

VU GRADUATE WINTER SCHOOL

13-15 JANUARY 2025



COURSE SYLLABUS

2 ECTS

FULLTIME ACADEMIC
PROGRAMME

CONTACT



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VRIJE
UNIVERSITEIT
AMSTERDAM

Graduate
Winter School

Econometrics of Networks

Contact Info

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Course Description

Networks play an increasingly dominant role in many social, business, and economic environments. Moreover, network data becomes increasingly important and available due to the rise of online social media and digitization. This course offers a concise introduction into the most recent econometric methods developed for processing, visualizing and learning from network data. The course will combine online lectures with hands-on empirical and programming exercises.

Learning Objectives

Upon successful completion of the course, students will:

- become acquainted with different statistical methodologies for analyzing networks while learning how to see these different methodologies complementing each other.
- learn to model network problem situations mathematically, and adapt the methods learned to new situations at hand.
- be able to recognize, understand, and analyze societal and business problems in which networks are central.
- learn how networks affect demand and supply in markets, how this leads to market failures, and how government policies can address these.

Reading List

All relevant material will be covered in the lecture slides. The slides will be made available to the students on the course website before the start of the course. The following literature is complementary to the course slides and covers some additional relevant material for further reading:

- Graham, Bryan, and De Paula, Aureo. *Econometric Analysis of Network Data*. Elsevier, 2020.
- Kolaczyk, Eric. *Statistical Analysis of Network Data: Methods and Models*, Springer, 2009.
- LeSage, James, and Robert Kelley Pace. *Introduction to Spatial Econometrics*. Chapman and Hall/CRC, 2009.
- Bramoullé, Yann, Andrea Galeotti, and Brian Rogers. *The Oxford Handbook of the Economics of Networks*. Oxford University Press, 2016.
- Goyal, Sanjeev. *Networks: An economics approach*. MIT Press, 2023.
- Jackson, Matthew. O. *Social and Economic Networks*. Princeton University Press, 2010.
- Carrington, Peter, John Scott, and Stanley Wasserman. *Models and Methods in Social Network Analysis*, Cambridge University Press, 2005.

Tutorials and Exercises

The course consists of three days in which you will practice the material of the lectures in the morning with tutorials in the afternoon using exercises that will be implemented in Matlab. During the tutorials, you are required to complete an exercise which will build on the skills you have obtained in the lectures. You can complete the exercises in groups of two or three students, but are required to submit the solutions individually by the 31st of January 2025. Exercise solutions and assignments should be submitted via email to m.d.konig@vu.nl. If you successfully completed the exercises you obtain a certificate for this course.

Grading

Tutorial and programming exercises: 100%

Daily Course Schedule

	Monday	Tuesday	Wednesday
09:30-10:30	Lecture 1: Networks - Basic Definitions and Characterizations	Lecture 3: Econometrics of Network Formation	Lecture 5: Network Formation with Multiple Activities
10:30-11:00	Break		
11:00-12:00	Lecture 2: Econometrics of Interactions in Networks	Lecture 4: Coevolution of Networks and Behavior	Lectures 6 & 7: Network Panel Estimation, Big Data Meets Networks, Q&As
12:00-14:00	Lunch Break		
14:00-15:00	Tutorial 1: Matlab Intro, Visualizing Networks and Fitting Degree Distributions	Tutorial 2: SAR Model and Logistic Regression	Tutorial 3: Double Metropolis-Hastings (DMH) Algorithm

Detailed Schedule

Day 1

Lecture 1: Networks: Basic Definitions and Characterizations

1. Examples of Networks and Data

2. Network Statistics, Visualization and Graphs

- Elements of Graph Theory
- Graphs and Matrices
- Bipartite Graphs
- Core-periphery Networks and Nested Split Graphs
- Network Statistics: Average path length, clustering and assortativity
- Centrality in Networks: Degree, eigenvector, Katz-Bonacich centrality and Google's Page Rank
- Network Visualization: Force-directed, circular and layered layout

Lecture 2: Econometrics of Interactions in Networks

3. Econometrics of Interactions in Networks

- Spatial Autoregressive (SAR) Model
- Linear Quadratic Utility
- Endogeneity of the Spatial Lag
- Two-Stage Least Squares (2SLS)
- Maximum Likelihood Estimation (MLE)
- Identification Issues
 - Correlated Effects, Sorting and Selection
 - Endogenous Link Formation
- Multiple Spatial Weight Matrices
- Spatial Panel Data

Day 2

Lecture 3: Econometrics of Network Formation

4. Econometrics of Network Formation

- Exponential Random Graph Model (ERGM)
- Conditional Edge-Independence
 - Erdős-Rényi Random Graph
 - Logistic Regression
 - Unobservable Characteristics (beta-model)
 - Tetrad Logit Estimator
- Random Utility Model
- Maximum Likelihood Estimation (MLE)
- Markov Chain Monte Carlo
 - Gibbs Sampling
 - Metropolis Hastings Algorithm
- Stochastic Block Model (SBM)
- Temporal ERGM

Lecture 4: Coevolution of Networks and Behavior

5. Joint Estimation of Outcomes and Network Formation

5.1. Coevolution of Networks and Behavior: An application to R&D collaboration networks

- Structural Model: Utility and the potential game
- Estimation
 - Computational Problem and the Exchange Algorithm
 - Double Metropolis-Hastings (DMH) Algorithm
 - Unobserved Heterogeneity
- Empirical Illustration: R&D collaborations

Tutorial 2: SAR Model and Logistic Regression

Day 3

Lecture 5: Network Formation with Multiple Activities

5.2. Network Formation with Multiple Activities: An application to team production and co-authorship networks

- Bipartite Network, Production Function, and Utility
- Equilibrium Characterization and Line Graphs
- Estimation with Endogenous Matching
- Empirical Illustration: Co-authorship networks

Lecture 6: Network Panel Estimation

6. Spatial Modeling Approach for Dynamic Network Formation and Interactions

- Spatial Dynamic Panel Data (SDPD) Model
- A General Dynamic Network Formation Model
- Combining SDPD with the Network Formation Model: Joint likelihood function
- An Empirical Application to Peer Effects in Academic Performance

Lecture 7: Big Data meets Networks

7. Big Data meets Networks

- The Digital Layer: How innovative firms relate on the Web
- Automated Robot for Generic Universal Scraping (ARGUS)
- Input, Interface and Output of ARGUS
- Sectoral Hyperlink Network
- Hyperlink Types

Tutorial 3: Double Metropolis-Hastings (DMH) Algorithm