be able to fit duration data using parametric or semi-parametric regression models
- be able to assess the validity of a model for a specific set of duration data

Competencies:

- be able to identify an appropriate duration data methodology for investigating a specified hypothesis of interest
- be able to interpret and critically assess results of the analysis carried out using the chosen methodology
- be able to convey the results of the analysis to a non-statistician

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Oral exam or individual ongoing during the course.

Evaluation criteria: Are stated in the Joint Programme Regulations.

3.2.1 Projects on 2'nd semester, MATØK8

The students chose project a or project b.

Project a

In-depth Study of Financial Engineering / Fordybelse inden for *Financial Engineering*

Recommended academic prerequisites**:** The module builds on knowledge obtained by the modules on the 1st semester.

Objectives: Students who have completed the module meet the following criteria concerning at least one central area within Mathematics-Economics

Knowledge:

- have expert understanding of relevant theories and methods within quantitative finance and computational statistics or continuous time finance in general
- are able to understand and on a scientific basis reflect on these subject areas' scientific issues

Skills:

- must be able to identify, formulate and analyse a scientific problem independently, systematically and critically
- must be able to relate the problem to a quantitative finance subject area, including explaining the choices that have been made in connection to the delimitation of the problem
- must be able to independently make and justify the choice of theories and methods
- must be able to communicate research-based knowledge and discuss the professional and scientific problems with other people both within mathematics and economics

Competencies:

- must be able to control work and development situations which are complex, unpredictable and require new models within quantitative finance and computational statistics or continuous finance in general
- must be able to initiate and complete collaborations within quantitative finance, and if relevant also interdisciplinary collaborations, as well as assume professional responsibility
- must be able to independently assume responsibility for own professional development and specialisation

Type of instruction: Project work.

Exam format: Group exam based on a written report.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Project b

Supply Chain Operations and Analysis / Implementering og analyse af forsyningskæder

Recommended academic prerequisites**:** The module builds on knowledge obtained by the modules on the 1st semester.

Objective**:** Students who complete the module:

Knowledge:

- have gained in-depth knowledge of supply chain operations and analyzing the behavior of supply chains.

The knowledge could be gained in a development project:

- with one or more companies or public organisations

or

- in a lab environment concerning supply chain software or techniques

Skills:

- should be able to analyse and model the behaviour of supply chains using data mining,
- should be able to model a Business Intelligence setup,
- should be able to critically evaluate the applied methods and their results

Competencies:

- possess the ability to identify and implement monitoring and analysis with special focus on cross-company issues (e.g. one or more customers or suppliers)
- should be able to implement supply chain systems in an industrial, service or public organisation

Type of instruction: Project work.

Exam format: Group exam based on a written report.

Evaluation criteria: Are stated in the Joint Programme Regulations.

3.2.2. Courses on 2'nd semester, MATØK8

Quantitative Finance and Computational Statistics / Quantitative Finance and Computational Statistics

Recommended academic prerequisites: The module builds on knowledge obtained by the modules Partial Differential Equations, Statistical Inference for Linear Models and knowledge of one or more programming languages from the BSc in Mathematics-Economics.

Objective: Students who have completed the module meet the following criteria:

Knowledge:

- know about quantitative software development with a focus on computational finance
- know about core models & products: stochastic volatility models, vanilla & exotic derivatives
- know about numerical treatment of stochastic differential equations (SDEs) and partial differential equations (PDEs)
- know about Monte Carlo foundations and applications
- know about Fourier transform pricing
- calibration (applied numerical optimization, market data)

Skills:

- are able to analyse a given model and apply it on market data
- are able to develop quantitative software in line with the existing practices in the financial industry
- are able to perform all stages of the verification and validation (V&V) process in quantitative software development – assessing the results obtained from a financial model

Competencies:

- are able to independently develop, analyse, and apply quantitative finance models relevant to a financial problem at hand
- are able to communicate the results of applying the models appropriate to a given financial problem to non-specialists in the financial industry
- discuss relative strengths and weaknesses of numerical methods (SDEs, PDEs, Fourier Transform) in relation to financial products (derivatives) and tasks (pricing, hedging, calibration)

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam, or individual ongoing during the course. In order to participate in the course evaluation, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Continuous Time Finance / Kontinuert-tids finansiering

Recommended academic prerequisites: The module builds on knowledge obtained by the modules on the 1st semester and in particular Measure Theory and Stochastic Processes.

Objective: Students who have completed the module will satisfy the following criteria:

Knowledge:

- know about the Black-Scholes model
- know about risk-neutral pricing
- know about the martingale representation theorem and the martingale approach to arbitrage theory
- know about the market price of risk
- know about options, exotic options, and American derivatives
- know about hedging
- know about standard models of the term structure of interest rates

Skills:

- are able to work in-depth in other financial theory topics, e.g., credit risk models or advanced option theory
- are able to construct a relevant continuous time financial model based on a concrete problem.
- are able to analyse the models through martingales and arbitrage theory
- are able to judge the validity of results obtained

Competencies:

- are able to communicate results of analysis of continuous time financial models to non-specialists in the financial world
- are able to develop the ability to individually develop own continuous time models suited for a given financial problem

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam, or individual ongoing during the course.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Data Mining / Data Mining

Recommended academic prerequisites: The module builds on knowledge obtained by the module Statistical Inference for Linear Models from the BSc in Mathematics-Economics.

Objective: Students who have completed the module meet the following criteria:

Knowledge:

- understand computer intensive techniques for validating models (cross validation and bootstrap) and can account for the variance-bias trade-off
- know of various methods for visualising high-dimensional data
- know the difference between classification and regression, and understand classification methods relying on classifications trees, prototype methods and Bayes classifiers
- know of various supervised and unsupervised methods within statistical learning
- know of association rule methods for the analysis of transaction data
- can perform link mining for network data e.g. internet pages
- have knowledge of methods to do hierarchical and partitioning cluster analysis
- know of model averaging, bagging and boosting

Skills:

- are able to identify and apply a relevant data mining algorithm in a specific context
- can identify and discuss weaknesses and strengths of different data mining algorithm in relation to a specific analysis task
- can interpret and communicate the results of a given data mining analysis to non-specialists

Competences:

- have the ability to survey potentials and limitations of different data mining software packages
- have the understanding to choose and apply specific software meeting user demands

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam, or individual ongoing during the course. In order to participate in the course evaluation, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Manufacturing and Supply Chain Systems / Fremstillings- og forsyningskædesystemer

(from: Study Regulations: Master of Science (MSc) in Engineering (Operations and Supply Chain Management), 2015. Faculty of Engineering, Study Board of Industry and Global Business Development.

Studieordning for Civilingeniør, cand.polyt. i virksomhedssystemer, 2015 (Master of Science (MSc) in Engineering (Operations and Supply Chain Management)
http://www.ses.aau.dk/studienaevn/industri-global-forretningsudvikling/studieordninger/)

Recommended academic prerequisites: The module builds on knowledge obtained by the modules on the 1st semester.

Objective: Students who complete the module are expected to:

Knowledge:

- Have gained knowledge of the structure and functionality of manufacturing and supply chain systems such as Enterprise Resource Planning, Advanced Planning & Scheduling, Vendor Managed Inventory, Optimisation Suites and Shop Floor Planning & Control
- Have gained knowledge of planning technologies and configuration of manufacturing and supply chain systems
- Have gained knowledge of how to share information and coordinate decisions in a supply chain

Skills:

- Be able to work with differentiated manufacturing and supply chain control
- Be able to work with manufacturing and supply chain control principles
- Be able to work with information sharing levels

Competences:

- Be able to select and design differentiated manufacturing and supply chain control principles
- Be able to develop planning and control solutions

Type of instruction: See Chapter 3.

Exam format: Internal oral or written examination according to the decision of the study board.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Business Intelligence and Analytics / Business Intelligence og analytiske metoder

(from: Study Regulations: Master of Science (MSc) in Engineering (Operations and Supply Chain Management), 2015. Faculty of Engineering, Study Board of Industry and Global Business Development.

Studieordning for Civilingeniør, cand.polyt. i virksomhedssystemer, 2015 (Master of Science (MSc) in Engineering (Operations and Supply Chain Management)
http://www.ses.aau.dk/studienaevn/industri-global-forretningsudvikling/studieordninger/

However, the following competences under objectives apply:

Competences
- Apply knowledge and skills in relation to business intelligence development projects and thereby apply the knowledge handling activities: knowledge acquisition, knowledge verification and knowledge engineering.
- Treatment of quality data issues)

Prerequisites: The module builds on knowledge obtained by the modules on the semester MATØK7.

Objective: Students who complete the module are expected to:

Knowledge:
- Have gained in-depth understanding of Business Intelligence (BI) concepts, theories and methods including:
    - Creation of knowledge from either people/employees/"experts" or from analysing existing data
    - Knowledge representation
    - Traditional BI handling systems such as expert systems, knowledge base systems, decision support systems and executive information systems

Skills:
- Be able to make decisions about optimal use of the BI, theories, methods and selected systems for identification of needs, development of alternative solutions, evaluation selection and implementation
- Be able to use BI in disciplines such as enterprise engineering/modelling, business analytics, data mining, etc.

Competences:
- Apply knowledge and skills in relation to business intelligence development projects and thereby apply the knowledge handling activities: knowledge acquisition, knowledge verification and knowledge engineering.
- Treatment of quality data issues

Type of instruction: See Chapter 3.

Exam format: Internal oral or written examination.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Spatial Statistics and Markov Chain Monte Carlo Methods / Rumlig statistik og Markovkæde Monte Carlo-metoder

Recommended academic prerequisites: The module builds on knowledge obtained by the module Statistical Inference for Linear Models from the BSc in Mathematics-Economics.

The course deals with Markov chain Monte Carlo methods as well as one or more of the three main topics within spatial statistics.

Objective: Students who have completed the module meet the following criteria:

Knowledge:

- know the fundamental models and methods within the chosen main topics (geostatistics, lattice processes or spatial point processes) as well as Markov chain Monte Carlo.
- have knowledge about the following subjects within the chosen main topic(s)
    - Geostatistics:
      Theory for second order stationary processes, variograms/covariograms, prediction and kriging, as well as model based geostatistics
    - Lattice processes:
      Markov fields, Brook's factorisation and Hammersley-Clifford's theorem and likelihood based statistical analysis
    - Spatial point processes:
      Poisson processes, Cox processes and Markov point processes, as well as statistical analyses based on non-parametric methods (summary statistics) and likelihood based methods
    - Markov chain Monte Carlo:
      Fundamental theory of Markov chains with a view to simulation, Markov chain Monte Carlo methods for simulation of distributions, including the Metropolis-Hastings algorithm and the Gibbs sampler

Skills:

- are able to explain the main theoretical results from the course
- are able to perform statistical analyses of concrete datasets
- are able to simulate the examined models

Competencies:

- are able to interpret a spatial statistical model in relation to a concrete dataset and give an account of the limitations of the model with respect to describing the variation in the dataset using the theoretical results within spatial statistics
- are able to simulate distributions using Markov chain Monte Carlo methods and evaluate the output of the Markov chain

Type of instruction: As described in the introduction to Chapter 3.

Exam format: Individual oral or written exam, or individual ongoing evaluation. In order to participate in the exam, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

Evaluation criteria: Are stated in the Joint Programme Regulations.

3.3.1 Projects on 3'rd semester, MATØK9

Advanced Topics with Applications / Videregående emner inden for matematik-økonomi med anvendelser

Recommended academic prerequisites: The module builds on knowledge obtained by the modules on the 2nd semester.

Objectives: Students who have completed the module meet the following criteria concerning at least one central area within mathematics-economics:

Knowledge:

- have expert understanding of relevant theories and methods within one of the main areas Financial Engineering or Operations Research
- knowledge of one or more applications of the theories within the scope of the first two semesters of the degree programme (for example, arbitrage theory and asset pricing, mean-variance analysis, martingale pricing, volatility analysis, quantitative risk management, operations management, project management, business intelligence , supply chain management, or data mining)

Skills:

- must be able to identify, formulate and analyse a scientific problem independently, systematically and critically
- must be able to relate the problem to either the financial engineering subject area or the operations research subject area, including explaining the choices that have been made in connection to the delimitation of the problem
- must be able to independently make and justify the choice of theories and methods
- must be able to communicate research-based knowledge and discuss the professional and scientific problems with other people both within mathematics and economics

Competencies:

- must be able to control work and development situations which are complex, unpredictable and require new models within financial engineering or within operations research
- must be able to initiate and complete collaborations within financial engineering or operations research, and if relevant also other interdisciplinary collaborations, as well as assume professional responsibility
- must be able to independently assume responsibility for own professional development and specialisation

Type of instruction: project work.

Exam format: Group exam based on a written report.

Evaluation criteria: Are stated in the Joint Programme Regulations.

3.3.2. Course on 3'rd semester, MATØK9

These are the elective courses on MATØK9:

- Financial Econometrics and Quantitative Methods in Finance
- Numerical Analysis
- Topics in Statistical Science I
- Topics in Statistical Science II
- Statistics for Duration Data
- Flexible Manufacturing (M-tech)
- Topics in Operations Research (M-tech)
- Advanced Fixed Income and Their Derivatives (oecon)

Only a limited number of elective courses from the list above will be offered at each semester. Students can only participate once in a course with a given title.

Description of the course Advanced Fixed Income and Their Derivatives can be found below. Description of the rest of the courses can be found in section 3.1.2 Courses MATØK7.

Advanced Fixed Income and Their Derivatives / Videregående finansieringsteori

(Elective course (valgfag) on the 7'th semester in the Study Regulations: Master of Science (MSc) in Engineering (Operations and Supply Chain Management).

Studieordning for Kandidatuddannelsen i Samfundsøkonomi, 2013 med ændringer 2015. Studienævnet for Oecon., Det Samfundsvidenskabelige Fakultet, Samfundsøkonomi, see web page:
http://www.fak.samf.aau.dk/uddannelse/studieordninger/oekonomi/

Description from Moodle (Modulbeskrivelse):
https://www.moodle.aau.dk/enrol/index.php?id=22623

Mål:
Ved valgfag forstås fag og faglige områder, der ikke indgår som konstituerende elementer i kandidatuddannelsen. Studienævnet for Oecon. kan alene eller i samarbejde med andre studienævn udbyde studieaktiviteter, der kan godkendes som valgfag. Valgfag kan også udbydes af andre studienævn ved Aalborg Universitet eller andre universiteter i Danmark eller i udlandet. Valgfagene skal forhåndsgodkendes af studienævnet og evalueres som angivet i den for valgfaget gældende studieordning.

Indhold:
Afhænger af valgfag.

Undervisnings- og arbejdsformer:
Afhænger af valgfag.

Forudsætninger for deltagelse:
Afhænger af valgfag.

Læringsmål:
Det er målet, at de studerende efter modulet kan:

- tilegne sig og anvende den viden og de færdigheder der er gældende for valgfaget,
- tage selvstændigt ansvar for egen faglige udvikling og specialisering.

Målopfyldelse/evalueringskriterier:
Afhænger af valgfag.

3.4.1 Project on 4'th semester, MATØK10

Master's Thesis / Kandidatspeciale
The student may write a Long Master's Thesis (over 2 semesters: 60 ECTS), if the thesis is of experimental character and approved by the study board. The extend of the experimental work must reflect the duration of the thesis. The Long Master's Thesis can also be combined with 2 elective courses, which means that a Long Master's thesis can either be 50 ECTS combined with 10 ECTS elective courses or 60 ECTS if no elective courses are chosen.

Objectives: Students who have completed the module meet the following criteria concerning at least one central area within mathematics-economics:

Knowledge:

- have
  - expert understanding within one or a few selected elements of a central mathematics-economics subject area based on high level research, or
  - a broader insight into a central mathematical-economics subject area with respect to theories and methods and their interrelationships
- must be able to understand and on a scientific basis reflect upon the knowledge of the mathematical-economics subject area and be able to identify scientific problems

Skills:

- must be able to identify, formulate and analyse a scientific problem independently, systematically and critically
- must be able to relate the problem to the mathematical-economics subject area, including explaining the choices that have been made in connection to the delimitation of the problem
- must be able to independently make and justify the choice of mathematical-economics theories and methods
- must be able to independently and critically evaluate the chosen theories and methods as well as the analyses, results and conclusions in the project, both during and at the end of the project period
- must be able to evaluate and choose between the scientific theories, methods, tools, and general skills within the mathematical-economics subject area

Competencies:

- must be able to control work and development situations which are complex, unpredictable and require new mathematical-economics models or methods for solution
- must be able to initiate and complete mathematically and economically oriented collaborations, and if relevant also other interdisciplinary collaborations, as well as assume professional responsibility
- must be able to independently assume responsibility for own professional development and specialisation

Type of instruction: Project work.

Exam format: Group exam based on project report.

Evaluation criteria: Are stated in the Joint Programme Regulations.

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean and enters into force as of September 2018.

Students who wish to complete their studies under the previous curriculum from 2017 must conclude their education by the summer examination period 2019 at the latest, since examinations under the previous curriculum are not offered after this time.

Chapter 5: Other Provisions

5.1 Rules concerning written work, including the Master's thesis

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as 'Pass' on the basis of good language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone.
The study board can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Master's thesis must include an English summary.[3] If the project is written in English, the summary must be in Danish.[4] The summary must be at least 1 page and not more than 2 pages. The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning credit transfer (merit), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad

The study board can approve successfully completed (passed) programme elements from other Master's programmes in lieu of programme elements in this programme (credit transfer). The study board can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made by the study board based on an academic assessment. See the Joint Programme Regulations for the rules on credit transfer.

5.3 Rules for examinations

The rules for examinations are stated in the Examination Policies and Procedures published by The Faculty of Engineering and Science on their website.

All students who have not participated in Aalborg University's PBL introductory course during their Bachelor's degree must attend the introductory course "Problem-based Learning and Project Management". The introductory course must be approved before the student can participate in the project exam. For further information, please see the School of Engineering and Science's website.

[3] Or another foreign language (upon approval from the study board.
[4] The study board can grant exemption from this.

5.4 Exemption

In exceptional circumstances, the study board can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.5 Rules and requirements for the reading of texts

It is assumed that the student can read academic texts in his or her native language as well as in English and use reference works etc. in other European languages.

5.6 Additional information

The current version of the curriculum is published on the study board's website, including more detailed information about the programme, including exams.

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4. december 2017/mnr
Skemajustering 3. april 2018 – Numerical Analysis (mangled "Numerical")