NETWORK ANALYSIS – STATISTICAL ANALYSIS OF SOCIAL NETWORK DATA

Universität St. Gallen
2023 Global School on Empirical Research Methods (GSERM)
June 12-16, 2023
9am-Noon & 1pm-3pm Central European Summer Time (CEST) / Swiss Time

Lecturer: Michael T. Heaney
Home Institution: University of Glasgow
Email: michaeltheaney@gmail.com

PREREQUISITES AND CONTENT

Earns 4 credits in the European Credit Transfer and Accumulation System (ECTS)

Prerequisite knowledge for the course includes the fundamentals of probability and statistics, especially hypothesis testing and regression analysis. This intermediate level course assumes that students can interpret the results of Ordinary Least Squares, Probit, and Logit regressions. They should also be familiar with the problems that are most common in regression, such as multicollinearity, heteroscedasticity, and endogeneity. Finally, students should be comfortable working with computers and data. No prior knowledge of R or network analysis is required.

The concept of "social networks" is increasingly a part of social discussion, organizational strategy, and academic research. The rising interest in social networks has been coupled with a proliferation of widely available network data, but there has not been a concomitant increase in understanding how to analyze social network data. This course presents concepts and methods applicable for the analysis of a wide range of social networks, such as those based on family ties, business collaboration, political alliances, and social media.

Classical statistical analysis is premised on the assumption that observations are sampled independently of one another. In the case of social networks, however, observations are not independent of one another, but are dependent on the structure of the social network. The dependence of observations on one another is a feature of the data, rather than a nuisance. This course is an introduction to statistical models that attempt to understand this feature as both a cause and an effect of social processes.

Since network data are generated in a different way than many other kinds of social data, the course begins by considering the research designs, sampling strategies, and data formats that are commonly associated with network analysis. A key aspect of performing network analysis is describing various elements of the network's structure. To this end, the course covers the calculation of a variety of descriptive statistics on networks, such as density, centralization, centrality, connectedness, reciprocity, and transitivity. We consider various ways of visualizing networks, including multidimensional scaling and spring embedding. We learn methods of estimating regressions in which network ties are the dependent variable, including the quadratic assignment procedure and exponential random graph models (ERGMs). We consider extensions of ERGMs, including models for two-mode data, networks over time, and valued edges.

Instruction is split between lectures and hands-on computer exercises. Students may find it to their advantage to bring with them a social network data set that is relevant to their research interests, but doing so is not required. The instructor will provide data sets necessary for completing the course exercises.

REQUIREMENTS

50% of grade: There will be four written, computer-based problem sets.

50% of grade: On the final of day of the course, each student will make a 10-15-minute presentation to the class on the results of her or his research project for the week. Giving a presentation to the course is required to receive credit for the course.

In order to receive credit for the course students must attend and participate fully in at least 80% of all sessions.

Students must install the latest version of R on their computer. As of May 22, 2023, this was version 4.3.0. Be on the lookout for the release of new versions.

BOOKS FOR PURCHASE

John T. Scott. 2017. *Social Network Analysis*, 4TH edition. London: Sage.
https://www.amazon.co.uk/Social-Network-Analysis-John-Scott-dp-1473952123/dp/1473952123/ref=dp_ob_image_bk

Skyler J. Cranmer, Bruce A. Desmarais, and Jason W. Morgan. 2021. *Inferential Network Analysis*. New York: Cambridge University Press.
https://www.amazon.co.uk/Inferential-Network-Analysis-Analytical-Research/dp/1316610853/ref=sr_1_1?dchild=1&keywords=inferential+network+analysis&qid=1610302795&s=books&sr=1-1

Other readings will be provided to course participants in .PDF form. Readings are recommended but not required.

OUTLINE FOR COURSE

<u>Monday, June 12</u>

1. Welcome, course procedures, requirements, and objectives

2. Lecture 01: Introduction to social network analysis

   <u>Recommended Readings</u>
   - John T. Scott. 2017. *Social Network Analysis*, 4th edition. London: Sage. Pages 1-40.
   - Mustafa Emirbayer. 1997. "Manifesto for a Relational Sociology." *American Journal of Sociology* 103 (2): 281-317.

- Ronald L. Breiger. 1974. "The Duality of Persons and Groups." *Social Forces* 53 (2): 181-190.
- Linton C. Freeman. 1977. "A Set of Measures of Centrality Based on Betweenness." *Sociometry* 40 (1): 35-41.
- Duncan Watts. 1999. *Small Worlds: The Dynamics of Networks Between Order and Randomness*. Princeton: Princeton University Press. Pp. 11-40.
- Steven Strogatz. 2010. "The Enemy of My Enemy." *New York Times* (February 14).
- David Knoke, Mario Diani, James Hollway, and Dimitris Christopolous. 2021. *Multimodal Political Networks*. New York: Cambridge University Press. Pp. 134-135.

3. Lecture 02: Major theories

   Recommended Readings
   - Mark Granovetter. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78 (6): 1360-1380.
   - Roger V. Gould and Roberto M. Fernandez. 1989. "Structures of Mediation: A Formal Approach to Brokerage in Transaction Networks." *Sociological Methodology* 19: 89-126.
   - Ronald S. Burt. 1992. *Structural Holes: The Social Structure of Competition.* Cambridge, MA: Harvard University Press. Pp. 8-49.
   - Joel M. Podolny. 2001. "Networks as the pipes and prisms of the market." *American Journal of Sociology* 107 (1): 33-60.
   - Miller McPherson, Lynn Smith-Lovin, and James M. Cook. 2001. "Birds of a Feather: Homophily in Social Networks." *Annual Review of Sociology* 27: 415-444.

4. Lecture 03: Research designs and data

   Recommended Readings
   - John T. Scott. 2017. *Social Network Analysis*, 4th edition. London: Sage. Pp. 41-56.
   - Edward O. Laumann, Peter V. Marsden, and David Prensky. 1983. "The Boundary Specification Problem in Network Analysis." Pp. 18-34 in Ronald S. Burt and Michael Minor, eds., *Applied Network Analysis*, eds. Beverly Hills, CA: Sage.
   - Douglas D. Heckathorn. 1997. "Respondent-Driven Sampling: A New Approach to the Study of Hidden Populations." *Social Problems* 44 (2): 174-199.
   - David Krackhardt. 1992. "The Strength of Strong Ties: The Importance of Philos in Organizations." Pp. 216-239 in Nitin Nohria and Robert Eccles, eds., *Networks and Organizations: Structure, Form, and Action*. Boston, MA: Harvard Business School Press.

Tuesday, June 13

5. Computer Exercises 01: Introduction to Network Analysis in R

   Recommended Readings
   - Carter T. Butts. 2008. "network: A Package for Managing Relational Data in R." *Journal of Statistical Software* 24 (2): 1-36.
   - Carter T. Butts. 2008. "Social Network Analysis with sna." *Journal of Statistical Software* 24 (6): 1-51.

6. Lecture 04: Descriptive statistics

   Recommended Readings
   - John T. Scott. 2017. *Social Network Analysis*, 4th ed. London: Sage. Pp. 57-136.

7. Computer Exercises 02: Descriptive statistics

8. Lecture 05: Inferential network analysis

   Recommended Readings
   - Skyler J. Cranmer, Bruce A. Desmarais, and Jason W. Morgan. 2021. *Inferential Network Analysis*. New York: Cambridge University Press. Pp. 3-32.

Wednesday, June 14

9. Lecture 06: Exponential Random Graph Models (ERGMs)

   Recommended Readings
   - Skyler J. Cranmer, Bruce A. Desmarais, and Jason W. Morgan. 2021. *Inferential Network Analysis*. New York: Cambridge University Press. Pp. 35-115.
   - Skyler J. Cranmer, Philip Leifeld, Scott D. McClurg, and Meredith Rolfe. 2017. "Navigating the Range of Statistical Tools for Inferential Network Analysis." *American Journal of Political Science* 61 (1): 237-251.

10. Computer Exercises 03: Exponential Random Graph Models (ERGMs)

    Recommended Readings
    - David R. Hunter, Mark S. Handcock, Carter T. Butts, Steven M. Goodreau, and Martina Morris. 2008. "ergm: A Package to Fit, Simulate and Diagnose Exponential-Family Models for Networks." *Journal of Statistical Software* 24 (3): 1-29
    - Martina Morris, Mark S. Handcock, and David R. Hunter. 2008. "Specification of Exponential-Family Random Graph Models: Terms and Computational Aspects." *Journal of Statistical Software* 24 (4): 1-24.
    - Michael T. Heaney. 2014. "Multiplex Networks and Interest Group Influence Reputation: An Exponential Random Graph Model." *Social Networks* 36 (1): 66-81.
    - Michael T. Heaney and Philip Leifeld. 2018. "Contributions by Interest Groups to Lobbying Coalitions." *Journal of Politics* 80 (2): 494-509.

11. Individual consultations

Thursday, June 15

12. Lecture 07: Temporal Exponential Random Graph Models (TERGMs)

    Recommended Readings
    - Skyler J. Cranmer, Bruce A. Desmarais, and Jason W. Morgan. 2021. *Inferential Network Analysis*. New York: Cambridge University Press. Pp. 116-147.

- Philip Leifleld and Skyler J. Cranmer. 2019. "A theoretical and empirical comparison of the temporal exponential random graph model and the stochastic actor-oriented model." *Network Science* 7 (1): 20-51.

13. Computer Exercises 04: Temporal Exponential Random Graph Models

    Recommended Readings
    - Philip Leifeld, Skyler J. Cramner, and Bruce A. Desmarais. 2018. "Temporal Exponential Random Graph Models with btergm: Estimation and Bootstrap Confidence Intervals." *Journal of Statistical Software* 83 (6):1-36.

14. Individual consultations. Participants should plan to work in the evening to refine their presentations for Friday morning.

Friday June 16

15. Student presentations (required if receiving credit for course)

16. Lecture 08: Generalized Exponential Random Graph Models (GERGMs)

    Recommended Readings
    - Skyler J. Cranmer, Bruce A. Desmarais, and Jason W. Morgan. 2021. *Inferential Network Analysis*. New York: Cambridge University Press. Pp. 148-164.

17. Computer Exercises 05: Generalized Exponential Random Graph Models (GERGMs)

    Recommended Readings
    - Matthew J. Denny. 2016. "Getting Started with GERGM." https://www.mjdenny.com/getting_started_with_GERGM.html

18. Closing discussion