Econometrics and Operations Research (MSc)

VU University Amsterdam - Fac. der Economische Wet. en Bedrijfsk. - M Econometrics and Operational Research - 2015-2016

The Master's programme in Econometrics and Operations Research is an academic programme focusing on the development and application of quantitative methods for analysing economic issues in a broad sense. It is a successful preparation for a professional career in which mathematics, statistics and ICT are used in analysing and solving complex issues in general economics, and business and financial economics. Econometrists are also employed as experts in optimizing strategic and operational business processes like transport flows, stock management and operating systems. Econometrists can be found working at the central banks of Europe, at federal banks in the United States, at central government agencies and ministries, financial institutions, consultancy firms and in the majority of listed companies.

The components of the Master's programme correspond closely with the department's research interests, which means that many of the latest scientific developments in areas like financial econometrics, logistics and game theory find their way directly into the teaching programme. Students also benefit from having the opportunity to study in small groups and work closely with the academic staff.

Read the full description of the programme or use the schedule below for information on the individual courses in the programme.

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M Econometrics - Ectr and Math Ec

Courses:

Name	Period	Credits	Code
Advanced Algorithms	Period 1+2	6.0	E_EORM_AA
Advanced Corporate Finance	Period 1	6.0	E_FIN_ACF
Advanced Econometrics	Period 1+2	6.0	E_EORM_AECTR
Advanced Macroeconomics	Period 2	6.0	E_EC_AMAEC
Asset Pricing	Period 1	6.0	E_FIN_AP
Asymptotic Statistics	Period 1+2	8.0	X_400323
Case Study	Period 3	6.0	E_EORM_CASE
Consumer Marketing	Period 1	6.0	E_MKT_CM
Customer Intelligence	Period 4	6.0	E_MKT_CI
Data Mining Techniques	Period 5	6.0	X_400108
Derivatives	Period 2	6.0	E_FIN_DER
Environmental Economics	Period 2	6.0	E_STR_EEC
Financial Markets and Institutions	Period 4	6.0	E_FIN_FMI
Globalization, Growth and Development	Period 4	6.0	E_EC_GGD
Labour Economics	Period 4	6.0	E_EC_LABEC
Mathematical Systems and Control Theory	Period 1+2	6.0	X_400180
Regional and Urban Economics	Period 2	6.0	E_STR_RUE
Simulation and Stochastic Systems	Period 4	6.0	E_EORM_SSS
Stochastic Processes for Finance	Period 1+2	6.0	X_400352
Strategic and Cooperative Decision Making	Period 2	6.0	E_EORM_SCDM
Thesis	Ac. Year (September)	18.0	E_EORM_THS
Time Series Econometrics	Period 4	6.0	E_EORM_TSE

M Econometrics - No specialisation

Courses:

Name	Period	Credits	Code
Advanced Algorithms	Period 1+2	6.0	E_EORM_AA
Advanced Corporate Finance	Period 1	6.0	E_FIN_ACF

Advanced Econometrics	Period 1+2	6.0	E_EORM_AECTR
Advanced Macroeconomics	Period 2	6.0	E_EC_AMAEC
Asset Pricing	Period 1	6.0	E_FIN_AP
Asymptotic Statistics	Period 1+2	8.0	X_400323
Case Study	Period 3	6.0	E_EORM_CASE
Consumer Marketing	Period 1	6.0	E_MKT_CM
Customer Intelligence	Period 4	6.0	E_MKT_CI
Data Mining Techniques	Period 5	6.0	X_400108
Derivatives	Period 2	6.0	E_FIN_DER
Distribution Logistics and Supply Chain Management	Period 1	6.0	E_BA_DLSCM
Environmental Economics	Period 2	6.0	E_STR_EEC
Evolutionary Computing	Period 1	6.0	X_400111
Financial Markets and Institutions	Period 4	6.0	E_FIN_FMI
Globalization, Growth and Development	Period 4	6.0	E_EC_GGD
Labour Economics	Period 4	6.0	E_EC_LABEC
Mathematical Systems and Control Theory	Period 1+2	6.0	X_400180
Neural Networks	Period 1	6.0	X_400132
Regional and Urban Economics	Period 2	6.0	E_STR_RUE
Simulation and Stochastic Systems	Period 4	6.0	E_EORM_SSS
Stochastic Optimization	Period 1+2	6.0	X_400336
Stochastic Processes for Finance	Period 1+2	6.0	X_400352
Strategic and Cooperative Decision Making	Period 2	6.0	E_EORM_SCDM
Thesis	Ac. Year (September)	18.0	E_EORM_THS
Time Series Econometrics	Period 4	6.0	E_EORM_TSE
Transport Economics	Period 4	6.0	E_STR_TREC

M Econometrics - OR and Bus Ectr

Courses:

Name	**Period**	**Credits**	**Code**
Advanced Algorithms	Period 1+2	6.0	E_EORM_AA
Advanced Econometrics	Period 1+2	6.0	E_EORM_AECTR
Asset Pricing	Period 1	6.0	E_FIN_AP
Case Study	Period 3	6.0	E_EORM_CASE
Data Mining Techniques	Period 5	6.0	X_400108
Derivatives	Period 2	6.0	E_FIN_DER

Distribution Logistics and Supply Chain Management	Period 1	6.0	E_BA_DLSCM
Environmental Economics	Period 2	6.0	E_STR_EEC
Evolutionary Computing	Period 1	6.0	X_400111
Institutional Investments and ALM for Finance	Period 4	6.0	E_FIN_IIALMF
Neural Networks	Period 1	6.0	X_400132
Simulation and Stochastic Systems	Period 4	6.0	E_EORM_SSS
Stochastic Optimization	Period 1+2	6.0	X_400336
Strategic and Cooperative Decision Making	Period 2	6.0	E_EORM_SCDM
Thesis	Ac. Year (September)	18.0	E_EORM_THS
Time Series Econometrics	Period 4	6.0	E_EORM_TSE
Transport Economics	Period 4	6.0	E_STR_TREC

Advanced Algorithms

Course code	E_EORM_AA ()
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. ir. R.A. Sitters
Examinator	dr. ir. R.A. Sitters
Teaching method(s)	Lecture
Level	400

Course objective
In this course you will learn how to develop efficient algorithms for solving fundamental optimization problems with applications in routing, network design and scheduling. The objectives of the course are to:
• get to know models to capture different types of optimization problems (offline, online, distributed)
• learn basic and advanced techniques to solve such optimization problems (primal-dual schema, randomized rounding, iterative rounding, potential functions, local search, etc.)
• use these techniques to design efficient algorithms
study the computational complexity of optimization problems

Course content
Some of the topics that will be covered in the course are:
- Facility location problems, scheduling problems, network routing, congestion games, network design
- Local search algorithms, online algorithms, randomized algorithms, approximation algorithms.
- Computational complexity and hardness of approximation

Form of tuition
Lectures and tutorials with take-home assignments: theory as well as Matlab programming exercises.

Type of assessment
The final grade is determined by a written exam and the assignments.

Course reading
The material to be covered in class is based on the following books. Book [1] will be used the most and is freely available for download (you may consider buying it though). The other books will be used occasionally and give a good impression of the theory.

[1] D.P. Williamson and D.B. Shmoys, The Design of Approximation Algorithms, Cambridge University Press, 2011
[2] V. V. Vazirani, Approximation Algorithms, Springer, 1998
[3] C. H. Papadimitriou and K. Steiglitz, Combinatorial Optimization; Algorithms and Complexity, Prentice-Hall, 1982.
[4] Kleinberg and E. Tardos, Algorithm Design, Addison Wesley, 2005.

Entry requirements
None. However, please see Recommended knowledge

Recommended background knowledge
Basic knowledge on algorithms, computational complexity, graph theory, linear programming, and combinatorial optimization is assumed. (The bachelor course Combinatorial Optimization (FEWEB, E_EOR3_COMB) is sufficient.) This Advanced Algorithms course is not recommended if you have very little knowledge of these subjects. A good check is to read Appendices A and B of book [1]. If this is completely new for you then this course may not be suitable. If you have any doubts please let me know.

Remarks
This course changes from year to year but it always has a substantial overlap with last year's course. See
http://personal.vu.nl/r.a.sitters/AdvancedAlgorithms/index.html

Advanced Corporate Finance

Course code	E_FIN_ACF ()
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	prof. dr. ir. H.A. Rijken
Examinator	prof. dr. ir. H.A. Rijken
Teaching staff	prof. dr. ir. H.A. Rijken
Teaching method(s)	Lecture, Study Group
Level	400

Course objective
Achieve advanced knowledge in the theory and practice of corporate finance. The main objective is to fully understand theoretical concepts (their strengths and limitations) and to use these theoretical frameworks to solve in an effective way practical issues in corporate finance. After following this course, you: - understand basic Corporate Finance concepts, including their strengths and limitations - have the

quantitative skills to apply these basic concepts - understand the interrelationship between various concepts and link them in a general framework - are able to apply this framework in real life cases.

Course content
This course elaborates on the course corporate finance in the bachelors program. The course has two focus areas: Corporate Security Design and Corporate (Financial) Risk Management

We will start off with a short review of the theory of Modigliani and Miller. Within the framework of these concepts we will pay attention to the issues on capital structure from the perspective of both the equity holders and the debt holders. A range of corporate financing options, like subordinated bond, convertibles and corporate securitization, will be discussed.

Thereafter we introduce comprehensively the concepts of the operational cash flow and the finance cash flow of a company. The added value of Corporate (Financial) Risk Management will be discussed from a cash flow perspective and a capital cost perspective. Links with Short Term Financial Management, Credit Risk Management and Value Based Management will be made.

Substantial attention will be given to real life cases (agency questions and restructuring cases in practice) during the course.

Form of tuition
Lectures (2 times 2 hours per week) and 3 working classes

Type of assessment
written exam (80%) and two cases (20%)

Course reading
Custom book "Advanced Corporate Finance" ISBN 9781783651931. This include a code to have (web) access to 5 online chapters from the book "Advanced Corporate Finance" (Odgen)

Entry requirements
Corporate Finance 3.2 or Corporate Financial Management 3.4. For students with no bachelor VU the admission to the Master of Finance is sufficient.

Recommended background knowledge
Corporate Finance 3.2 or Corporate Financial Management 3.4. Students with no VU bachelor in Economics or BA should be familiar with a standard textbook in Corporate Finance, like "Principles in Corporate Finance" (Brealey and Myers) or "Corporate Finance" (Berk and DeMarzo).

Advanced Econometrics

Course code	E_EORM_AECTR (64412001)
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. F. Blasques Albergaria Amaral

Examinator	dr. F. Blasques Albergaria Amaral
Teaching staff	dr. F. Blasques Albergaria Amaral
Teaching method(s)	Lecture, Study Group
Level	400

Course objective
To gain a profound and detailed understanding of advanced econometric theory and methods. By the end of this course, participants will:

Have detailed knowledge of
- principles of econometric theory and practical methods at the graduate level
- advanced statistical concepts used in econometric theory and their application in econometric modelling

know how to
- estimate and test linear and nonlinear dynamic models
- solve theoretical and practical econometric exercises

understand
- the interplay between econometric techniques and modelling assumptions
- the proofs of asymptotic properties of important estimators and test statistics

Course content
Advanced Econometrics I

This course is devoted to advanced dynamic modeling and estimation theory for univariate stationary models. The contents covered in Advanced Econometrics I include:

Weeks 1 and 2
- Recap of linear time-series models, estimation and inference
- Formal introduction to nonlinear probability models and nonlinear stochastic processes
- Advanced topics in invertibility, stationarity, dependence, ergodicity and bounded moments

Weeks 3 and 4
- Introduction to extremum, M and Z estimators
- Existence and measurability of extremum estimators
- The general consistency theorem for extremum estimators
- Stochastic equicontinuity and uniform laws of large numbers
- Establishing identification and uniform convergence of the criterion function
- Advanced topics in estimation of nonlinear autoregressive models and nonlinear time-varying parameter models

Weeks 5 and 6
- Asymptotic normality of extremum, M and Z estimators
- Establishing the asymptotic normality of the score and the uniform convergence of the hessian
- Advanced topics in nonlinear model selection and specification
- Estimation under incorrect specification and metric selection
- Advanced topics on statistical inference under incorrect model specification

Note: the econometrics programme is currently under revision. Some topics may change. Please consult the latest version of the online study guide.

Advanced Econometrics II

This course is devoted to advanced methods for modeling multivariate non-stationary data, with special emphasis on unit-root processes and cointegration. The contents covered in Advanced Econometrics II include:

Weeks 1 and 2
- Introduction to multivariate time-series
- Advanced topics in vector autoregressive (VAR) models
- Estimation and inference for VAR models
- Marginalizing, conditioning, exogeneity and super-exogeneity

Weeks 3 and 4
- Stochastic trends and non-stationarity time series
- Characteristic equations and unit roots
- Advanced unit root tests and non-standard asymptotics

Weeks 5 and 6
- Integration and cointegration
- Advanced integration and cointegration tests
- Limit theory for cointegrated processes
- Advanced topics in vector error correction (VECM) models
- Estimation and inference for VECM models

Note: the econometrics programme is under revision. The examination format may change slightly. Please consult the latest version of the online study guide.

Form of tuition
lecture and tutorial

Some lectures can be used for students to give presentations on selected topics.

Type of assessment
Written examination.

There are two separate written exams for Advanced Econometrics I (period 1) and for Advanced Econometriecs II (period 2). Minimum required result for Advanced Econometrics I is 5.5 and for Advanced Econometrics II is 5.0. Total grade for the combined 6 ECTS version is the average of the two grades and must be at least 5.5 for a pass. The two partial grades are measured in one decimal point; the total grade is the rounded average of the two grades.

Starting September 2010, the first part can be taken as a single elective course for 3 ECTS.

Note: the econometrics programme is under revision. The examination format may change slightly. Please consult the latest version of the online study guide.

Course reading
Lecture notes on "Advanced Econometrics" by F. Blasques and R. Okui.

Davidson J., "Econometric Theory", Blackwell Publishing, 2000.

Other sources:
van der Vaart A., "Asymptotic Statistics". Cambridge Series in Statistical
and Probabilistic Mathematics. Cambridge University Press, 2000.

White H., "Estimation, Inference and Specication Analysis". Econometrics Society Monographs, 1996.

Lütkepohl H., "New Introduction to Multiple Time Series Analysis", Springer, 2005.

Hamilton J. D., "Time Series Analysis", Princeton University Press. 1994.
Davidson J., "Stochastic Limit Theory". Advanced Texts in Econometrics, Oxford University Press, 1994.

B. Potscher and I.R. Prucha, "Dynamic Nonlinear Econometric Models: Asymptotic Theory". Springer-Verlag, 1997.

R. Gallant and H. White, "A Uni
ed Theory of Estimation and Inference
for Nonlinear Dynamic Models", Basil Blackwell Ltd., Oxford, 1987.

Hansen, B E, Econometrics. Manuscript, University of Wisconsin.2009.
Current URL: www.ssc.wisc.edu/~bhansen/econometrics/

Advanced Macroeconomics

Course code	E_EC_AMAEC (60422010)
Period	Period 2
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	prof. dr. P.A. Gautier
Examinator	prof. dr. P.A. Gautier
Teaching staff	prof. dr. P.A. Gautier
Teaching method(s)	Lecture
Level	400

Course objective
The students will be able to actively read current literature and embark on their own research projects using the knowledge gained about the analytical, mathematical, and statistical tools of modern macroeconomics. The tools include dynamic optimization, signal extraction, Nash bargaining, and the basic building blocks of DSGE models.

Course content
This course provides coverage at an advanced level of the building blocks of macroeconomics. Models of economic growth will be built up from intertemporal optimization decisions of firms and households. Special attention is given to the distribution of income (i.e. the implications of modern growth theory for the theory of Piketty). Next,

the course
will present the basic tools of Real Business Cycle and New Keynesian models. We also consider modern theories of financial crises and pay a lot of attention to the recent financial and euro crisis. Then, we will consider equilibrium search models which form the core of macro labor. Finally, we discuss budget deficits and Ricardian equivalence plus new political economy models where the behavior of policy makers are part of the model.

Form of tuition
lecture

Type of assessment
written interim examination
plus problem sets.

Course reading
Romer, David Advanced Macro Economics. 3rd edition, McGraw Hill.

Asset Pricing

Course code	E_FIN_AP ()
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. R.C.J. Zwinkels
Examinator	dr. R.C.J. Zwinkels
Teaching staff	dr. R.C.J. Zwinkels
Teaching method(s)	Lecture, Study Group
Level	400

Course objective
This course aims to deepen your knowledge in the field of asset pricing and asset allocation.

After completion of the course, you should:
- Have a thorough understanding of how security prices are determined in equity
markets.
- Understand the drivers of equity returns.
- Understand and be able to apply optimal asset allocations for both individual and institutional investors.
- Acquire an academic and critical attitude towards competing theories in investment problems.
- Be comfortable with doing advanced analyses in Software such as Microsoft Excel.

Course content
Starting from basic (undergraduate) Investments knowledge, this course centers around the issues of asset pricing and asset allocation. In the first week we revisit the well-known mean-variance framework and derive the standard CAPM in this set-up. Starting from the second week, we carefully study the assumptions underlying the CAPM framework and ask ourselves what they imply for asset pricing. Examples include the

assumption of mean-variance utility, rational expectations, and complete arbitrage. In the final week, we take a sidestep towards delegated asset management. Throughout the course, neoclassical and behavioral theories confronted with each other. In addition, the course builds on both theory and empirics.

Form of tuition
Each of the six weeks of the course feature four hours of lectures and two hours of tutorials. The content of the tutorials varies. There will, for example, be guest lectures from finance practitioners, discussions of the assignments (see below), and in-depth discussion of particular technical issues. In addition, there are three assignments: one individual assignment (Excel test) and two group assignments. The focus of these assignments is to apply the theoretical knowledge from class to real world problems using actual stock market data in Excel or other software. In addition to gaining a deeper understanding of the topics in the course, the assignments will train you in quantitative computer skills you will need later in their career and prepare you for similar assignments in other courses and your thesis.

Type of assessment
To pass this course, you need a minimum final grade of 6.0 and a minimum grade on the written exam of 5.0. If you score less than 5.0 on the written exam, your final grade is equal to that grade. If you score 5.0 or higher, the final grade is given by:

Final grade = 0.75*(Written exam grade) + 0.2*(Average group assignment grades) + 0.05*(Individual assignment grade).

Course reading
- Selected research articles and news clippings.
- Lecture notes.
- [For background reading] Boadie, Kane, Markus: Investments (2008; MacGraw-Hill)

Entry requirements
You should be familiar with investments at the level of Bodie, Kane & Marcus, Investments. Undergraduate level knowledge of statistics and mathematics is also required (e.g., Berenson, Levine, Krehbiel: Basic Business Statistics; and Sydsaeter and Hammond (2006; Prentice Hall): Essential Mathematics for Economic Analysis, Sydsaeter, Hammond, Seierstad, and Strom (2005; Prentice Hall): Further mathematics for Economic Analysis (chapters 4 and 11)).

Recommended background knowledge
You are expected to be very versatile in a relevant software package, such as Microsoft Excel (or any other similarly advance package) and use it to perform estimation and optimization. Core texts here are Benninga, Financial Modeling, or (more advanced) Jackson and Staunton, Advanced modeling in Finance using excel and VBA.

Remarks
This course may have an in-depth empirical follow-up by choosing an appropriate Investments team-research-project during the January / February period.

Asymptotic Statistics

Course code	X_400323 (400323)
Period	Period 1+2
Credits	8.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Level	500

Course content
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl.

Target group
mMath

Registration procedure
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

Case Study

Course code	E_EORM_CASE (64422000)
Period	Period 3
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. L.F. Hoogerheide
Examinator	dr. L.F. Hoogerheide
Teaching staff	prof. dr. G.T. Timmer, prof. dr. S.J. Koopman, prof. dr. ir. G. van der Laan, dr. L.F. Hoogerheide
Teaching method(s)	Practical
Level	400

Course objective
Practicing methods of econometrics and operational research using real-life case studies.

Course content
Students can opt for three variants of this course:

- Financial Econometrics, period 3, Hoogerheide: This part focuses on the measurement and modelling of volatility in time series of financial returns. An introduction will be given of generalised autoregressive conditional heteroskedasticity (GARCH) models for the forecasting of volatility in daily (or lower frequency) financial returns. The Stochastic Volatility (SV) model is considered as an alternative approach that is more closely related to financial theory for option pricing. Moreover, we use high-frequency data to compute realized volatility measures, that are used in Realized GARCH models. The merits of these models will be investigated empirically using up-to-date

financial time series. The final aim is to use the
models for forecasting volatility. Case-work is done in small groups and
when a
sufficiently large number of groups can be formed, a volatility forecast
competition can be part of the course.

- Applied Optimization, period 3, Timmer: Participants who chose
this variant will be trained in the design and implementation of
advanced optimization algorithms which make use of proven optimization
technology such as (integer) linear programming solvers. Examples
include the generation of valid inequalities to strengthen formulations
and lead to sophisticated branch and cut algorithms. After explaining
how to implement such techniques in MatLab the participants will be
asked to form small groups and focus on a specific hard problem with
known benchmark instances and design and implement an exact algorithm
for it. Their findings lead to a written essay.

- Allocation Problems, period 3, Van der Laan: In this variant
participants will be trained in solving real-life problems allocating
costs or benefits of joint projects. The training concerns the
formulation of the problem in a manageable quantitative model, to
evaluate the theoretical properties of available solutions and their
computational complexity, to select appropriate and computational
tractable solutions, to develop a software tool for solving the problem,
to carry out the required calculations and to report the results in an
essay. Participants work on a real-life case in small groups of 2 or 3
students.

Standard lectures will guide the student through the computational
aspects of statistical estimation, simulation and optimisation methods.
To gain further insights in the practical detail, computer programs for
the implementation of some computer-intensive methods will be developed.

Form of tuition
lecture
working group

Type of assessment
essay

Course reading
Selection of articles and papers

Consumer Marketing

Course code	E_MKT_CM (61422120)
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. J. Eelen
Examinator	dr. J. Eelen
Teaching staff	drs. I.J.C. Leijen, dr. J. Eelen
Teaching method(s)	Lecture, Study Group
Level	400

Course objective
- Acquire knowledge of and insight into concepts and topics that are important to effective consumer marketing management (e. g., consumer decision making processes, social influences, customer engagement, and sustainability).
- Being able to analyze current and potential applications of consumer behavior and consumer psychology theories for developing marketing strategies.

Course content
In business, the importance of what is known as 'customer insights' cannot be overstated. It is widely recognized that focusing on consumers is a key to success in the marketplace. This course provides insight into how consumers behave and discusses the theoretical and managerial implications of such behavior for firms. Specifically, the learning objectives involve the attainment of understanding of the concepts and theories of consumer marketing through a literature review and through selected articles. In addition, the course focuses on competence development, i. e., the ability to effectively use and apply these concepts in the business problem. The course will focus exclusively on consumer markets and will address in greater depth a selection of consumer marketing concepts introduced in bachelor Consumer Behavior courses. In addition, the course will introduce a number of recent developments in consumer marketing.

Form of tuition
Lectures, workgroups

Type of assessment
Written examination: 70%;
Assignment: 30%;
each to be completed with a minimum score of 5.0

Course reading
Academic articles

Entry requirements
Third- year courses Consumer Behavior, Marketing 3.1, Marketing Research and Research tutorial Marketing or equivalent.

Customer Intelligence

Course code	E_MKT_CI ()
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. A. Aydinli
Examinator	dr. A. Aydinli
Teaching staff	dr. A. Aydinli
Teaching method(s)	Lecture, Study Group
Level	400

Course objective
The overarching objective of this course is to equip students with the knowledge and skills on how to approach marketing-related problems from a rigorous, analytical, data-based perspective.
During the course, students will get acquainted with the various practical customer intelligence questions that managers may struggle with (e.g.; how to segment the market based on usage and attitudes; how to determine customers' preferences over product attributes; how to evaluate the effects of marketing activities). Students will learn to work with different types of customer intelligence data (e.g.; customer survey data, transactional data, marketing expenditure data) and obtain rigorous knowledge of the data analysis techniques (e.g.; factor analysis, conjoint analysis, cluster analysis, multiple regression, and logistic regression) for solving the salient customer intelligence questions. Students will excel in applying these techniques in the statistical software package SPSS and interpreting the output of such applications in terms of the marketing research problem at hand.
On completion of this course, students will be able to:
• Develop the ability to select the correct data analysis technique for a practical customer intelligence problem
• Construct and validate a scale using factor analysis
• Create a perceptual map for understanding customers' perceptions of market offerings
• Conduct a conjoint analysis for understanding individual-level preferences
• Predict customer response using logistic regression
• Perform a standard customer-based segmentation study
• Estimate market response models and use them to evaluate the impact of past marketing activities

Course content
The past couple of decades have witnessed an unprecedented explosion in the quantity and quality of information available to managers. To reach well-informed decisions, marketing research practitioners and marketing academics have developed and implemented a wide variety of analytical tools and models. This course will familiarize students with the state-of-art techniques and approaches that have become fundamental to marketing decision making in order to collect, analyse, and act on customer information. While the course guides students through the use of quantitative methods, it is not a statistic or math course. Through a combination of lectures and computer exercises, the course aims that students gain the expertise and confidence to analyse real marketing problems in rigorous manner, and support their analysis using appropriate analytical tools. The course also forms a preparation for the empirical research to be conducted for the Master's thesis.

Form of tuition
The course uses a combination of lectures and tutorials. The lectures focus on probing, extending and applying the course concepts and methods. Importantly, the lectures discuss for which marketing problems the techniques are typically used and how conclusions can be made for marketing management. The tutorials enable students to practice the concepts and methods discussed during the lectures.

Type of assessment
Written examination: 70%;
Assignment: 30%;

each to be completed with a minimum score of 5.0

Course reading
- Hair, Joseph F., William, C. Black, Barry J. Babin and Rolph E. Anderson (2014), Multivariate Data Analysis (7th edition) – Pearson New International Edition, Harlow (UK): Pearson Education Limited. ISBN 10: 1-292-02190-X.

Data Mining Techniques

Course code	X_400108 (400108)
Period	Period 5
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. M. Hoogendoorn
Examinator	dr. M. Hoogendoorn
Teaching staff	dr. M. Hoogendoorn
Teaching method(s)	Lecture
Level	500

Course objective
The aim of the course is that students acquire data mining knowledge and skills that they can apply in a business environment. How the aims are to be achieved: Students will acquire knowledge and skills mainly through the following: an overview of the most common data mining algorithms and techniques (in lectures), a survey of typical and interesting data mining applications, and practical assignments to gain "hands on" experience. The application of skills in a business environment will be simulated through various assignments of the course.

Course content
The course will provide a survey of basic data mining techniques and their applications for solving real life problems. After a general introduction to Data Mining we will discuss some "classical" algorithms like Naive Bayes, Decision Trees, Association Rules, etc., and some recently discovered methods such as boosting, Support Vector Machines, and co-learning. A number of successful applications of data mining will also be discussed: marketing, fraud detection, text and Web mining, possibly bioinformatics. In addition to lectures, there will be an extensive practical part, where students will experiment with various data mining algorithms and data sets. The grade for the course will be based on these practical assignments (i.e., there will be no final examination).

Form of tuition
Lectures (h) and compulsory practical work (pra). Lectures are planned to be interactive: there will be small questions, one-minute discussions, etc.

Type of assessment
Practical assignments (i.e. there is no exam). There will be two assignments done in groups of three. There is a possibility to get a grade without doing these assignments: to do a real research project instead (which will most likely to involve more work, but it can also be

more rewarding). For the regular assignments the first assignment counts for 40% and the second for 60%. The grade of both assignments needs to be sufficient to pass the course.

Course reading
Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques (Third Edition). Morgan Kaufmann, January 2011
ISBN 978-0-12-374856-0

Recommended background knowledge
Kansrekening and Statistiek or Algemene Statistiek (knowledge of statistics and probabilities) or equivalent. Recommended: Machine Learning.

Target group
mBA, mCS, mAI, mBio

Derivatives

Course code	E_FIN_DER (60442060)
Period	Period 2
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. N.J. Seeger
Examinator	dr. N.J. Seeger
Teaching staff	dr. N.J. Seeger
Teaching method(s)	Lecture, Study Group
Level	400

Course objective
The primary objective of this course is to provide students with an advanced introduction to derivative instruments. By the end of the course students should have a sound understanding of the pricing concepts, practical applicability, operational complexity, and risks of several linear and non-linear derivatives.

Course content
In todays financial world, the role of derivatives gets increasingly important. Banks and pension funds use derivatives to manage their balance sheet risk, corporate treasuries need derivatives for mitigation of international trade risk, insurance companies actively apply derivatives strategically in order to hedge long term interest rate exposures. Worldwide derivatives trading has exploded to unprecedented levels in the last decades. Therefore, a sound understanding of derivatives is indispensable for anyone pursuing a job in finance.

The course aims to help students in developing a general understanding of the fundamental principles related to derivative instruments. When we try to understand derivative instruments we will ask questions like:

1. How do derivative instruments work?
2. Is it possible to decompose derivatives in basic assets?
3. How to determine the fair value of derivative instruments?

4. What are the risks of using derivative instruments?
5. How are derivative instruments applied in practice and are there any relevant operational issues in the real world?

Hence, the course focuses on facilitating conceptual understanding of derivative instruments and of the methods that are needed to apply derivatives in different settings of finance applications; whether it is for trading purposes, structuring products, risk management, etc.

The field of derivatives is one of the most mathematically sophisticated in finance. Therefore, to understand derivatives it is inevitable to deal with mathematical methods. However, we want to emphasize that in the course mathematical methods are primarily used as tools to understand derivatives. We intend to serve a balanced mix of theory, intuition and practical aspects.

The course will treat the following subjects:

- Why derivatives?
- Forwards, futures and options
- Pricing concepts of derivative instruments
- Discrete and continuous time option pricing models
- Understanding Black-Scholes formula
- Beyond Black-Scholes (stochastic volatility and jumps)
- Hedging strategies
- Estimating model parameters
- Credit derivatives / Financial Crisis

Form of tuition
The course spans a period of six weeks. There will be 12 lecture sessions of 2 x 45 minutes each (for dates and times see course schedule), in which the course material is presented. There will be two additional tutorial sessions in which solutions to programming problems related to derivatives topics will be discussed.

Type of assessment
The final grade of the course is the grade of the written exam.

Course reading
- John Hull: Options, Futures and other Derivatives, 8th Edition, 2011
- Lecture slides

Further References:
- Das, R.K. and S.R. Sundaram: Dervatives: Principles and Practice, McGRAW-Hill International Edition, 2010
- Jarrow, R. and A. Chatterjea: An Introduction to Derivative Securities, Financial Markets, and Risk Management, W. W. Norton & Company, 2013
- Baxter/Rennie: Financial Calculus, Cambridge, 1996. - Neftci: Principles of Financial Engineering, Elsevier, 2nd edition, 2008.
- Bingham/Kiesel: Risk-Neutral Valuation: Pricing and Hedging of Financial Derivatives, Springer, 2004.
- Björk, T.: Arbitrage Theory in Continuous Time, Oxford University Press, 2004.

Entry requirements
Students entering this course should be familiar with the basic corporate finance principles and techniques (e. g. Berk/DeMarzo, Corporate Finance. 2013) and investment management concepts (e. g.

Bodie, Investments. 2010). In order to follow the course material right from the start it is recommended to review the derivatives material that has been covered in the courses: Financiering 2.5 and Investments 3.4. For solving the assignments, programming experience with Excel/VBA is required. A very good introduction to Excel/VBA can be found on the homepage http://xlvu.weebly.com; provided by Dr. Arjen Siegmann.

Distribution Logistics and Supply Chain Management

Course code	E_BA_DLSCM (61412300)
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. E. Spiliotopoulou
Examinator	dr. E. Spiliotopoulou
Teaching method(s)	Lecture, Seminar
Level	400

Course objective
So far, the Bachelor courses have predominantly focused on decision problems within the context of an individual company. During the Master TSCM courses, this context will be expanded to encompass multiple companies. The central theme is cooperation between shippers, customers and logistics service providers. The objective of this course is to introduce students to the topic of demand & supply chain management and to discuss relevant concepts to matching supply and demand in these chains.

Course content
We will focus on demand driven Supply Chain Management. After an introduction to the concepts of SCM, we will discuss the design and implementation of SCM concepts taking into account the flow of information, money and materials across the supply chain. More specifically we will discuss:
- Logistics network planning
- Inventory management and forecasting
- Supply contracts for strategic as well as commodity components
- The value of information and the effective use of information in the supply chain
- Supply chain integration
- Centralized and decentralized distribution strategies
- Strategic alliances
- Outsourcing, off-shoring, and procurement strategies
- International supply chain management
- Supply chain management and product design
- Revenue management and pricing strategies.

Form of tuition
Lectures and assignments. In small groups, the students will work on an assignment for a specific supply chain. Separate assignment meetings will be scheduled. Additional relevant theory and literature has to be searched for by the groups.

Type of assessment
Combination of written examination and assignment

Course reading
- Simchi-Levi, D., Kaminsky, P., Simchi-Levi, E. (2008). Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies (3rd ed). Irwin: McGraw-Hill.
- additional articles (via blackboard)

Entry requirements
All non-TSCM Master students (including all exchange students) are required to contact the course coordinator before enrolling; permission from the course coordinator is obligatory prior to participating in this course.

Recommended background knowledge
Pre-master TSCM or bachelor with specialization similar to TSCM.

Environmental Economics

Course code	E_STR_EEC (60442040)
Period	Period 2
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. G.C. van der Meijden
Examinator	dr. G.C. van der Meijden
Teaching staff	dr. G.C. van der Meijden
Teaching method(s)	Lecture
Level	400

Course objective
The course aims to learn students that natural resource management should not be left to the free market. After following this course, students are able to characterize several types of market failure and to explain how each of these causes environmental problems, such as air pollution and overexploitation of natural resources. Moreover, students will be capable of explaining which policy instruments can be used by the government to tackle environmental problems that arise in a market economy. Finally, students will be taught how renewable resources (such as forestries and fisheries), and non-renewable resources (such as fossil fuels) should optimally be exploited from a social welfare perspective and how the optimal exploitation differs from the exploitation in a market equilibrium.

The course consists of lectures, homework assignments, tutorials, and presentation/discussion sessions. The lectures are aimed at developing a thorough understanding of key economic, environmental and ethical aspects of environmental problems, and of the link between theory, methods and empirical analysis. The goal of the homework assignments that will be discussed during the tutorials is to practice modern economic methods to analyse and solve problems in the field of environmental economics. The presentation/discussion sessions are intended to improve the participants' economic reasoning and communication skills. In these sessions, students will present a journal

article in class, and they are expected to participate in a group discussion afterwards.

After following this course, you:
• are able to describe the most important interactions between the economy and the environment, and their relationship with sustainable development.
• can explain why, and under which conditions, the free market does not result in an efficient outcome.
• are capable of showing how externalities can be ‘internalized’ by using market instruments, like Pigouvian taxes, quotas and tradable permits, etc.
• are able to advise environmental policy makers on which policy instruments to use under different circumstances in order to correct the market outcome
• can explain how non-renewable resources like fossil fuels, are exploited in a market economy and how the exploitation differs from the optimum
• can show how renewable resources, like fisheries and forestries, are exploited in a market economy and how the exploitation differs from the social optimum
• are able to describe and explain the optimal climate policy in the global economy
• can explain how sub-optimal climate policies can lead to a ‘Green Paradox’, in the sense that the problem of climate change is aggravated instead of diminished upon the introduction of those policies
• are able to explain why resource rich countries often suffer from low rates of economic growth, and what they can do to avoid this so-called Resource Curse.
• can explain the theoretic measures of ‘willingness to pay’ (WTP) and ‘willingness to accept’ (WTA) to obtain a monetary valuation of environmental changes
• are able to use stated preference methods (e.g., contingent valuation) and ‘revealed preference’ methods (e.g., travel cost model) to determine the WTA and WTP for environmental changes
• are able to work with simple mathematical models to analyse the effects of environmental policy and to determine the time profile of renewable and non-renewable resources, both in the optimum and in the market equilibrium
• have improved your presentation and discussion skills

Course content
The following topics will be dealt with in the course:
- interaction between the economy and the environment
- sustainable development
- welfare economics and market failures
- environmental policy: Pigouvian taxes, quotas, and tradable emission permits
- non-renewable resource use: scarcity and market structure
- renewable resource use: fishery and forestry
- non-renewable resource use and climate change
- climate policy and the ‘Green Paradox’
- resource-rich economies and the ‘Resource Curse’
- theory and methods for environmental valuation
The topics for the group discussions and student presentations can be chosen by the participants. They should be based on articles published in scientific journals.

Form of tuition
Lectures, tutorials, assignments, student presentations, and group discussions.

Type of assessment
Written exam (60%), assignments (30%), and presentation/participation (10%). Passing the course is conditional on the exam grade being 5.0 or higher.

Course reading
- Hanley, Nick, Jason F. Shogren and Ben White (2007), Environmental Economics in Theory and Practice. Palgrave Macmillan, 2nd Ed.
- Additional articles from the economics literature, to be announced on Blackboard

Recommended background knowledge
Advanced microeconomics.

Evolutionary Computing

Course code	X_400111 (400111)
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. A.E. Eiben
Examinator	prof. dr. A.E. Eiben
Teaching staff	prof. dr. A.E. Eiben, J.V. Heinerman MSc
Teaching method(s)	Lecture
Level	400

Course objective
To learn about computational methods based on Darwinian principles of evolution. To illustrate the usage of such methods as problem solvers and as simulation, respectively modelling tools.To gain hands-on experience in performing experiments.

Course content
The course is treating various algorithms based on the Darwinian evolution theory. Driven by natural selection (survival of the fittest), an evolution process is being emulated and solutions for a given problem are being "bred". During this course all "dialects" within evolutionary computing are treated (genetic algorithms, evolutiestrategieën, evolutionary programming, genetic programming, and classifier systems). Applications in optimisation, constraint handling, machine learning, and robotics are discussed. Specific subjects handled include:
various genetic structures (representations), selection techniques, sexual and asexual variation operators, (self-)adaptivity. Special attention is paid to methodological aspects, such as algorithm design and tuning. If time
permits, subjects in Artificial Life will be handled. Hands-on-experience is gained by a

compulsory programming assignment.

Form of tuition
Oral lectures and compulsory programming assignment. Highly motivated students can replace the programming assignment by a special research track under the personal supervision of the lecturer(s).

Type of assessment
Written exam and pogramming assignment (weighted average).

Course reading
Eiben, A.E., Smith, J.E., Introduction to Evolutionary Computing. Springer, 2003 ISBN 3-540-40184-9.
Slides available from http://www.cs.vu.nl/~gusz/ecbook/ecbook.html .

Target group
mBA, mAI, mCS, mPDCS

Financial Markets and Institutions

Course code	E_FIN_FMI (60442080)
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. I.P.P. van Lelyveld
Examinator	dr. I.P.P. van Lelyveld
Teaching staff	dr. I.P.P. van Lelyveld
Teaching method(s)	Lecture
Level	400

Course objective
The purpose of this course is to develop an understanding of the economics underlying financial intermediation, financial markets and banking, with a particular focus on the recent financial turmoil and its consequences.

Course content
We start by discussing the traditional role of commercial banks in the financial system and how banks manage risks. Topics include the major risks faced by banks, lending and asymmetric information, credit rationing, and securitisation. This leads us into a discussion of financial fragility covering, inter alia, liquidity provision, bank runs, deposit insurance and opacity. Then we discuss how various regulations could be helpful or not. A natural follow up is laying out the causes, triggers and dynamics of the Great Crisis (2007-2009). Given the depth of the crisis, there has been a flurry in new regulation. What are the objectives of these regulations, are these or will these be met. Since traditionally regulation has been focussed on solvency will dedicate a lecture on liquidity as well as this has proven to be quite a separate type of risk.
The next two lectures cover the plumbing of the system and other large institutional participants. The former lecture will provide us some understanding of how risks in the system not only originate with the actions (i.e., trades) but also with the markets are set up. The latter

will discuss how, next to (investment) banks, other large institutional investors are coming to the fore.
In the final part of the course we will turn to three distinct markets: the derivatives market, the interbank and the international banking market. How do these markets operate, particularly in the crisis, and how are they evolving.
Two guest lectures from practitioners will provide more colour on how central banks have handled the sovereign crisis and how asset managers function.

Form of tuition
The lectures will be complemented by a writing assignment (see below)
All information regarding the timetable of the course can be found at http://rooster.vu.nl.
To facilitate the Writing Assignment a non-compulsory lecture on writing in English will be organised in the second week (9 February, 9.00-10.00 am, 5A-24).
In the second week there will be an additional non-compulsory lecture to discuss question Mishkin et al for those without a banking background (e.g. econometrics students). (9 February, 10.00-11.00 am, 5A-32)
Question should be raised on the Blackboard forum.

Type of assessment
Final grade is based on a two-hour, closed-book written final exam (80%) and the grade on an open-book essay to be written in groups of at most three students (20%). More details regarding the topics and the structure of the essay will be provided during the lectures and tutorials. If no essay was submitted, it will be graded 0 (zero). In the case of a resit in later periods (i.e., in 2017 or later), the essay result will be disregarded and the resit grade will be based 100% on the examination. The exam questions will cover the topics and the exercises treated in the class. The lecture notes and solutions published on Blackboard can be used as a faithful guide for the required material and level of difficulty.
Part of understanding is being able to present your findings. In many cases, getting the form right is just as important as the actual content. Findings can be presented in many ways. For example as an academic article, a thesis, a Powerpoint or a column. In this writing assignment we will aim for a contribution to a policy oriented blog such as VoxEU (www.voxeu.org).
Currently the topic is set to be the split between investment banking (the casino) from retail banking (the utility). Such a split has been argued to increase financial stability and reduce moral hazard. However, if a more interesting policy question arises closer to the course, the topic might change.
The assignment should be written in groups of at most three. Please use the appropriate sign up tool on Blackboard. Further details will be given in the first lecture. Note that a non-compulsory lecture on writing in English will be planned in the first week.
The deadline for the assignment is Lecture 10.

Course reading
We will make use of the following non-mandatory textbook:
• Mishkin, F., K. Matthews, and M. Giuliodori, The Economics of Money, Banking and Finance, European edition. From this book we will cover all of Chapters 8 through 12.

In addition several mandatory academic papers will posted to Blackboard.
Lecture notes will be available on Blackboard just before each class.

Solutions for all exercises will be available after lectures.
Other non-mandatory (but useful) materials such as academic papers, press articles or book titles will be posted on Blackboard.

Entry requirements
Students should have followed a bachelor course in Money and Banking.

Globalization, Growth and Development

Course code	E_EC_GGD (60442050)
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	prof. dr. C.T.M. Elbers
Examinator	prof. dr. C.T.M. Elbers
Teaching staff	prof. dr. C.T.M. Elbers
Teaching method(s)	Lecture
Level	400

Course objective
Aim of the course is to study aspects of globalization, growth and development that are fruitfully studied from the perspective of the economics discipline. After following the course the student will

- know the basic facts concerning the topics discussed in the course
- have a thorough understanding of these topics, in particular their economic dimension
- have learnt various empirical research techniques that can be applied within this field of economics
- be able to present and discuss current journal articles and book chapters on globalization

Course content
Globalization poses both challenges and offers opportunities to rich and poor countries. The course focuses on a number of themes that have been central in the academic and public discussion of recent trends in the world economy. Among them are:
• Relationship between growth, trade and poverty
• Globalization and inequality
• Trade shocks, resources and civil conflict
• Environmental and labour standards
• Volatility of terms-of-trade
• Institutions
• Migration
• Financial stability
More topics in globalization are introduced in the course in the form of student presentations. The course stresses the importance of empirical research and devotes significant time to the empirical strategies that have been used by researchers in studying globalization.

Form of tuition
Lectures, Student Presentations and Discussions

Course reading
Selected articles

Entry requirements
Advanced Macroeconomics 4.2 and International Economics 3.2

Institutional Investments and ALM for Finance

Course code	E_FIN_IIALMF ()
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. M. Boes
Examinator	dr. M. Boes
Teaching staff	dr. M. Boes
Teaching method(s)	Lecture
Level	400

Course objective
This course has a dual objective.

First, students should achieve advanced knowledge of the investment process of institutional investors, like pension funds, and the concept of balance sheet management (Asset Liability Management).

Second, students should acquire a thorough knowledge of the developments in fixed income space, in particular the recent advances in the pricing of fixed income derivatives instruments like swaps and swaptions.

The course not only develops the theoretical background, but also discusses the way these concepts are used in practice.

After following the course, you:

- Have a thorough understanding of the theory of strategic dynamic asset allocation (SAA) and Asset Liability Management (ALM) and its implementation by institutional investors.

- Have a thorough understanding of basic fixed income derivatives such as (inflation) swaps and swaptions and their strategic use by institutional investors.

- Have an overview of the practical implementation of ALM studies in the financial industry.

- Have an up-to-date knowledge of the recent developments in regulations.

- Have a sound understanding on how linear and non-linear derivatives can be used by pension funds in their balance sheet management.

- Have knowledge on how pension funds decide on issues like currency hedging and benchmark choice for investment portfolios.

Course content
The first week gives a broad introduction to pension funds. Specifically, the course starts with an overview of the Dutch pension system, some basic definitions, and the regulatory framework. In addition to that the investment problem of a pension fund is explained and subsequently linked to the investment decision problems that were treated in earlier courses.

In weeks 2 and 3 we will focus on fixed income derivatives. The approach taken won't be purely theoretical as the practical usage of these derivatives will be shown by means of a real-life investment portfolio of a large Dutch pension fund.

In weeks 4 and 5 the ideas and theories treated so far are translated into practical balance sheet management of pension funds. We won't focus solely on fixed income but will also look at the practical consequences of strategic choices on equity investing and currency hedging.

We intend to finish the course in the sixth week by a guest lecture and by some exam preparation.

Form of tuition
Lectures (2 times 2 hours per week) plus two cases.

Type of assessment
Written exam and two cases.

Course reading
- Hull: Options, futures, and other derivatives (8th edition)
- Additional course material (academic papers, etc.) will be provided on Blackboard

Remarks
The course brings students up to date with the recent developments in the field of fixed income derivatives and institutional investing. To do so efficiently, the course builds on earlier courses.

In particular for the fixed income derivatives part, the course presumes students are familiar with the material from the course Derivatives (period 2), including the programming assignments of that course.

Students should also master basic Asset Pricing (period 1) theory, and simple time series models such as the vector autoregression (VAR, e.g., Empirical Finance in period 2).

Labour Economics

Course code	E_EC_LABEC (60422030)
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. S. Dobbelaere
Examinator	dr. S. Dobbelaere
Teaching staff	dr. S. Dobbelaere, prof. dr. P.W.C. Koning

Teaching method(s)	Lecture
Level	400

Course objective
This course is an introduction to labor economics with an emphasis on applied micro-economic theory and empirical analysis. The aim of the course is to acquaint students with traditional and contemporary topics in labor economics, including wage and employment determination, earnings inequality, technological change and globalization, search, human capital, government policy, and institutions in the labor market. As to the role of institutions, special emphasis will be devoted to the design of active labor market policies.

The following course objectives are defined:
- Demonstrating a theoretical understanding of how labor markets operate.
- Understanding the recent developments of wage determination in imperfect labor markets and of human capital theory.
- Understanding how institutional forces, technological change and globalization shape labor market performance.
- Understanding the impact of policy instruments on the search behavior of individuals.
- Learning how to distinguish alternative theories empirically and how key parameters are obtained from data.
- Mastering economic and analytical tools to explain labor market outcomes.
- Exploring competing theories and critically evaluating existing empirical evidence.

Course content
This course covers a systematic development of theories of wage determination over the past decades. We focus on wage-determination models that assume that labor markets are imperfectly competitive, in particular wage determination under trade unions and wage determination under oligopsonistic competition. We study employment in a dynamic context, emphasizing the role of search frictions. We concentrate on earnings inequality, technical change and globalization. These topics are politically and economically important and underscore a lot of modern labor economics. We focus on human capital investment models. We conclude with an analysis of labor market institutions, in particular the design of active labor market policies.

Form of tuition
Main lectures and tutorials.

Type of assessment
Interim assessment: Problem sets, academic research paper presentations and discussions. End of period: Written, closed-book exam.

Course reading
To be determined.

Mathematical Systems and Control Theory

Course code	X_400180 (400180)
Period	Period 1+2

Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. A.C.M. Ran
Examinator	prof. dr. A.C.M. Ran
Teaching staff	prof. dr. A.C.M. Ran
Teaching method(s)	Lecture, Seminar
Level	400

Course objective
The course aims to introduce the student to the mathematical theory of control systems.

Course content
Many phenomena are characterized by dynamic behaviour where we are interested in a certain input/output behaviour. Examples are to be found in the exact and natural sciences (mechanics, biology, ecology), in engineering (air- and spacecraft design, mechanical engineering) as well as in economics and econometrics (macro- economical models, trend and seasonal influences in demand and supply, production systems). Systems theory is concerned with modeling, estimation and control of dynamical phenomena. During the course the following subjects will be treated: models and representations (linear systems, input-output, state space, transfer function, stochastic systems, spectrum), control (stabilisation, feedback, pole placement, dynamic programming, the LQ problem), and identification and prediction (parameter estimation, spectral analysis, Kalman- filter, model reduction). Applications are in the area of optimal control and prediction.

Form of tuition
There is a lecture of two hours each week. In addition, there is another session which will be half lecture and half practicum, in which there is the possibility to ask questions about the compulsary computerpracticum. The practicum makes use of the Matlab package.

Type of assessment
The computerpracticum counts for 70%, the oral examination concerns the theory and counts for 30%.

Course reading
Chr. Heij, A.C.M. Ran and F. van Schagen, Introduction to Mathematical Systems Theory, Birkhauser Verlag.

Recommended background knowledge
Analysis, probability theory, statistics.
Complex analysis and Fourier theory would be useful, but are not absolutely necessary.

Target group
3W, mBA, mMath

Neural Networks

Course code	X_400132 (400132)
Period	Period 1

Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. M. Hoogendoorn
Examinator	dr. M. Hoogendoorn
Teaching staff	dr. M. Hoogendoorn
Teaching method(s)	Lecture, Practical
Level	500

Course objective
The course provides an introduction to key concepts and algorithms for pattern recognition and neural networks. It strives towards providing insight both from a theoretical perspective as well as more practical settings. In the end, the student should be able to confidently apply the aforementioned techniques in real-life settings and understand their theoretical basis.

Course content
The course provides an introduction to key concepts and algorithms for pattern recognition and neural networks. It covers the following topics:

- classification, regression, and clustering problems,
- elements of statistical pattern recognition,
- methods for estimation of probability distributions,
- linear classifiers, including Support Vector Machines,
- single-layer and multi-layer networks,
- RBF-networks and kernel methods
- methods for dimensionality reduction
- methods for feature extraction and selection

Moreover, several real-life applications of pattern recognition, including recognition of speech, handwritten characters, images, etc., will be discussed in depth.

Form of tuition
Lectures (h) and practical (pra).

Type of assessment
Practical assignments and written examination. Both count for 50% of the final grade and both grades should be sufficient in order to pass the course.

Course reading
Simon Haykin, Neural Networks and Learning Machines, Pearson Education, 3rd international edition, 2008

Target group
mAI mBio, mBA, mCS

Remarks
More information will be available via Blackboard.

Regional and Urban Economics

Course code	E_STR_RUE (60442140)

Period	Period 2
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	prof. dr. H.L.F. de Groot
Examinator	prof. dr. H.L.F. de Groot
Teaching staff	prof. dr. H.L.F. de Groot, prof. dr. J. Rouwendal
Teaching method(s)	Lecture
Level	400

Course objective
The aim of this course is to provide students with an advanced introduction in the field of regional and urban economics. Students learn the theoretical and empirical methods applied in the field, and get a good understanding of the fundamental questions that are addressed in the field and the current state of affairs in the literature. They are trained to critically read and properly understand contributions in the leading journals in the field. At a more specific level, after having taken this course, students have a good understanding of the New Economic Geography Model, are familiar with the theoretical foundations of agglomeration economies and their empirical relevance, understand the theoretical foundations of and can apply spatial interaction modelling, are familiar with regional growth theories, understand the function of regional labour and housing markets, and have a good understanding of the determinants of urban structures.

Course content
This course covers advanced topics in theoretical and empirical research on regional and urban economics. Key issues are location and potential reasons for clustering of economic activity, spatial interaction (migration, trade, FDI and commuting), patterns of regional economic convergence and divergence, the role of geographic factors in explaining regional economic growth performance, the impact of (spatial) externalities of knowledge production, urban size and growth, urban land use, housing markets and the functioning of regional labour markets. The topics are addressed from a theoretical as well as an empirical perspective.

Form of tuition
Lectures and Tutorials

Type of assessment
Written interim examination (75 percent) and Assignments (25 percent)

Course reading
• Brakman, S., J.H. Garretsen and C. van Marrewijk (2009): The New Introduction to Geographical Economics, Cambridge University Press, Cambridge.
• Ciccone, A. and R.E. Hall (1996): ‘Productivity and the Density of Economic Activity’, American Economic Review, 86, pp. 54-70.
• Gallup, J.L., J.D. Sachs and A.D. Mellinger (1999): ‘Geography and Economic Development’, International Regional Science Review, 22, pp. 179-232.
• Glaeser, E.L. and M.E. Kahn (2003): ‘Sprawl and Urban Growth’, in: J.V. Henderson and J.-F. Thisse (eds), Handbook of Urban and Regional Economics, Volume 4, Chapter 56, Elsevier, Amsterdam.

• Glaeser, E.L., H.D. Kallal, J.A. Scheinkman and A. Shleifer (1992): ‘Growth in Cities’, Journal of Political Economy, 100, pp. 1126-1151.
• Krugman, P. (1991): ‘History and Industry Location: The Case of the US Manufacturing Belt’, American Economic Review, 81, pp. 80-83.

Simulation and Stochastic Systems

Course code	E_EORM_SSS (64412010)
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. A.A.N. Ridder
Examinator	dr. A.A.N. Ridder
Teaching staff	dr. A.A.N. Ridder
Teaching method(s)	Lecture
Level	400

Course objective
The objective of this course is to learn how to develop and execute a simulation study of a stochastic system. This incorporates all aspects of an operations research study: data collecting, modeling, analyzing, programming, writing a report and presenting the results.

Course content
The course gives a broad treatment of the important aspects of stochastic simulation and its applications to queuing, reliability, manufacturing, risk analysis, and financial models. The topics covered include random number generators, generating random variates, simulation of Lindley processes, statistical output analysis, steady-state simulation, variance reduction techniques, importance sampling and other rare-event simulation techniques, Markov chain Monte Carlo, and stochastic optimization. The emphasis is on the mathematical analysis of properties of these simulation methods. There will be assignments in which the students apply simulation issues to problems either by theoretical analysis, or by programming. The simulation programs are written in C, C++, Java, Matlab, or Python. Towards the end of the course the student studies a scientific paper on a simulation topic and gives a presentation of it.

Form of tuition
lecture and tutorial

Type of assessment
1. homework problems
2. Paper presentation
3. Written exam

Course reading
R.Y. Rubinstein and D.P. Kroese. Simulation and the Monte Carlo Method, second edition, Wiley 2008.

Entry requirements

Probability and Statistics, Stochastic models, Programming experience.

Recommended background knowledge
Probability and Statistics; Stochastic models; Programming skills

Stochastic Optimization

Course code	X_400336 (400336)
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. S. Bhulai
Examinator	dr. S. Bhulai
Teaching staff	dr. S. Bhulai
Teaching method(s)	Lecture
Level	400

Course objective
The goal of the course is to discuss techniques from the field of stochastic optimization and their applications.

Course content
This course deals with the theory and algorithms for stochastic optimization with an application to controlled stochastic systems (e.g., call center management, inventory control, optimal design of communication networks). We discuss aspects of semi-Markov decision theory and their applications in certain queueing systems. In a programming assignment, students learn to implement optimization algorithms and experiment with them. Experience with and insight into the more theoretical subject is obtained through homework exercises.

Form of tuition
Lectures.

Type of assessment
Programming and written exercises, final exam.

Course reading
Lecture notes will be posted on BlackBoard

Entry requirements
Stochastische Methoden (400391) or equivalent and a programming language.

Recommended background knowledge
Stochastische Processen (X_401026) and Wachtrijmodellen (X_401061) or equivalent courses on Stochastic Processes and Queueing Theory and a programming language.

Target group
mBA, mBa-D, mMath, mSFM

Stochastic Processes for Finance

Course code	X_400352 (400352)
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. E.N. Belitser
Examinator	dr. E.N. Belitser
Teaching staff	dr. E.N. Belitser
Teaching method(s)	Lecture
Level	400

Course objective
Learn basics of stochastic processes in continuous time, including the concepts of martingales and stochastic integration; apply these concepts to price options on stocks and interest rates by the no-arbitrage principle.

Course content
Financial institutions trade in risk, and it is therefore essential to measure and control such risks. Financial instruments such as options, swaps, forwards, etc. play an important role in risk management, and to handle them one needs to be able to price them. This course gives an introduction to the mathematical tools and theory behind risk management.
A "stochastic process" is a collection of random variables, indexed by a set T. In financial applications the elements of T model time, and T is the set of natural numbers (discrete time), or an interval in the positive real line (continuous time). "Martingales" are processes whose increments over an interval in the future have zero expectation given knowledge of the past history of the process. They play an important role in financial calculus, because the price of an option (on a stock or an interest rate) can be expressed as an expectation under a so-called martingale measure. In this course we develop this theory in discrete and continuous time. Most models for financial processes in continuous time are based on a special Gaussian process, called Brownian motion. We discuss some properties of this process and introduce "stochastic integrals" with Brownian motion as the integrator. Financial processes can next be modeled as solutions to "stochastic differential equations". After developing these mathematical tools we turn to finance by applying the concepts and results to the pricing of derivative instruments. Foremost, we develop the theory of no-arbitrage pricing of derivatives, which are basic tools for risk management.

Form of tuition
Lectures and exercises.

Type of assessment
Assignments and written examination.

Course reading
Lecture notes.
In addition, it is useful to have the following books:
Shreve, "Stochastic Calculus for Finance I: The Binomial Asset Pricing Model", Springer;
Shreve, "Stochastic Calculus for Finance II: Continuous-time models",

Springer.

Entry requirements
Probability (X_400622) and Analysis 1 (X_400005), or their equivalents.

Recommended background knowledge
Measure Theory.

Target group
mBA, mBA-D, mMath, mSFM, master Econometrics.

Remarks
A significant part of the course is used to introduce mathematical subjects and techniques like Brownian motion, stochastic integration and Ito calculus. In view of this, the course is NOT meant for students who already followed the master course "Stochastic Integration". On the other hand, after completing this course, students may be motivated to follow the other one (Stochastic Integration) to study the above mentioned mathematical subjects in a deeper and more rigorous way.

Strategic and Cooperative Decision Making

Course code	E_EORM_SCDM (64422010)
Period	Period 2
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. J.R. van den Brink
Examinator	dr. J.R. van den Brink
Teaching staff	prof. dr. ir. G. van der Laan, dr. J.R. van den Brink, dr. I.D. Lindner
Teaching method(s)	Lecture
Level	400

Course objective
The aim of this course is to learn and apply methods and techniques from cooperative and noncooperative game theory to economic and managerial problems. Special attention will be given to the analysis and economic application of networks. Students should be able to understand and to apply results that recently appeared in the international journals.

Course content
In this course we study strategic and cooperative decision making in situations where more than one party or agent is involved. In these situations the outcome is the result of the individual decisions made by the agents. In strategic decision theory we focus on the decisions made by the agents, where each agent takes account of the fact that its decision influences the outcome, and therefore the decision problem of the other agents. Agents behave strategically if each agent tries to behave in a way that is best for itself. In cooperative decision theory we focus on the outcome (and not on the individual decisions), taking into account the interests of all agents. We study different criteria that an outcome can satisfy, such as efficiency or equity, and look how to find a compromise between these criteria when they are conflicting.

The methods we use to analyze and solve these problems borrow from (non-cooperative and cooperative) game theory, general equilibrium theory and social choice theory. Topics that will be discussed come from the field of
economics and operations research and include: bargaining problems, auctions, cost sharing and allocation problems, operations research games, market games, assignment problems, profit distribution, voting problems, score rules, and location problems. Recently, various network models gained attention in the economic literature and applications. Therefore, in this course we give special attention to the analysis and economic application of networks.

Form of tuition
lecture
working group

Type of assessment
written examination
home assignment

Course reading
- Moulin, H., Fair Division and Collective Welfare. MIT Press, 2003.
- Lecture sheets, material from MOOC and a selection of recent articles from the literature

Entry requirements
- Mathematical Economics 1
- Recommended: Mathematical Economics 2

Thesis

Course code	E_EORM_THS ()
Period	Ac. Year (September)
Credits	18.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. A.A.N. Ridder
Examinator	dr. A.A.N. Ridder
Level	500

Time Series Econometrics

Course code	E_EORM_TSE (64432000)
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	prof. dr. S.J. Koopman
Examinator	prof. dr. S.J. Koopman
Teaching method(s)	Lecture
Level	400

Course objective
To gain insights in economic time series modelling with a focus on theory, methods and computations.

Course content
This course focuses on the advances of theory and computational methods for time series econometrics. A methodology of econometric programming is explored for a number of selected topics in time series analysis. In particular, time series properties in time and frequency domains, different modeling strategies, likelihood evaluations, filtering methods and Monte Carlo simulation methods are studied. Theory and methods are studied thoroughly while some computer programs need to be developed for the implementation of the methods.

Form of tuition
lecture
tutorial

Type of assessment
written interim examination
50 percent
written assignments
50 percent

Course reading
Selection of literature:
- Brockwell, P.J. & R.A. Davis, Time Series: Theory and Methods. Springer-Verlag, 1991,2nd edition.
- Durbin, J. & S.J. Koopman, Time Series Analysis by State Space Methods. Oxford University Press, 2001.
- Kim, C-J & C.R. Nelson, State-Space Models with Regime Switching. The MIT Press, 1999.

Transport Economics

Course code	E_STR_TREC (60432050)
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. A.J.H. Pels
Examinator	dr. A.J.H. Pels
Teaching staff	dr. A.J.H. Pels
Teaching method(s)	Lecture
Level	400

Course objective
The aim of this course is to provide students with an advanced knowledge of contemporary transport economics, considering both intra-city transport (e.g. congested road traffic, urban transit) and inter-city transport (notably aviation). Students

- learn theoretical and empirical methods applied in the field of

transport economics and in related fields, such as transport planning.
- get a good understanding of the fundamental policy questions that are addressed in the field, and the methods with which these are addressed.
- learn the current state of affairs in the literature.
are trained to critically read and properly understand contributions in the leading journals in the field.

Course content
This course covers advanced topics in theoretical and empirical research on urban transport economics. Key issues are demand analysis; cost functions and scale economies for various modes; congestion analysis in static and dynamic formulations; network equilibrium and optimum for deterministic and stochastic network models; first-best and second-best pricing in static and dynamic networks; investment analysis under first-best and second-best pricing; and industrial organization aspects of intra-city (e.g. roads and transit) and inter-city (e.g. airports and airlines) transport. The topics are addressed from a theoretical as well as an empirical perspective.

Type of assessment
written interim examination: 70 percent
assignments: 30 percent (paper review tutorial 10 percent, network optimization tutorial 10 percent, methods tutorial 10 percent)

Course reading
- Small, K.A. and E.T. Verhoef, The Economics of Urban Transportation. Routledge, 2007.
- Additional literature for more specialized topics will be announced at the start of the course.

Recommended background knowledge
Microeconomics for spatial policy or a similar course