Economics 970 **Networks** Location TBA

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M,W 1:00-2:30
M,W 3:00-4:30

To contain the spread of H1N1, how many Purel dispensers should Harvard buy? Where should the dispensers be placed to be most effective? How many people should be vaccinated? Would a school with the same number of students as Harvard need the same number of Purel dispensers to contain the spread of H1N1 as effectively?

In a game of telephone in which a message is whispered from person to person, how many people must a message pass through to be distorted beyond recognition? How short must a message be to make it through five people intact? If each person heard the message from two different people instead of just one, how much clearer would the final message be?

Are segregated neighborhoods always the result of discrimination? If a revolution is brewing, how many people must the revolutionaries personally recruit in order to incite widespread revolution? How debilitating will a snowed-in Boston Logan Airport be to national air travel? Why are all actors separated from Kevin Bacon by 6 degrees or fewer? Why did Blu-Ray dominate HD DVD?

The budding new field of Network Analysis offers the tools to answer questions like these. Network analysis is a recent import into economics, and has been developed in a diverse set of fields, from physics to computer science to sociology. Recognizing that objects of study (people, genes, web pages, virus hosts, etc.) are often influenced by 'neighboring' objects of study, these fields have created a paradigm and a set of tools that economists can use to study segregation, the spread of ideas, learning, management, the adoption of new technologies, epidemics, migration, trade, revolutions, and various other phenomena that involve a group of people interacting.

Because network analysis has such diverse origins, mastering it requires a willingness to learn about a variety of applications, some of which are in fields outside of economics, and the creativity to bring techniques and approaches used outside of economics into the field. The blend of networks and economics covered in this course will reveal a wealth of untapped research opportunities and chances to make real contributions to the field of economics.

Since network analysis is a relatively new field, we will not be working though a textbook. Instead, we will be working through a collection of papers (the bulk of which were published in the last five years) to learn the methods and range of applications. **This course assumes no background in social network analysis**: we will begin with the basics and progress from there. Some of the readings can be quite technical, and some relatively short pieces may take considerable time to read through. Each week has relatively few pages of reading so that you may devote time to carefully reading the

assigned pieces. That being said, I do not expect you to be able to reproduce, or even fully understand, the intricate math in some of the articles. **One of the skills this course will help you to hone is the ability to extract meaning from an academic article, even if the level of technical proficiency assumed in the article is well above your own.** (Read: some articles are hard. You can get a lot out of them anyway.)

By the end of the course, you will have the skills necessary to explain or make predictions about real world phenomena using network techniques. As we encounter various network models throughout the course that seek to describe or explain the world, we will focus on understanding, replicating and improving upon the models, and on applying the models to other phenomena not yet explored with a networks approach. We will also discuss strategies for empirically verifying the explanations or predictions offered by the models. Throughout the course, you will have the opportunity to explore network analysis through discussions, brief lectures, activities, short assignments, an empirical exercise, and a final research project.

Attendance, preparation and thoughtful participation are expected and are crucial to making section a valuable experience for everyone.

Course requirements (and their weight in the final grade):

Attendance and participation (20%): attendance is mandatory and thoughtful participation is expected in discussions and activities.

Short assignments (15%): these are intended to clarify course material, offer practice in applying course concepts, and facilitate discussion. Assignments will include one problem set (due 2/14/11 at the beginning of section), preparation of one short presentation (to be given in section 2/28/11), and 3 response papers. Response papers are 1-2 page reactions to a day's readings due in hard copy at the beginning of the section containing that day's readings. Some options for response papers include: offer a critique of a paper, suggest an alternate application of a model or empirical study in a paper, find and briefly summarize a paper directly related to a day's readings and point out the relative merits or drawbacks of its approach, etc. You may choose any day between 2/9/11 and 4/20/11 to submit response papers. You may submit up to 4; I will record the best 3 grades.

Empirical exercise (15%): 5-6 page memo detailing an empirical exercise completed with a partner, due beginning of section on 3/21/11. In section on 3/21/11, the pairs will present methods and results. We will spend section on 3/7/11 discussing what will be expected in the empirical exercise.

Prospectus for the final project (10%): 3-4 page memo proposing the topic and plan for the final research project, due by email to the class at 11:59pm on 4/22/11. 4/25/11 will be a double-length class to enable two sections to present their prospectuses and receive feedback to help guide the final project (and this double class will count as our make-up for President's Day).

Final research project (40%): 15-18 page research paper creating a network model to explain some real world phenomenon, deriving predictions from the model, and discussing a possible empirical test of the model's predictions which could be conducted. Due 11:59pm, 5/1/11.

Late policy: Because response papers are meant to facilitate discussion, no late response papers will be accepted. Papers (the empirical exercise, the prospectus, and the final research project) submitted after the due date and time will be penalized half a letter grade for each 24 hours past the due date. Exceptions for personal emergencies will be assessed on a case-by-case basis. Papers will receive a zero 120 hours past the due date.

Additional course information will be announced in section or distributed via the email list or the course website.

Below are the readings for the course. **Papers listed for a day are to be read in time for class that day.** Course readings can be found on the course website or on reserve at Lamont.

Week 1: Introduction to Networks

What is network analysis? What topics are in the domain of network analysis? What advantages and disadvantages does network analysis have compared to other tools and paradigms available to economists? What can a simple network model tell us about residential segregation and discrimination? Does segregation imply discriminatory preferences?

1/31/11

Chapter 1, "In the Thick of It," (p. 3-32) of Christakis, Nicholas A. and James H. Fowler, *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives,* Little, Brown and Company, 2009.

2/02/11

Chapter 4, "Sorting and Mixing: Race and Sex," (p. 137-166) of Schelling, Thomas C., *Micromotives and Macrobehavior,* W.W.Norton and Company, 1978/2006.

Week 2: Preliminary details

How can networks be described? What do abstract network characteristics have to do with real world phenomena like epidemics, internet searches, financial markets and scientific collaboration?

2/7/11

Chapter 2, "Representing and Measuring Networks," (p. 20-51) of Jackson, Matthew O., *Social and Economic Networks,* Princeton UP, 2008.

2/9/11

Newman, M.E.J., "Who is the Best Connected Scientist? A Study of Scientific Coauthorship Networks," in *Complex Networks,* E. Ben-Naim, H. Fraudenfelder, and Z. Toroczkai (eds.), p. 337-370, Springer, 2004.

Intro (p. 23-27) of Konig, Michael D. and Stefano Battiston, "From Graph Theory to Models of Economic Networks. A Tutorial." in A.K. Naimzada et al. (eds.), *Networks, Topology and Dynamics,* Lecture Notes in Economics and Mathematical Systems 613, Springer 2009.

Week 3: Basic modeling with graphs

How can a complex phenomenon be represented by a simple network, and what novel insights can the simple network offer? How can immigration be modeled with a network, and what can be learned about immigrants' employment opportunities? How can income inequality be studied with networks? Why are all actors a mere 6 degrees from Kevin Bacon? How connected are strangers, and why would this matter? How could an experiment be designed to determine the characteristics of a network or the effects of a network?

2/14/11: Problem set due in hard copy at beginning of section

Chapter 3, "Transportation Problems," (p. 51-77) of Chartrand, Gary, *Introductory Graph Theory,* Dover Publications, 1977.

Calvo-Armengol, Antoni and Matthew O. Jackson, "The Effects of Social Networks on Employment and Inequality," *American Economic Review* 94(3), p. 426-454, 2004.

Munshi, Kaivan, "Networks in the Modern Economy: Mexican Migrants in the US Labor Market," *Quarterly Journal of Economics 118(2), p. 549-599, 2003.*

2/16/11

Chapter 3, "The Third Link: Six Degrees of Separation," (p. 25-40) of Barabasi, Albert-Laszlo, *Linked,* Plume, 2003.

Duflo, Esther and Emmanuel Saez, "The Role of Information and Social Interactions in Retirement Plan Decisions: Evidence From a Randomized Experiment," *Quarterly Journal of Economics* 118(3), p. 815-842, 2003.

Fowler, James H. and Nicholas A. Christakis, "Cooperative Behavior Cascades in Human Social Networks," working paper, 2009.

Week 4: Finding networks in less obvious places

What role do social networks play in bank runs? Financial crises? Political campaigns? Crime? How problematic would it be to ignore the role of social networks when studying these kinds of phenomena?

2/21/11: No Class (President's Day)

2/23/11

Chapter 5, "The Buck Starts Here," (p. 135-171) of Christakis, Nicholas A. and James H. Fowler, *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives,* Little, Brown & Company, 2009.

Bellair, Paul E., "Social Interaction and Community Crime: Examining the Importance of Neighbor Networks," *Criminology* 35(4), p. 677 – 704, 1997.

Glaeser, Edward L., Bruce Sacerdote and Jose A. Scheinkman, "Crime and Social Interactions," *Quarterly Journal of Economics* 111(2), p. 507-548, 1996.

Week 5: Empirical estimates of descriptive networks

How can we learn the features of true networks describing the transmission of AIDS, coauthorships, inventions, health care decisions, etc.? Once we have an estimate of the empirical networks, what can we learn from it?

2/28/11: Presentations

Presentations of applications

3/2/11

Friedman, S.R. et al., "Some Data-Driven Reflections on Priorities in AIDS Network Research," *AIDS and Behavior* 11(5), p. 641-651, 2007.

Rosenblat, Tanya S. and Markus M. Mobius, "Getting Closer or Drifting Apart?" *Quarterly Journal of Economics* 119(3), p. 971-1009, 2004.

Uzzi, Brian, "A Social Network's Changing Statistical Properties and the Quality of Human Innovation," *Journal of Physics A: Mathematical and Theoretical* 41(22), p. 1-12, 2008.

Week 6: Empirical estimates and how to contribute

How can we learn the features of true networks describing the way people create inventions or make decisions about their health? Remember how to run regressions?

3/7/11: Description of empirical exercise

3/9/11: No Class

Week 7: Information in a Network

What can "spread along" a network? If a social network encodes friendship, what are ways that friends convey private information to each other? If two friends also have a mutual friend, how might that affect the quality of information that the two friends receive? Why might cliques matter for the type and quality of information friends receive? What are possible applications of models of information flow among friends?

3/21/11: Empirical exercise due beginning of section

Presentations of empirical exercises

3/23/11

Granovetter, M. J., "The Strength of Weak Ties," *American Journal of Sociology* 78(6), p. 1360-1380, 1973.

Chapter 6, "Politically Connected," (p. 172-220) of Christakis, Nicholas A. and James H. Fowler, *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives,* Little, Brown & Company, 2009.

Week 8: Homophily v. Influence, and Network Formation

How can we estimate characteristics of empirical networks, like the similarity of members belonging to voluntary organizations? Do similar people tend to become friends (is there homophily), or do friends influence each other to become more similar (is there influence)? If policymakers could influence who becomes friends, might that affect discrimination? What would this mean for the policy of assigning college roommates? How do networks form?

3/28/11

McPherson, J.M. and L. Smith-Lovin, "Homophily in Voluntary Organizations: Status Distance and the Composition of Face-to-face Groups," *American Sociological Review* 52(3), p. 370-379, 1987.

Boisjoly, J. et al., "Empathy or Antipathy? The Impact of Diversity," *American Economic Review* 96(5), p. 1890-1905, 2006.

Currarini, S. et al., "Identifying the Roles of Race-Based Choice and Chance in High School Friendship Network Formation," *Proceedings of the National Academy of Sciences* 107(11), 2010.

3/30/11

Chapters 4-7 (p. 41-92) of Barabasi, Albert-Laszlo, *Linked,* Plume, 2003.

Jackson, M.O., and Wolinsky, A., "A Strategic Model of Social and Economic Networks," *Journal of Economic Theory* 71(1), 1996.

Week 9: Diffusion through a Network

How does a social network influence people's vaccination decisions? What explains the observation that obese people tend to be friends with obese people- are they friends because they are obese, or do they learn to be obese from each other? How can we model the process of learning from friends? How could we empirically verify our predictions about learning from friends? What can a model of diffusion show about the adoption of new technologies? The impact of a snowed-in Boston Logan on national air travel? The resilience of the world wide web to a web page that is down?

4/4/11

Rao, Neel, Markus M. Mobius and Tanya Rosenblat, "Social Networks and Vaccination Decisions," working paper, 2007.

Christakis, Nicholas A. and James H. Fowler, "The Spread of Obesity in a Large Social Network Over 32 Years," *New England Journal of Medicine* 357(4), p. 370-379, 2007.

4/6/11

Chapter 7, "Diffusion Through Networks," (p. 185-222) of Jackson, Matthew O., *Social and Economic Networks,* Princeton UP, 2008.

Judd, Stephen et al., "Behavioral Dynamics and Influence in Networked Coloring and Consensus," *Proceedings of the National Academy of Sciences* 107(34), 2010.

Week 10: Learning Information from Neighbors in a Network

Do people adapt their opinions and beliefs to their friends' opinions and beliefs? If everyone hears some information related to a fact, will everyone eventually know the fact? How could policymakers use information about social networks to improve the effectiveness of policies? How could educators use this information? Advertising executives?

4/11/11

Chapter 8, Sections 1 and 2 (p. 223 -228) of Jackson, Matthew O., *Social and Economic Networks,* Princeton UP, 2008.

Degroot, Morris H., "Reaching a Consensus," *Journal of the American Statistical Association* 69(345), p. 118-121, 1974.

Conley, Timothy G. and Christopher R. Udry, "Learning About a New Technology: Pineapple in Ghana," *American Economic Review* (forthcoming).

4/13/11

Valente, Thomas W. et al., "Effects of a Social-Network Method for Group Assignment Strategies on Peer-Led Tobacco Prevention Programs in Schools," *American Journal of Public Health* 93(11), p. 1837-1843, 2003.

Carpenter, Daniel P., Kevin M. Esterling and David M. J. Lazer, "Friends, Brokers and Transitivity: Who Informs Whom in Washington Politics?" *The Journal of Politics* 66(1), p. 224-246, 2004.

Sorensen, A.T., "Social Learning and Health Plan Choice," *The RAND Journal of Economics* 37(4), p. 929-945, 2006.

Week 11: Games on a Network

How can networks be used to model large group phenomena, like social movements or revolutions? What kind of information about neighbors or friends is relevant to the decision to join a revolution? How would this kind of information spread through a network? What other sorts of interactions can be modeled with networks? What is known about strategic interactions (i.e. games) played by neighbors or friends on a network?

4/18/11

Chwe, M. S. Y., "Communication and Coordination in Social Networks," *The Review of Economic Studies* 76(1), p. 1-16, 2000.

Opp, Karl-Dieter and Christiane Gern, "Dissident Groups, Personal Networks, and Spontaneous Cooperation: The East German Revolution of 1989," *American Sociological Review* 58(5), p. 659-680, 1993.

4/20/11: Last day for response papers

Chapter 3, "Games on Networks," of Goyal, Sanjeev, *Connections: An Introduction to the Economics of Networks,* Princeton UP, 2007.

Larson, Jennifer M., "A Failure to Communicate: Group Structure and Interethnic Conflict," working paper, 2011.

*****Prospectus due 11:59pm, 4/22/11 by email to section**

Week 12: Your Contributions to the Field

4/25/11: DOUBLE CLASS, 1:00pm-4:00pm

Prospectus/paper progress presentations.

4/27/11

Wrap-up, final discussion

*****Final paper due 11:59pm, 5/01/11 by email to me**