Syllabus
Social Science Methodology: Network Analysis

Instructor: Oliver Westerwinter
Fall Semester 2017

Time & room
Thursday, 12:15-14h in 01-U179
Exception: Wednesday, 22.11
14:15-16h in 01-U179
Note: No class on 21.12

Office
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Office hours: By appointment

This syllabus may be subject to adjustments.

Overview and goals

Politics, and social life more generally, is about networks. People, organizations, groups, and states are connected through a range of relationships. Organizations, for example, can be linked through project collaborations, flows of financial resources, or shared members. States in the international system are related to each other through trade, military alliances, and violent conflict among others. The patterns of such relationships constitute networks. The position of actors within these networks as well as the overall structural characteristics of networks can have an important impact on the behavior of agents and other outcomes of interest for social scientists. For example, the network ties of individuals may influence their voting behavior in an election, nongovernmental organizations that occupy central positions in the network of human rights organizations may be more successful in launching human rights advocacy campaigns, and states that are central in the international trade network may be less likely to engage in violent conflict.

The study of networks in the social sciences has grown rapidly in recent years. Social scientists are investigating the effects of networks on a broad range of sociopolitical phenomena including political participation, voting behavior, congressional voting, terrorism, revolutions, transnational advocacy campaigns, policy diffusion, alliance formation, and war. Network analysis provides a repertoire of theoretical propositions and methods to study the properties, antecedents, and consequences of networks.

This course is an introduction to network analysis. Students will learn the basic concepts and analytic techniques of network analysis and how they can be employed to study substantive socio-political phenomena. Topics covered include network data collection and management, formulation of network hypotheses, network description and visualization, and methods for making statistical inferences with and about networks. We will make use of substantive applications in various social sciences with a focus on political science and international relations. Students will be introduced to common software packages for network analysis in R. Students will engage in their own analyses, using either their own data or replication data

that has appeared in published work in political science.

Prerequisites

A willingness to work through possibly unfamiliar material. A basic understanding of statistics, matrix algebra, and programing in R is helpful, but not required.

There is the opportunity to participate in an optional refresher for matrix algebra as well as an introduction to the R programing language. The refresher will take place on Monday, September 25 at 12:15-4pm in room 01-U102. If you are interested in participating in the refresher, please email the course instructor: `oliver.westerwinter@unisg.ch`.

Class requirements

Final grades will be based on:

- Term paper (55% of final grade)
- Three homework assignments (45% of final grade)
- Participation in lectures and exercises

There will be three homework assignments, each of which will contribute 15% to your final grade for this class. The homework assignments will consist of analytical problems, computer programing in R, and data analysis. The solutions of the assignments together with, where applicable, the R code needed to reproduce the results have to be submitted electronically or as hard copy at the beginning of each class at which they are due. The assignments will be available one week prior to the class at which they are due. No late homework submissions will be accepted. All submitted homework will be graded. Comprehensive solutions will be available electronically in form of R scripts.

The homework assignments are solo exams. Thus, you always need to write and submit your own solutions. Please always make sure that you write your name on every page of your submission. Please note that the homework assignments are designed to support and deepen your understanding of the material discussed in class. They will help you to self-assess your level of accomplishment and plan your term paper project.

The term paper will contribute 55% to your final grade. It has to be submitted either as hard copy or electronically (pdf) by January 15, 2018. Late submissions will not be accepted. The term paper is expected to present a short independent empirical research project that uses the theoretical and analytical repertoire of network analysis. It has to present a research question, hypothesis, and an empirical analysis suitable for testing the motivating hypothesis. The maximum length of the paper is 5,000 words (including footnotes, references, etc.). The term paper is a solo exam. You are therefore expected to work on and submit your term paper project individually.

Course website

We use StudyNet as communication platform for the class. The course site at StudyNet can be accessed here: `https://loginpages.unisg.ch/studynet`.

The course website at StudyNet will provide readings, homework assignments, datasets, R scripts, and supplementary materials.

Computation

The course will be taught in R. R is an open-source computing language that is widely used in statistics. You can download it for free from `www.r-project.org` and it is recommended that you install R on your private computer prior to the start of class. For those of you who are not yet familiar with the basics of R, the refresher in the second week of the semester is recommended. Tutorials and other resources to learn about the basics of R are available at `http://wiki.math.yorku.ca/index.php/R:Gettingstarted`.

Data

Many example datasets will be provided in order to illustrate the application of the methods discussed throughout the course. In addition, there will be ample opportunities for students to work on their own data or data in which they are interested. For the homework assignments as well as the term paper, students may either use the example data discussed in class or their own data. The example datasets that will be used in class will be available on the StudyNet website of the course.

Textbooks

The course will be taught without using a single textbook. The required readings in combination with the slides and R scripts provided throughout the course will be the primary teaching materials. Students who are interested in consulting a textbook in parallel to the required readings and class materials can choose from a broad variety of options with different strengths and weaknesses including:

Carrington, Peter J., John Scott, and Stanley Wasserman. 2005. *Models and Methods in Social Network Analysis.* New York: Cambridge University Press.

Easley, David and Jon Kleinberg. 2010. *Networks, Crowds, and Markets. Reasoning about a Highly Connected World.* Cambridge: Cambridge University Press.

Hanneman, Robert A. and Mark Riddle. 2005. *Introduction to social network methods.* Riverside: University of California, Riverside (`http://faculty.ucr.edu/ hanneman/`)

Jackson, Matthew. 2008. *Social and Economic Networks.* Princeton: Princeton University Press.

Knoke, David and Song Yang. 2008. *Social Network Analysis.* Second edition. London: Sage.

Robins, Garry. 2015. *Doing Social Network Research. Network-based Research Design for Social Scientists.* London: Sage.

Scott, John. 2013. *Social Network Analysis.* Third edition. London: Sage.

Vega-Redondo, Fernando. 2007. *Complex Social Networks.* Cambridge: Cambridge University Press.

Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis. Methods and Applications.* Cambridge: Cambridge University Press.

Schedule

The weekly coverage might change as it depends on the progress of the class. The assigned required and optional readings are listed in the class schedule for each session. The required readings should be completed prior to the session for which they are listed and studied carefully. In addition, it is recommended to consult the optional readings. The optional readings may prove useful to students looking for additional coverage of some of the course topics as well as for developing the topic of your term paper project. This schedule is subject to adjustments.

September 21: Introduction: Network terminology and data

Required readings:

Dourssen, Han, Erik Gartzke and Oliver Westerwinter. 2016. "Networked international politics: Complex interdependence and the diffusion of conflict and peace." *Journal of Peace Research* 53:283-291.

Robins, Garry. 2015. *Doing Social Network Research. Network-based Research Design for Social Scientists.* London: Sage. Ch. 1+4.

Optional readings:

Butts, Carter T. 2008a. "network: A Package for Managing Relational Data in R." *Journal of Statistical Software* 24:1-36.

Knoke, David and Song Yang. 2008. *Social Network Analysis.* Second edition. London: Sage. Ch. 1+2.

Lazer, David. 2011. "Networks in Political Science: Back to the Future." *PS: Political Science & Politics* 44:61-68.

Scott, John. 2013. *Social Network Analysis.* Third edition. London: Sage. Ch. 1+2.

Ward, Michael D., Katherine Stovel and Audrey Sacks. 2011. "Network Analysis and Political Science." *Annual Review of Political Science* 14:245-64.

Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis. Methods and Applications.* New York: Cambridge University Press. Ch. 1, 2-2.4.1.

September 28: Network theory and hypotheses

Required readings:

Robins, Garry. 2015. *Doing Social Network Research. Network-based Research Design for Social Scientists.* London: Sage. Ch. 2.

Optional readings:

Avant, Deborah and Oliver Westerwinter. 2016. Introduction: Networks and Transnational Security Governance. In *The New Power Politics: Networks and Transnational Security Governance*, eds. Deborah Avant and Oliver Westerwinter. New York: Oxford University Press pp. 1-18.

Borgatti, Stephen P. and Daniel S. Halgin. 2011. "On Network Theory." *Organization Science* 22:1168-1181.

Carpenter, Daniel P., Kevin M. Esterling, and David M. J. Lazer. 2004. "Friends, Brokers, and Transitivity: Who Informs Whom in Washington Politics?" *Journal of Politics* 66:224-246.

Hafner-Burton, Emilie M., Miles Kahler and Alexander H. Montgomery. 2009. "Network Analysis for International Relations." *International Organization* 63:559-92.

Maoz, Zeev. 2011. *Networks of Nations. The Evolution, Structure, and Impact of International Networks, 1816-2001.* New York: Cambridge University Press. Ch. 5.

Wellman, Barry. 1983. "Network Analysis: Some Basic Principles." *Sociological Theory* 1:155-200.

October 05: Collecting and manipulating network data

Required readings:

Robins, Garry. 2015. *Doing Social Network Research. Network-based Research Design for Social Scientists.* London: Sage. Ch. 5.

Optional readings:

Butts, Carter T. 2008a. "network: A Package for Managing Relational Data in R." *Journal of Statistical Software* 24:1-36.

Costenbader, Elizabeth and Thomas W. Valente. 2003. "The stability of centrality measures when networks are sampled." *Social Networks* 25:283-307.

Frank, Ove. 2005. Network Sampling and Model Fitting. In *Models and Methods in Social Network Analysis*, eds. Peter J. Carrington, John Scott, and Stanley Wasserman. New York. Cambridge University Press pp. 31-56.

Knoke, David and Song Yang. 2008. *Social Network Analysis.* Second edition. London: Sage. Ch. 3.

Kolaczyk, Eric D. and Gabor Csardi. 2014. *Statistical Analysis of Network Data with R.* New York: Springer. Ch. 2.

Marsden, Peter V. 1990. "Network Data and Network Measurement." *Annual Review of Sociology* 16:435-63.

Marsden, Peter V. 2005. Recent Developments in Network Measurement. In *Models and Methods in Social Network Analysis*, eds. Peter J. Carrington, John Scott, and Stanley Wasserman. New York. Cambridge University Press pp. 8-30.

Robins, Garry. 2015. *Doing Social Network Research. Network-based Research Design for Social Scientists.* London: Sage. Ch. 3+6.

Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis. Methods and Applications.* New York: Cambridge University Press. Ch. 2.4.2-2.4.4.

Westerwinter, Oliver. 2015. "Measuring Transnational Networks: A Multiple-Sources and Multiple-Measurement Approach." Manuscript: University of St. Gallen.

October 12: Network descriptive statistics (first problem set available)

Required readings:

Knoke, David and Song Yang. 2008. *Social Network Analysis.* Second edition. London: Sage. Ch. 4.

Optional readings:

Butts, Carter T. 2008a. "network: A Package for Managing Relational Data in R." *Journal of Statistical Software* 24:1-36.

Butts, Carter T. 2008b. "Social Network Analysis: A Methodological Introduction." *Asian Journal of Social Psychology* 11:13-41.

Butts, Carter T. 2008c. "Social Network Analysis with sna." *Journal of Statistical Software* 24: 1-51.

Jackson, Matthew O. 2008. *Social and Economic Networks.* Princeton: Princeton University Press. Ch. 2.

Kolaczyk, Eric D. and Gabor Csardi. 2014. *Statistical Analysis of Network Data with R.* New York: Springer. Ch. 4.

October 19: Network visualization (first problem set due)

Required readings:

Robins, Garry. 2015. *Doing Social Network Research. Network-based Research Design for Social Scientists.* London: Sage. Ch. 8.

Optional readings:

Butts, Carter T. 2008c. "Social Network Analysis with sna." *Journal of Statistical Software* 24: 1-51.

Freeman, Linton C. 2005. Graphic Techniques for Exploring Social Network Data. In *Models and Methods in Social Network Analysis*, eds. Peter J. Carrington, John Scott, and Stanley Wasserman. New York. Cambridge University Press pp. 248-269.

Kolaczyk, Eric D. and Gabor Csardi. 2014. *Statistical Analysis of Network Data with R.* New York: Springer. Ch. 3.

McGarth, Cathleen, David Krackhardt and Jim Blythe. 2003. "Visualizing Complexity in Networks: Seeing Both the Forest and the Trees." *Connections* 25: 37-47.

October 26: Partitioning networks into groups

Required readings:

Scott, John. 2013. *Social Network Analysis.* Third edition. London: Sage. Ch. 6+7.

Optional readings:

Csardi, Gabor. 2015. "Package 'igraph'." June 26, 2015.

Girvan, M. and M. E. J. Newman. 2002. "Community structure in social and biological networks." *Proceedings of the National Academy of Sciences* 99:7821-7826.

Knoke, David and Song Yang. 2008. *Social Network Analysis.* Second edition. London: Sage. Ch. 4.

Kolaczyk, Eric D. and Gabor Csardi. 2014. *Statistical Analysis of Network Data with R.* New York: Springer. Ch. 4.

Lupu, Yonatan and Vincent A. Traag. 2012. "Trading Communities, the Networked Structure of International Relations, and the Kantian Peace." *Journal of Conflict Resolution* 57:1011-1042.

Newman, M. E. J. 2004a. "Fast algorithm for detecting community structure in networks." *Physical Review E* 69.

Newman, M. E. J. 2004b. "Detecting community structure in networks." *European Physical Journal B* 38:321-330.

Wasserman, Stanley and Katherine Faust. 1994. *Social Network Analysis. Methods and Applications.* New York: Cambridge University Press. Ch. 7+10.

Zhang, Yan, A. J. Friend, Amenda L. Traud, Mason, A. Porter, James H. Fowler, and Peter J. Mucha. 2008. "Community structure in Congressional cosponsorship networks." *Physica A* 387:1705-1712.

November 16: Inferential statistics with networks (second problem set available)

Required readings:

Cranmer, Skyler J., Philip Leifeld, Scott D. McClurg and Meredith Rolfe. 2017. "Navigating the Range of Statistical Tools for Inferential Network Analysis." *American Journal of Political Science* 61:237-51.

Krackhardt, David. 1988. "Predicting with Networks: Nonparametric Multiple Regression Analysis of Dyadic Data." *Social Networks* 10:359-381.

Optional readings:

Cranmer, Skyler J. and Bruce A. Desmarais. 2016. "A Critique of Dyadic Design." *International Studies Quarterly* 60:355-362.

Hoff, Peter D. and Michael D. Ward. 2010. "Modeling Dependencies in International Relations Networks." *Political Analysis* 12:160-175.

Krackhardt, David. 1987. "QAP Partialling as a Test of Spuriousness." *Social Networks* 9:171-186.

Maoz, Zeev, Ranan D. Kuperman, Lesley Terris, and Ilan Talmud. 2006. "Structural Equivalence and International Conflict. A Social Network Analysis." *Journal of Conflict Resolution* 50:664-689.

Murdie, Amanda. 2014. "The Ties That Bind: A Network Analysis of Human Rights International Nongovernmental Organizations." *British Journal of Political Science* 44:1-27.

Poast, Paul. 2016. "Dyads are Dead, Long Live Dyads! The Limits (but not Rejection) of Dyadic Designs in International Relations Research." *International Studies Quarterly* 60:369-374.

November 22: Models of network formation (second problem set due)

Required readings:

Kolaczyk, Eric D. and Gabor Csardi. 2014. *Statistical Analysis of Network Data with R.* New York: Springer. Ch. 5.

Optional readings:

Barabasi, Albert-Laszlo and Reka Albert. 1999. "Emergence of Scaling in Random Networks." *Science* 286:509-512.

Frank, Ove and David Strauss. 1986. "Markov Graphs." *Journal of the American Statistical Association* 81:832-842.

Jackson, Matthew O. 2008. *Social and Economic Networks.* Princeton: Princeton University Press. Ch. 4+5.

Watts, Duncan J. and Steven H. Strogatz. 1998. "Collective dynamics of 'small-world' networks." *Nature* 393:440-442.

November 23: Exponential random graph models: Introduction and statistical background

Required readings:

Cranmer, Skyler J. and Bruce A. Desmarais. 2011. "Inferential Network Analysis with Exponential Random Graph Models." *Political Analysis* 19:66-86.

Optional readings:

Lusher, Dean, Johan Koskinen, and Garry Robins. 2013. *Exponential Random Graph Models for Social Networks. Theory, Methods, and Applications.* New York: Cambridge University Press. Ch. 2+4.

Pattison, Philippa. 1999. "Logit models and logistic regressions for social networks: II Multivariate relations." *British Journal of Mathematical and Statistical Psychology* 52: 169-193.

Robins, Gary, Pip Pattison, Yuval Kalish, and Dean Lusher. 2007. "An introduction to exponential random graph (p*) models for social networks." *Social Networks* 29:173-191.

Robins, Garry, Tom Snijders, Peng Wang, Mark Handcock, and Philippa Pattison. 2007. "Recent developments in exponential random graph (p*) models for social networks." *Social Networks* 29:192-215.

Wasserman, Stanley and Philippa Pattison. 1996. "Logits Models and Logistic Regressions for Social Networks: I An Introduction to Markov Graphs and p*." *Psychometrika* 61:401-425.

November 30: Exponential random graph models: Application and interpretation

Required readings:

Hunter, David R., 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* 24:1-29.

Optional readings:

Desmarais, Bruce A. and Sklyer J. Cranmer. 2012. "Micro-Level Interpretation of Exponential Random Graph Models with Application to Estuary Networks." *Policy Studies Journal* 40:402-434.

Heaney, Machael T. 2014. "Multiplex networks and interest group influence reputation: An exponential random graph model." *Social Networks* 36:66-81.

Leifeld, Philip. 2015. "Package 'texreg'." April 28, 2015.

December 07: Temporal exponential random graph models (third problem set available)

Required readings:

Leifeld, Philip, Skyler J. Cranmer, and Bruce A. Desmarais. "Temporal Exponential Random Graph Models with btergm: Estimation and Bootstrap Confidence Intervals." *Journal of Statistical Software* (forthcoming)

Optional readings:

Cranmer, Skyler J., Bruce A. Desmarais, and Justin H. Kirkland. 2012. "Toward a Network Theory of Alliance Formation." *International Interactions* 38:295-324.

Hanneke, Steve, Wenjie Fu, and Eric P. Xing. 2010. "Discrete temporal models of social networks." *Electronic Journal of Statistics* 4:585-605.

Robins, Garry and Philippa Pattison. 2001. "Random Graph Models for Temporal Processes in Social Networks." *Journal of Mathematical Sociology* 25:5-41.

Westerwinter, Oliver. 2016. "Interdependent Choices: Using Temporal Exponential Random Graph Models for Studying Alliances." Manuscript: University of St. Gallen.

December 14: Stochastic actor-oriented models (third problem set due)

Required readings:

Snijders, Tom A. B. 2005. "Models for Longitudinal Network Data." In Models and Methods in Social Network Analysis, ed. Peter J. Carrington, John Scott, and Stanley Wasserman. New York: Cambridge University Press pp. 215247.

Snijders, Tom A.B., Gerhard G. van de Bunt and Christian E.G. Steglich. 2010. "Introduction to stochastic actor-based models for network dynamics." *Social Networks* 32:44-60.

Optional readings:

Kinne, Brandon. 2013. "Network Dynamics and the Evolution of International Cooperation." *American Political Science Review* 107:766-785.

Leifeld, Philip and Skyler J. Cranmer. 2016. "A Theoretical and Empirical Comparison of the Temporal Exponential Random Graph Model and the Stochastic Actor-Oriented Model." Manuscript: Ohio State University.

Ripley, Ruth M., Tom A. B. Snijders, Zsofia Boda, Andras Voros, and Paulina Preciado. 2015. "Manual for RSiena." August 21, 2015.

Snijders, Tom A. B. 2001. "The Statistical Evaluation of Social Network Dynamics." *Sociological Methodology* 31: 361-95.

Warren, T. Camber. 2010. "The Geometry of Security: Modeling Interstate Alliances as Evolving Networks." *Journal of Peace Research* 47: 697-709.

Further optional readings

The following texts may turn out helpful for students who want to deepen some of the materials covered in class and review the basics of statistical analysis and research design.

For statistical analysis:

Agresti, Alan and Barbara Finlay. 2014. *Statistical Methods for the Social Sciences.* Fourth edition.

Diez, David M., Christopher D. Barr and Mine Cetinkaya-Rundel. 2014. *OpenIntro Statistics.* Second edition. The book and the complementary materials are available at `https://www.openintro.org/stat/textbook.php`.

Wooldridge, Jeffrey. 2013. *Introductory Econometrics. A Modern Approach.* Fifth edition. New York: South-Western.

For research design:

King, Gary, Robert O. Keohane and Sidney Verba. 1994 *Designing Social Inquiry: Scientific Inference in Qualitative Research.* Princeton: Princeton University Press.

For probability:

Bertsekas, Dimitri and Tsitsiklis, John. 2002. *Introduction to Probability.* Second edition.

Blitzstein, Joseph K. and Jessica Hwang. 2015. *Introduction to Probability.* New York: Taylor & Francis.

Ugarte, Maria Dolores, Ana F. Militino and Alan T. Arnholt. 2016. *Probability and Statistics with R.* Second edition. London: Taylor & Francis.

For matrix algebra:

Fieller, Nick. 2016. *Basics of Matrix Algebra for Statistics with R.* London: Taylor & Francis.

For math background:

Gill, Jeff. 2006. *Essential Mathematics for Political and Social Research.* New York: Cambridge University Press.

Moore, Wil H. and David A. Siegel. 2013. *A Mathematical Course for Political and Social Science.* Princeton: Princeton University Press.

Simon, Carl and Blume, Lawrence. 2010. *Mathematics for Economists.* New York: Norton.

For statistical analysis and programing with R:

Dalgaard, Peter. 2008. *Introductory Statistics with R.* Second edition. New York: Springer.

Chambers, John M. 2008. *Software for Data Analysis. Programing with R.* New York: Springer.

Monogan III, James E. 2015. *Political Analysis Using R.* New York: Springer.