TI SUMMER SCHOOL

3-7 JULY 2023

COURSE SYLLABUS | 3 ECTS | FULLTIME ACADEMIC PROGRAMME

CONTACT

https://www.tinbergen.nl/summer-school/

summerschool@tinbergen.nl

tinbergen institute

Networks in Micro- and Macroeconomics

Lecturers
Prof. Andrei Levchenko
Department of Economics, University of Michigan, United States.
Email: alev@umich.edu
URL: https://alevchenko.com/

Prof. Michael D. König
Department of Spatial Economics, School of Business and Economics, Vrije Universiteit Amsterdam, The Netherlands.
Email: m.d.konig@vu.nl
URL: https://research.vu.nl/en/persons/michael-konig

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 digital data sources. This course offers a concise introduction into the most recent economic models and econometric methods developed for processing, visualizing and learning from network data. We provide a comprehensive approach for analyzing networks, both, from microeconomic as well as macroeconomic perspectives. This will provide course participants with a generic network analysis toolbox that can then be applied to particular environments and applications, depending on idiosyncratic needs and interests. To further aid the understanding of network concepts and methods the course will combine lectures with hands-on empirical and programming exercises.

Learning Objectives
Upon successful completion of the course, participants will:

- become acquainted with different 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:

- Bramoulle, Yann, Andrea Galeotti, and Brian Rogers. *The Oxford Handbook of the Economics of Networks*. Oxford University Press, 2016.
- Dixit, A. and V. Norman (1980). Theory of International Trade: A Dual, General Equilibrium Approach. Cambridge Economic Handbooks. Cambridge University Press.
- Eaton, Jonathan and Sam Kortum (2005) Technology in the Global Economy: A Framework for Quantitative Analysis.
- Feenstra, R. C. (2015). Advanced international trade: theory and evidence. Princeton university press.
- Goyal, S. Networks: An Economics Approach. MIT Press, 2023.
- Graham, Bryan, and De Paula, Aureo. *Econometric Analysis of Network Data*. Elsevier, 2020.
- Helpman, E. and P. Krugman (1985). Market Structure and Foreign Trade. MIT Press.

- Jackson, Matthew. O. *Social and Economic Networks*. Princeton University Press, 2010.
- Kolaczyk, Eric, *Statistical Analysis of Network Data: Methods and Models*, Springer, 2009.

Tutorials and Exercises

The course consists of five days in which you will practice the material of the lectures in the mornings with tutorials in the afternoons using exercises that will be implemented in Matlab or Stata. 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 (in work groups or remotely), but are required to submit the solutions individually by the 31st of July 2023. 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	Thursday	Friday
	Introduction to Networks	Microeconomics of Networks		Macroeconomics of Networks	
09:30-10:30	**Lecture 1**: Networks - Basic Definitions and Characterizations	**Lecture 3**: Modeling Interactions in Networks	**Lecture 5**: Coevolution of Networks and Behavior	**Lecture 7**: International Business Cycle 1	**Lecture 9**: Propagation of shocks through networks 1
10:30-11:00	Break				
11:00-12:00	**Lecture 2**: Games on Networks – It's All About Centrality!	**Lecture 4**: Network Formation	**Lecture 6**: Network Panel Estimation & Big Data Meets Networks	**Lecture 8**: International Business Cycle 2	**Lecture 10**: Propagation of shocks through networks 2
12:00-14:00	Lunch Break				
14:00-15:00	**Tutorial 1:** Visualizing Networks and Fitting Degree Distributions	**Tutorial 2:** SAR Model and Logistic Regression	**Tutorial 3:** Double Metropolis-Hastings (DMH) Algorithm	**Tutorial 4:** Solving input-output model in general equilibrium & estimation with larger-scale international network data	**Tutorial 5:** Working with firm-level data; estimating power laws & firm size-volatility relationship
15:00-17:00	Work groups				

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: Games on Networks

3. Games on Networks – It's All About Centrality!

- Linear Quadratic Games
  - A Linear Quadratic Specification
  - Nash Equilibrium & Katz-Bonacich Centrality
  - Welfare
  - Key Players
- Applications
  - R&D Collaboration Networks
  - Cournot Competition in Networked Markets
  - Coauthorship Networks and Team Production
  - Production Networks and Supply Chains
  - Networks in Conflict

Lecture 3: Modeling Interactions in Networks

4. Modeling and Estimating 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

Tutorial 1
- Introduction to Matlab

• Visualizing Networks
• Fitting Degree Distributions

Day 2

Lecture 4: Network Formation

5. Modeling and Estimating the Formation of Networks

• Exponential Random Graph Model (ERGM)
• Conditional Edge-Independence
  – Erdös-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 5: Coevolution of Networks and Behavior

6. 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
• Spatial Autoregressive (SAR) Model
• Logistic Regression

Day 3

Lecture 6: Network Panel Estimation & Big Data Meets Networks

7. 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

8. 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
- Application to R&D Networks

Day 4

Lectures 7 & 8: International Business Cycle

9. International Business Cycle

- Introducing the international production network: the global value chains
- National accounting conventions: constructing GDP from output and input data
- Key data concept: the Input-Output matrix
- Key data sources: EU KLEMS and the World Input-Output Database (WIOD)
- The basic production network model -- closed economy
- The multi-country production network model
- Analyzing international GDP comovement

Tutorial 4
- Solving the basic input-output model in general equilibrium
- Larger-scale international input network model

Day 5

Lectures 9 & 10: Granularity; Propagation of shocks through networks

10. Granularity; Propagation of shocks through networks

- The firm-size distribution: Zipf's Law
- Granular business cycle fluctuations: large firms relevant for the macroeconomy
- Granularity in the open economy:
  – aggregate fluctuations with superstar trading firms
  – propagation of foreign business cycle shocks through large firms

Tutorial 5
- Working with firm-level data
- Estimating power laws in firm size
- Estimating the size-volatility relationship