SOCY 732 – Inferential Social Network Analysis
Spring 2025 – Sloan 315   Class Time: 14:50-17:35

Professor: jimi adams (jimi.adams@sc.edu)
Office: Sloan 216
Office Hours: Th 115-215pm (drop in, or by appointment - https://calendly.com/jimiadams)
                    NOTE: Drop-in hours will be in person only. Appointments can be virtual (a link
                    will be auto-generated) or in person.

Course Description

This course will explore a variety of families of statistical analyses for examining social network data, with an eye towards hypothesis testing. Given the *relational* nature of network data, traditional forms of statistical inference make inappropriate assumptions, therefore necessitating different approaches to building inferential strategies. We will explore strategies that allow for examining individual-level outcomes based on network features (e.g., actor-partner independence, and network autoregression models), predict network outcomes from individual and network attributes (e.g., p1/p2, exponential random graph, and relational event models), and frameworks that simultaneously incorporate each of those (e.g., stochastic actor-oriented models). We will approach each of these conceptually, empirically, and computationally (in R).

Objectives

By the end of the semester, participants will:
• Be able to differentiate between types of modeling aims and corresponding strategies.
• Have improved their coding skills in R.
• Identify the appropriate modeling strategy/strategies according to the nature of a research question.
• Develop a research proposal for a network-based question and conduct preliminary analysis to evaluate it empirically.
• Be a better writer than at the beginning of the course.

Assigned Readings

All required readings and supplemental materials will be readily findable online or provided on Blackboard. That said, if you plan to incorporate much SNA into your future work the following are likely to be useful resources to have on your shelf:
• Wasserman, Stanley & Katherine Faust. 1994. *Social Network Analysis: Methods and Applications.* (Structural Analysis in the Social Sciences series, Volume 8). Cambridge University Press – This is the "Networks Bible" and provides a foundation for descriptive network analysis.
• Cranmer, Skyler J, Bruce A. Desmarais and Jason W. Morgan. 2021. *Inferential Network Analysis*. (Analytical Methods for Social Research series) Cambridge University Press – This is presently the most comprehensive coverage of inferential models used in the social sciences.
• adams, jimi. 2020. *Gathering Social Network Data* (Quantitative Analysis in the Social Sciences Series, Volume 180). Sage – This is one of the "little green book" overviews of the current (though rapidly evolving) state of a field.

A note about reading: Occasionally in this class, the assigned readings will constitute more than you can reasonably complete in the time allotted. As you continue in your career, you will find that this is often the case. Again, this course is not meant to comprehensively cover any of the covered topics, but to be an introduction to each. As such, you should develop a strategy for extracting the key elements of each reading **as it pertains to the aims of this class**; if you have questions about how to do this; let's chat.

Course Structure & Requirements

This seminar will be approximately equal parts conceptual, empirical, mathematical and computational. As such, it will be a healthy mix of lecture, discussion and tutorial. To make the most of this structure, you need should show up to each class fully prepared to participate. Requirements include in-class participation, a series of homework assignments and a final paper.

Requirements

I – **In-class Participation**

The seminar structure of this course requires that you contribute to class meetings. Doing so will require keeping up with the assigned readings and homework assignments. As *part of* this, you will be asked at times to introduce the key ideas from one (or more) of the assigned readings for a given class meeting.

II – Homework/Lab Assignments

A series of homework problem sets are designed to develop familiarity with the concepts introduced in class, and your capacity to use available software to apply analytic techniques to estimate their computation. Problem sets will only be graded for completion, with solutions to be posted to Blackboard *after* they are due. There are 8 possible assignments (noted w/ *s on the Topic schedule below); two homework assignments can be dropped/missed with no penalty.

III – Research Paper

The primary product of this course will be a research paper that applies some SNA inferential modeling framework(s) to a question of your choosing. This can be a new idea or a revision of a previous paper, but any revisions must demonstrate how SNA-models alter the papers central idea(s). For this paper, you are permitted, but not required to, collaborate with one additional student. You should plan to meet with the instructor to confirm your topic and to devise an appropriate project for your skills/interests/background, *before* Spring Break.

A note about writing: The majority of a practicing researcher's job is spent writing. One of your primary aims in graduate school should therefore be to develop your writing skills. As such, all written work should be edited and *carefully* proofread. If necessary, please make use of University writing services and/or writing style guides. Some examples worth having on your shelf are:

-   Becker, Howard S. 1983. Writing for Social Scientists: How to Start and Finish Your Thesis, Book or Article. University of Chicago Press (multiple updated editions)
-   Thomas & Turner. 1994. Clear and Simple as the Truth: Writing Classic Prose. Princeton University Press
-   Zinsser, William. 1990. On Writing Well: An Informal Guide to Writing Nonfiction. Harper

Grading

Grading Expectations:

Grades you earn will reflect how thoroughly your work demonstrates the particular assignment requirements *and* overall course aims, which will correspond to the following sets of expectations:

-   A   Work that, **in addition to** meeting an assignment's **minimum requirements**, also *consistently* reflects **engagement** with other material from the course where appropriate & in ways that **exceed course objectives** will earn grades in the A range.
-   B   Work that, **in addition to** meeting an assignment's **minimum requirements**, also *occasionally* reflects **engagement** with other material from the course where appropriate, in ways that **meet course objectives** will earn grades in the B range.
-   C   Work that **addresses only** an assignment's **minimum requirements** will earn grades in the C range.

D   Work that **incompletely addresses** an assignment's **minimum requirements** will earn grades in the D range.

F   Work that **fails to address** an assignment's **minimum requirements** will earn grades in the F range.

As such, all grades will be recorded as letter grades or equivalents (i.e., A=4, A-=3.7, B+=3.3, etc.). Final grades will be computed as a weighted average over each of the required components:
- Participation (15%) – 5% of this will be from your introduction of course readings.
- Problem Sets (25%)
- Paper (60%) – 10% of this will be a preliminary presentation of your project to the class.

A note about grading: If you haven't figured it out by now – grades in grad school should not matter. If you do well on each of the components described above, you will earn an A in the course. If you do not contribute to in-class discussion, or write a poor proposal, you will not earn an A. I do NOT discuss individual student's grades in class or over email; that should be reserved for office hours.

Due Dates & Late Assignments:
- Homework assignments are due to Blackboard before class on the day they are due (1 class session after the material they address was covered). Late HW assignments are not accepted.
- A late final paper will be deducted by 15% per day late, and not accepted after 3 days.

Course Expectations

What we all can expect from each other:
Behave in a manner reflecting common courtesies. Show up to office hours or other appointments as scheduled. Maintain professionalism in all electronic communication (e.g., email/Blackboard messages). Put forth our best efforts to maintain a productive and welcoming course.

What I expect from you:
1 – *Make a concerted effort to bring the best you can to the course.* This means doing readings each week, completing required assignments on time, putting forth effort into the evaluated elements of the course. It also means taking ownership over the grades you earn.
2 – *Treat others in the class with respect.* This includes simple norms of regular interaction in an online forum and thoughtfully considering the contributions of others. At times we'll potentially cover material of a sensitive nature; being able to respect other's expressed opinions makes critical discourse possible.

Personal Computers Use: Personal electronics may be used only for legitimate classroom purposes, such as taking notes, downloading class information, or working on an in-class exercise.

What you can expect from me:
1 – *Make a concerted effort to bring the best I can to the course.* This means leading a class appropriate to its level, selecting "up to date" material that helps illustrate the course's key aims (though I'll aim to keep covid from over-taking our course, even despite its direct relevance), regularly being available for interaction via Blackboard & office hours, and adapting as is appropriate for the needs of the class.
2 – *Treat others in the class with respect.* This includes being prepared for class, returning graded materials in a timely manner with useful feedback, seeking to be impartial in the assessment of student work, while holding it to the standards of the course and college. It also means fostering an environment where diverse perspectives can comfortably be shared in class.

Course Communication:
- *The Syllabus* has answers to the most common questions pertaining to the course. Be sure check the syllabus first, before asking me about due-dates, assignment requirements, etc.
- *Office Hours* are available to add to your experience in this course. **Please make use of them.** These are meant to supplement required course work and in-class elements. As such, while I am happy to discuss course materials or other aspects of sociology/academia in general with you during this time, they should not be viewed as an opportunity to ask, "What did I miss in class?" (You should find peers in the class with whom you can share notes for that purpose.)
- *Blackboard* will be used for the majority of communication in this course. You can find a copy of the syllabus, additional assigned readings, and all assignments there. I will also post any lecture notes after each class. To make your experience in this course successful, you should expect to make this resource a *regular* part of your preparation for this course.
- *E-mail* should be used for quick communications (things that can be responded to in no more than a few sentences); use office hours for anything requiring more depth. You should only use your USC email account for communication related to this course; I will not read/reply to emails from your personal accounts (e.g., Yahoo!, Hotmail, etc; honestly they very regularly get filtered from my inbox and I simply don't see them). Please consider e-mail as subject to the same standards of communication as you would all other forms written material in this course (i.e., you should use complete sentences, proper punctuation, etc.). I will typically respond to email within ***48 hours***.

University, CAS, and other Important Administrative Policies

Academic Integrity. You are expected to practice the highest possible standards of academic integrity. Any deviation from this expectation will result in a minimum academic penalty of your failing the assignment (i.e., receiving a zero) and will result in additional disciplinary measures. This includes improper citation of sources, using another student's work and any other form of academic misrepresentation.

Plagiarism. Using the words or ideas of another as if they were one's own is a serious form of academic dishonesty. If another person's complete sentence, syntax, key words, or the specific or unique ideas and information are used, one must give that person credit through proper citation.
Please remember that avoiding plagiarism is only a minimal threshold for maintaining academic integrity. Additionally, the first tenet of the Carolinian Creed is, "I will practice personal and academic integrity." There are useful resources on what this entails available for you at:
- [Carolinian Creed](http://www.sa.sc.edu/creed) (http://www.sa.sc.edu/creed)
- [Academic Responsibility](http://www.sc.edu/policies/staf625.pdf) (http://www.sc.edu/policies/staf625.pdf)
- [Office of Student Conduct and Academic Integrity](https://www.sa.sc.edu/academicintegrity/) (https://www.sa.sc.edu/academicintegrity/)

If you remain unsure what this means for your successful participation in and completion of assignments in this course, ask, don't assume.

Accommodations for Disabilities and Other Personal Circumstances - Please notify me if you believe you will have trouble completing course assignments or meeting course requirements for any reason, including, but not limited to: disabilities; family circumstances; poor health; or economic hardship. All discussions will be confidential. I will make reasonable accommodations to ensure your inclusion and success in the course. Students with disabilities can contact the Student Disability Resource Center (SDRC: http://www.sa.sc.edu/sds/) at 803-777-6142, sadrc@mailbox.sc.edu, or at LeConte College, Room 112A for additional assistance.

Student Success Center – In partnership with USC faculty, the Student Success Center (SSC; www.sc.edu/success) offers a number of free programs to assist you in better understanding your course material and to aid you on your path to success. SSC programs are facilitated by professional staff, graduate students, and trained undergraduate peer leaders who have previously excelled in their courses. Resources available to you in this course include:

- Peer Tutoring: You can make a one-on-one appointment with a peer tutor. Drop-in Tutoring and Online Tutoring may also be available for this course. Visit their website for a full schedule of times, locations, and courses.
- Peer Writing: Improve your college-level writing skills by bringing writing assignments from any of your classes to a Peer Writing Tutor. Similar to Tutoring, you can visit the website to make an appointment, and to view the full schedule of available drop-in hours and locations.
- Success Consultations: In Success Consultations, SSC staff assist you in developing study skills, setting goals, and connecting to a variety of campus resources. Throughout the semester, I may communicate with the SSC via Success Connect, an online referral system, regarding your progress in the course. If contacted by the SSC, please schedule a Success Consultation. Success Connect referrals are not punitive and any information shared by me is confidential and subject to FERPA regulations.

Writing Center – This course has many of writing assignments. The University Writing Center (http://artsandsciences.sc.edu/write/university-writing-center) is open to help any USC student needing assistance with a writing project at any stage of development.

Counseling Services - The University offers counseling and crisis services as well as outreach services, self-help, and frequently asked questions: https://sc.edu/about/offices_and_divisions/student_health_services/medical-services/counseling-and-psychiatry/index.php

Grades of Incomplete: The current university policy concerning incomplete grades will be followed in this course. Incomplete grades are given only in situations where unexpected emergencies prevent a student from completing the course. Students have up to one year (three semesters) to complete course requirements. Dr. adams is the final authority on whether you qualify for an incomplete. Incomplete work must be finished within the time allowed or the "I" will automatically be recorded as an "F" on your transcript.

Course Schedule Overview

Week 1   Jan 16   Introductions, Network Logics, & Network Data
                        Readings: Borgatti et al 2009; adams 2020; adams & Lubbers 2024
Week 2   Jan 23   * Network Descriptives Firehose
                        Readings: Ettekal & adams 2025; Butts 2008; Rawlings et al 2023
Week 3   Jan 30   Random Graph Models & General Permutation Approaches
                        Readings: Newman et al 2002; van Borkulo et al 2023; Bearman et al 2004
Week 4   Feb 6   * Actor-Partner Independence
                        Readings: Cook & Kenny 2005; Wolff et al 2020; Mancuso & Vezzoni 2018
Week 5   Feb 13   Simulation & Generative Models
                        Readings: Farine 2017; Barabasi & Albert 1999; Watts & Strogatz 1998
                        Choose 1: (Smith & Burow 2018; Allard et al 2023)
Week 6   Feb 20   * QAP, CUG, p1/p2
                        Readings: Faust 2007; Krackhardt 1987; Van Duijn et al 2004
                        Choose 1: (Barnett & Nam 2023; Sijtsema et al 2009)
Week 7   Feb 27   * Latent Space Models
                        Readings: Cranmer et al 2021; Fisher 2019; Ward et al 2013; Leal et al 2019
Week 8   Mar 6   Presentations
Week 9   Mar 20   * Network Autoregression (ALAAM) Models
                        Readings: Doreian 2001; Parker et al 2022; Barnes et al 2020
Week 10 Mar 27   * Exponential Random Graph Models
                        Readings: Robins et al 2007; Goodreau et al 2009; Agneessens et al 2024
Week 11 Apr 3   Advances in ERGM
                        Readings: Krivitsy et al 2023; McMillan et al 2022
                        Choose 2: (Krivitsky et al 2020; Tolochko & Boomgaarden 2024; Duxbury 2023)
Week 12 Apr 10   * Relational Event Models
                        Readings: Butts 2008; Brandenberger 2018; Schaefer & Marcum 2021
Week 13 Apr 17   * Stochastic Actor Oriented Models, part I
                        Readings: Snijders et al 2010; Waxenecker & Prell 2024;
                        Choose 1: (Schaefer & Kreager 2020; Stadtfeld et al 2019)
Week 14 Apr 24   Advances & Adaptations of SAOM
                        Readings: Berry et al 2019; adams & Schaefer 2016; Block 2018

Required Reading List
(Those readings not readily available online are posted to Blackboard – noted BB below.)

adams, jimi. 2020. "What Are Covid-19 Models Modeling?" *The Society Pages*. Available from (https://thesocietypages.org/specials/what-are-covid-19-models-modeling/).

adams, jimi, and Miranda Lubbers. 2023. "Social Network Data Collection: Principles and Modalities." *The SAGE Handbook of Social Network Analysis*. Available from (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4216936).

adams, jimi, and David R. Schaefer. 2016. "How Initial Prevalence Moderates Network-Based Smoking Change: Estimating Contextual Effects with Stochastic Actor Based Models." *Journal of Health and Social Behavior* 57(1):22–36.

Agneessens, Filip, Francisco J. Trincado-Munoz, and Johan Koskinen. 2024. "Network Formation in Organizational Settings: Exploring the Importance of Local Social Processes and Team-Level Contextual Variables in Small Groups Using Bayesian Hierarchical ERGMs." *Social Networks* 77:104–17. doi: 10.1016/j.socnet.2022.07.001.

Allard, Antoine, Cristopher Moore, Samuel V. Scarpino, Benjamin M. Althouse, and Laurent Hébert-Dufresne. 2023. "The Role of Directionality, Heterogeneity, and Correlations in Epidemic Risk and Spread." *SIAM Review* 65(2):471–92. doi: 10.1137/20M1383811.

Barabasi, Albert-Laszlo, and Reka Albert. 1999. "Emergence of Scaling in Random Networks." *Science* 286(5439): 509-512.

Barnes, Michele L., Peng Wang, Joshua E. Cinner, Nicholas A. J. Graham, Angela M. Guerrero, Lorien Jasny, Jacqueline Lau, Sarah R. Sutcliffe, and Jessica Zamborain-Mason. 2020. "Social Determinants of Adaptive and Transformative Responses to Climate Change." *Nature Climate Change* 10(9):823–28. doi: 10.1038/s41558-020-0871-4.

Barnett, George A., and Yoonjae Nam. 2024. "A Network Analysis of International Migration: Longitudinal Trends and Antecedent Factors Predicting Migration." *Global Networks* 24(2):e12455. doi: 10.1111/glob.12455.

Bearman, Peter S., James Moody, and Katherine Stovel. 2004. "Chains of Affection: The Structure of Adolescent Romantic and Sexual Networks." *American Journal of Sociology* 110(1):44–91. doi: 10.1086/386272.

Berry, George, Christopher J. Cameron, Patrick Park, and Michael Macy. 2019a. "The Opacity Problem in Social Contagion." *Social Networks* 56:93–101. doi: 10.1016/j.socnet.2018.09.001.

Berry, George, Christopher J. Cameron, Patrick Park, and Michael Macy. 2019b. "The Opacity Problem in Social Contagion." *Social Networks* 56:93–101. doi: 10.1016/j.socnet.2018.09.001.

Block, Per, Johan Koskinen, James Hollway, Christian Steglich, and Christoph Stadtfeld. 2018. "Change We Can Believe in: Comparing Longitudinal Network Models on Consistency, Interpretability and Predictive Power." *Social Networks* 52:180–91. doi: 10.1016/j.socnet.2017.08.001.

Borgatti, S. P., A. Mehra, D. J. Brass, and G. Labianca. 2009. "Network Analysis in the Social Sciences." *Science* 323(5916):892–95. doi: 10.1126/science.1165821.

Brandenberger, Laurence. 2018. "Trading Favors—Examining the Temporal Dynamics of Reciprocity in Congressional Collaborations Using Relational Event Models." *Social Networks* 54:238–53. doi: 10.1016/j.socnet.2018.02.001.

Butts, Carter T. 2008a. "A Relational Event Framework for Social Action." *Sociological Methodology* 38(1):155–200. doi: 10.1111/j.1467-9531.2008.00203.x.

Butts, Carter T. 2008b. "Social Network Analysis with SNA." *Journal of Statistical Software* 24(6). doi: 10.18637/jss.v024.i06.

Cook, William L., and David A. Kenny. 2005. "The Actor–Partner Interdependence Model: A Model of Bidirectional Effects in Developmental Studies." *International Journal of Behavioral Development* 29(2):101–9. doi: 10.1080/0165025044000405.

Cranmer, Skyler J., Bruce A. Desmarais, and Jason W. Morgan. 2021. "The Basic Latent Space Model." Chapter 8 in *Inferential network analysis*, *Analytical methods for social research*. Cambridge: Cambridge University Press. (BB)

Duxbury, Scott. 2023. "Temporal Exponential Random Graph Models." Chapter 2 in *Longitudinal Network Analysis*. Quantitative Applications in the Social Sciences Series, #192. SAGE. (BB)

Ettekal, Andrea Vest, and jimi adams. 2022. "Applications of Social Network Analysis in Developmental Science." *SSRN Electronic Journal*. doi: 10.2139/ssrn.4231406.

Farine, Damien R. 2017. "A Guide to Null Models for Animal Social Network Analysis" edited by R. Freckleton and S. Rands. *Methods in Ecology and Evolution* 8(10):1309–20. doi: 10.1111/2041-210X.12772.

Faust, Katherine. 2007. "7. Very Local Structure in Social Networks." *Sociological Methodology* 37(1):209–56. doi: 10.1111/j.1467-9531.2007.00179.x.

Fisher, Jacob C. 2019. "Social Space Diffusion: Applications of a Latent Space Model to Diffusion with Uncertain Ties." *Sociological Methodology* 49(1):258–94. doi: 10.1177/0081175018820075.

Fredrickson, Mark M., and Yuguo Chen. 2019. "Permutation and Randomization Tests for Network Analysis." *Social Networks* 59:171–83. doi: 10.1016/j.socnet.2019.08.001.

Goodreau, Steven M., James A. Kitts, and Martina Morris. 2009. "Birds of a Feather, or Friend of a Friend? Using Exponential Random Graph Models to Investigate Adolescent Social Networks." *Demography* 46(1):103–25. doi: 10.1353/dem.0.0045.

Krackhardt, David. 1987. "QAP Partialling as a Test of Spuriousness." *Social Networks* 9:171–86.

Krivitsky, Pavel N., David R. Hunter, Martina Morris, and Chad Klumb. 2023. "**Ergm** 4: New Features for Analyzing Exponential-Family Random Graph Models." *Journal of Statistical Software* 105(6). doi: 10.18637/jss.v105.i06.

Krivitsky, Pavel N., Laura M. Koehly, and Christopher Steven Marcum. 2020. "Exponential-Family Random Graph Models for Multi-Layer Networks." *Psychometrika* 85(3):630–59. doi: 10.1007/s11336-020-09720-7.

Mancuso, Moreno, and Cristiano Vezzoni. 2018. "Actor-Partner Interdependence Models (APIM) and Voting Behavior: Methodology and Applications." *Political Psychology* 39(1):163–76. doi: 10.1111/pops.12400.

McMillan, Cassie, Derek A. Kreager, and René Veenstra. 2022. "Keeping to the Code: How Local Norms of Friendship and Dating Inform Macro-Structures of Adolescents' Romantic Networks." *Social Networks* 70:126–37. doi: 10.1016/j.socnet.2021.11.012.

Newman, M. E. J., D. J. Watts, and S. H. Strogatz. 2002. "Random Graph Models of Social Networks." *Proceedings of the National Academy of Sciences* 99(Supplement 1):2566–72. doi: 10.1073/pnas.012582999.

Parker, Andrew, Francesca Pallotti, and Alessandro Lomi. 2022. "New Network Models for the Analysis of Social Contagion in Organizations: An Introduction to Autologistic Actor Attribute Models." *Organizational Research Methods* 25(3):513–40. doi: 10.1177/10944281211005167.

Rawlings, Craig M., Jeffrey A. Smith, James Moody, and Daniel A. McFarland, eds. 2023. "How Are Social Network Data Visualized?" Pp. 88–114 in *Network Analysis: Integrating Social Network Theory, Method, and Application with R*, *Structural Analysis in the Social Sciences*. Cambridge University Press. (BB)

Robins, Garry, Pip Pattison, Yuval Kalish, and Dean Lusher. 2007. "An Introduction to Exponential Random Graph (P*) Models for Social Networks." *Social Networks* 29(2):173–91. doi: 10.1016/j.socnet.2006.08.002.

Schaefer, David R., and Derek A. Kreager. 2020. "New on the Block: Analyzing Network Selection Trajectories in a Prison Treatment Program." *American Sociological Review* 85(4):709–37. doi: 10.1177/0003122420941021.

Schaefer, David R., and Christopher Steven Marcum. 2021. "Modeling Network Dynamics." Chapter 14 in *The Oxford Handbook of Social Networks*, edited by R. Light and J. Moody. Oxford University Press. Available from: (https://osf.io/6rm9q).

Sijtsema, Jelle J., René Veenstra, Siegwart Lindenberg, and Christina Salmivalli. 2009. "Empirical Test of Bullies' Status Goals: Assessing Direct Goals, Aggression, and Prestige." *Aggressive Behavior* 35(1):57–67. doi: 10.1002/ab.20282.

Smith, Jeffrey A., and Jessica Burow. 2020. "Using Ego Network Data to Inform Agent-Based Models of Diffusion." *Sociological Methods & Research* 49(4):1018–63. doi: 10.1177/0049124118769100.

Snijders, Tom A. B., Gerhard van de Bunt, and Christian E. G. Steglich. 2010. "Introduction to Stochastic Actor-Based Models for Network Dynamics." *Social Networks* 32:44–60.

Stadtfeld, Christoph, András Vörös, Timon Elmer, Zsófia Boda, and Isabel J. Raabe. 2019. "Integration in Emerging Social Networks Explains Academic Failure and Success." *Proceedings of the National Academy of Sciences* 116(3):792–97. doi: 10.1073/pnas.1811388115.

Tolochko, Petro, and Hajo G. Boomgaarden. 2024. "Same but Different: A Comparison of Estimation Approaches for Exponential Random Graph Models for Multiple Networks." *Social Networks* 76:1–11. doi: 10.1016/j.socnet.2023.05.003.

Van Borkulo, Claudia D., Riet Van Bork, Lynn Boschloo, Jolanda J. Kossakowski, Pia Tio, Robert A. Schoevers, Denny Borsboom, and Lourens J. Waldorp. 2023. "Comparing Network Structures on Three Aspects: A Permutation Test." *Psychological Methods* 28(6):1273–85. doi: 10.1037/met0000476.

Van Duijn, Marijtje A. J., Tom A. B. Snijders, and Bonne J. H. Zijlstra. 2004. "P$_2$: A Random Effects Model with Covariates for Directed Graphs." *Statistica Neerlandica* 58(2):234–54. doi: 10.1046/j.0039-0402.2003.00258.x.

Ward, Michael D., John S. Ahlquist, and Arturas Rozenas. 2013. "Gravity's Rainbow: A Dynamic Latent Space Model for the World Trade Network." *Network Science* 1(1):95–118. doi: 10.1017/nws.2013.1.

Watts, Duncan J., and Steven H. Strogatz. 1998. "Collective Dynamics of 'Small-World' Networks." *Nature* 393**:** 440–442. doi: https://doi.org/10.1038/30918.

Waxenecker, Harald, and Christina Prell. 2024. "Corruption Dynamics in Public Procurement: A Longitudinal Network Analysis of Local Construction Contracts in Guatemala." *Social Networks* 79:154–67. doi: 10.1016/j.socnet.2024.07.001.