Economic Theory of Networks Syllabus

Department of Economics, Temple University
Econ 3522 Section 001 CRN 40812, 3 credit hours
Spring 2020
Instructor: Dr. Dimitrios Diamantaras, Associate Professor of Economics
Class meets Tuesdays and Thursdays 12:30 pm to 1:50 pm in Wachman 109

Course Goals and Methods

This course presents an overview of networks with emphasis on social networks, online and offline. Students will learn the basic mathematical techniques for representing networks as well as techniques from game theory and economics for the analysis of network structure and evolution. Upon completing this course, students should be able to understand the economic functioning and implications of social networks and to develop economic analyses of aspects of social networks.

Office Hours and Contact Information

My office is in Ritter Annex 883. I will hold office hours there every Monday from 2:30 pm to 4:30 pm and every Wednesday from 1 pm to 2 pm, with the exception of Martin Luther King Day (January 20) and Spring Break week. Office hours may be preempted by meetings; I will announce such events ahead of time on Canvas and offer alternative times. *Students can also request to meet with me outside my office hours and also via online video conferencing.* Such requests should be submitted via email to dimitrios.diamantaras@temple.edu at least 48 hours in advance of the desired time. My office phone number is 215-204-8169, but you have a far better chance to reach me quickly via email than via phone.

Disability Statement

Any student who has a need for accommodations based on the impact of a documented disability or medical condition should contact Disability Resources and Services (DRS) in 100 Ritter Annex (*drs@temple.edu*; 215-204-1280) to request accommodations and learn more about the resources available to you. If you have a DRS accommodation letter to share with me, or you would like to discuss your accommodations, please contact me as soon as practical. I will work with you and with DRS to coordinate reasonable accommodations for all students with documented disabilities.
All discussions related to your accommodations will be confidential.

Statement on Academic Freedom

Freedom to teach and freedom to learn are inseparable facets of academic freedom. The University has adopted a policy on Student and Faculty Academic Rights and Responsibilities (Policy # 03.70.02) which can be accessed at http://policies.temple.edu/getdoc.asp?policy_no=03.70.02.

Prerequisites

Econ 1102, Principles of Microeconomics, or Econ 1902 (honors version). There is no formal mathematical prerequisite; the necessary mathematical tools will be explained in the course. However, a willingness to think with logical rigor for sustained periods of time will be essential.

Textbook and online resources

The required textbook for this course is *Networks, Crowds, and Markets,* by David Easley and Jon Kleinberg, Cambridge University Press 2010. The book is available online as chapter-by-chapter PDF files at http://goo.gl/omWV and the printed book can be purchased from the Temple bookstore on the Main campus. The course is modeled after a course offered at Cornell University by the authors of the textbook. You can find the latest syllabus for that course at https://courses.cit.cornell.edu/info2040_2017fa/ and the archived edX on-line version of the course as of Spring 2015 is at https://www.edx.org/course/networks-crowds-markets-cornellx-info2040x-2. I recommend checking out the latter for different presentations of this material than mine, and for additional practice problems.

Our course is on Canvas, and if you are enrolled in the course, you should be automatically enrolled on the course page on Canvas. Canvas can be accessed via a browser at https://canvas.temple.edu/ and via apps for iOS and Android. Please ask me if you have any questions on how to use Canvas. You will be expected to check the course page Blackboard at least once daily for announcements and new materials. You should also monitor your Temple email address closely for course-related emails.

Grading

Student progress will be evaluated on the basis of attendance (15% of the grade, of which 5% comes from attendance and 10% is measured with daily quizzes), homework assignments (25%, the two worst assignment grades are dropped from the calculation), two in-class midterm examinations, and an in-class final examination. The weights of the exams are as follows, where E1 stands for the exam where a student earned the highest exam score among the student's three exam scores (as percentages), E2 for the student's second-highest exam score, and E3 for third: 30% for E1, 20% for E2, 10% for E3. Attendance will be taken at the start of every class by a short quiz that checks whether the students have read ahead in the textbook as instructed.

There will be 7 homework sets, each consisting of problems designed to help the student practice network analysis along the lines of the material covered in the most recent class meetings. Each assignment will be due by Monday of the week after the class meetings which covered the material included in the assignment. Late homework assignments will NOT be accepted. However, only the 5 best homework assignment grades will be counted when computing the homework average grade.

Homework assignments and exams will be graded for correctness and clarity. Letter grades will be given according to the following scale, stated in percentages: A: 93-100; A-: 90-92.99; B+: 87-89.99; B: 83-86.99; B-: 80-82.99; C+: 77-79.99; C: 73-76.99; C-: 70-72.99; D+: 67-69.99; D: 63-66.99; D-: 60-62.99; F: 0-59.99.

The midterm exams and the final will be held as shown in the course outline below and available on the online calendar on Canvas. The final exam will be held as scheduled by the University during exam week; please do not ask me to change its date, unless you happen to have two more exams scheduled for the same date. All exams are closed-book. There is no opportunity for extra credit.

Course Policies

Class *attendance* is required. Students who know they will miss class, come late, or leave early, are requested to let me know in advance. I will not count up to two absences against your attendance grade. If circumstances prevent you from attending 20% or more of the class meetings, consider withdrawing from the course. You can get 5 points for class attendance by being on time, prepared, and participating, 3 for being on time and participating but not well prepared, and 1 point for attending but being more than 5 minutes late. As stated above, the attendance grade is 5% of your final grade and the quiz grade, distinct from the attendance grade, is 10% of the grade.

Missing an exam is not acceptable except if (1) you have a very serious reason (such as being treated in a hospital at the time of the exam) ***and*** (2) you notify me as early as possible and at the latest before the start time of the exam. If, and only if, both conditions (1) and (2) are met, I will offer you a make-up exam, upon seeing credible proof of the condition that necessitated missing the exam.

Academic dishonesty is reprehensible and I will punish it severely by referring the student for University disciplinary action ***and*** giving a zero grade for the exam or assignment involved. Please refer to the *Student Code of Conduct*, which can be found at http://studentconduct.temple.edu/, and to the Student Responsibilities document for details about academic dishonesty, which can be found at http://studentconduct.temple.edu/conduct-process. The following text in italics is quoted verbatim from the Temple University bulletin for 2006—2007 and it clarifies what the University's (and my) expectation is regarding academic integrity and honesty.

Temple University believes strongly in academic honesty and integrity. Plagiarism and academic cheating are, therefore, prohibited. Essential to intellectual growth is the development of independent thought and a respect for the thoughts of others. The

prohibition against plagiarism and cheating is intended to foster this independence and respect.

Plagiarism is the unacknowledged use of another person's labor, another person's ideas, another person's words, another person's assistance. Normally, all work done for courses -- papers, examinations, homework exercises, laboratory reports, oral presentations -- is expected to be the individual effort of the student presenting the work. Any assistance must be reported to the instructor. If the work has entailed consulting other resources -- journals, books, or other media -- these resources must be cited in a manner appropriate to the course. It is the instructor's responsibility to indicate the appropriate manner of citation. Everything used from other sources -- suggestions for organization of ideas, ideas themselves, or actual language -- must be cited. Failure to cite borrowed material constitutes plagiarism. Undocumented use of materials from the World Wide Web is plagiarism.

Academic cheating is, generally, the thwarting or breaking of the general rules of academic work or the specific rules of the individual courses. It includes falsifying data; submitting, without the instructor's approval, work in one course which was done for another; helping others to plagiarize or cheat from one's own or another's work; or actually doing the work of another person.

Course Outline

Week 1, 8/28, 8/30. Chapters 1, 2.

Chapter 1
Brief overview of networks and the theories that have been developed by mathematicians, game theorists, and economists to analyze networks. Introduction of the main topics of the course: markets and games on networks, information networks, and network dynamics.
Chapter 2
Basics of graph theory as needed for the analysis of networks: edges and nodes on graphs; paths; connectivity; graph components; network distance; the small worlds phenomenon; six degrees of Kevin Bacon and Erdős numbers; network data set sources.

Week 2, 9/4, 9/6. Chapters 3, 4.

Chapter 3
Strong and weak ties; the strength of weak ties; strength and network structure in large data sets; strength, social media, and passive engagement; closure, structural holes, and social capital.
Chapter 4
Homophily; mechanisms underlying homophily; affiliation; tracking link formation in online data; a spatial model of segregation.

Week 3, 9/11, 9/13. Chapter 6.

Chapter 6
Introduction to games; how to reason about behavior in a game; best responses and dominant strategies; Nash equilibrium; multiple equilibria and coordination games; multiple equilibria and the hawk-dove game; mixed strategies; Pareto optimality and social optimality.

Week 4, 9/18, 9/20. Chapters 7, 8, 9.

Chapter 7
Evolutionary game theory: fitness as a result of interaction, evolutionarily stable strategies; relationship of Evolutionary and Nash equilibria; evolutionarily stable mixed strategies.
Chapter 8
Modeling network traffic with game theory: traffic at equilibrium; Braess's paradox (adding more roads may increase congestion); social cost of traffic at equilibrium.

Chapter 9

Auctions: types of auctions; relationships between auction formats; second-price auctions and truthful bidding; first-price auctions and other auction formats; common values and the winner's curse.

Week 5, 9/25, 2/27. Chapter 10, 11.

Chapter 10
Matching markets: bipartite graphs and perfect matchings; valuations and optimal assignments; prices and market clearing; constructing a set of market-clearing prices; relation to single-item auctions.

Chapter 11
Network models of markets with intermediaries: price setting in markets; modeling trade on networks; equilibria in trading networks; auctions and ripple effects; trader profits.

Week 6, 10/2, 10/4. Chapter 12.

Midterm 1 (10/2; covers chapters 1, 2, 3, 4, 6, 7, 8, 9) and Chapter 12 (10/4).

Chapter 12
Bargaining and power in networks: power in social networks; experiments on power and exchange; connection to buyer-seller networks; Nash bargaining solution; ultimatum game; stable outcomes; balanced outcomes.

Week 7, 10/9, 10/11. Chapters 13, 14.

Chapter 13
The structure of the Web: World Wide Web; information networks, hypertext, associative memory; the Web as a directed graph; the bow-tie structure of the Web; Web 2.0 emerging.

Chapter 14
Link analysis and Web search: the problem of ranking; hubs and authorities; PageRank; applying link analysis in modern Web search; applications beyond the Web (scientific citation analysis, U.S. Supreme Court Citation analysis).

Week 8, 10/16, 10/18. Chapter 15.

Chapter 15
Sponsored search markets: advertising based on search behavior; advertising as a matching market; encouraging truthful bidding in matching markets with the Vickrey-Clarke-Groves principle; truth-telling as a dominant strategy in the VCG mechanism; the generalized second-price auction and its equilibria; ad quality; complex queries and interactions among keywords.

Week 9, 10/23, 10/25. Chapter 16.

Chapter 16
Information cascades: following the crowd; a herding experiment; Bayes's rule; Bayes's

rule in the herding experiment; a simple, general cascade model; sequential decision making and cascades; lessons from cascades.

Week 10, 10/30, 11/1. Chapter 17.

Chapter 17
Network effects: network effects as externalities; the economy without network effects; the economy with network effects; stability, instability, and tipping points, dynamic view of the market; industries with network goods; mixing individual effects with population-level effects.

Week 11, 11/6, 11/8. Review and Midterm 2 (11/8; covers chapters 10, 11, 12, 13, 14, 15).

Week 12, 11/13, 11/15. Chapters 18, 19.

Chapter 18
Power laws and rich-getting-richer: popularity as a network phenomenon; power laws; rich-get-richer models; the unpredictability of rich-get-richer effects; the long tail; the effect of search tools and recommendation systems.

Chapter 19
Cascading behavior in networks: diffusion in networks; modeling diffusion through a network; cascades and clusters; diffusion, thresholds, and weak ties; extensions of the basic cascade model; knowledge, thresholds, and collective action.

Week 13, 11/27, 11/29. Chapter 20.

Chapter 20
The small-world phenomenon: six degrees of separation; structure and randomness; decentralized search; modeling the process of decentralized search; empirical analysis and generalizations; core-periphery structures and difficulties in decentralized search.

Week 14, 12/4, 12/6. Chapter 21.

Chapter 21
Epidemics: diseases and their transmission networks; branching processes; the SIR epidemic model; the SIS epidemic model; synchronization; transient contacts and the dangers of concurrency; genealogy, genetic inheritance, and mitochondrial Eve.

Week 15. FINAL EXAM Thursday, April 30, 2020, 10:30 am – 12:30 pm. Covers chapters 16, 17, 18, 19, 20, 21.

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