RSM3090 Advanced Topics in Management Science: Modeling Interactions on Networks

Tentative Syllabus

Description:
Networks are ubiquitous in our modern society. The World Wide Web that links us to and enables information flows with the rest of the world is the most visible example. But it is only one of many networks within which we are situated. Our social life is organized around networks of friends and colleagues. These networks determine our information, influence our opinions, and shape our political attitudes. They also link us, often through important but weak ties, to everybody else in the world. Economic and financial markets also look much more like networks than anonymous marketplaces. Firms interact with the same suppliers and customers and use web-like supply chains. Financial linkages, both among banks and between consumers, companies and banks, also form a network over which funds flow and risks are shared. Systemic risk in financial markets often results from the counterparty risks created within this financial network. Food chains, interacting biological systems and the spread and containment of epidemics are some of the other natural and social phenomena that exhibit a marked networked structure. This course will introduce the tools for the study of networks. It will show how certain common principles permeate the functioning of these diverse networks and how the same issues related to robustness, fragility and interlinkages arise in several different types of networks.

Time and Place: Tuesdays 3-5 pm,
over zoom: https://utoronto.zoom.us/j/84394189711
Start Date: January 12, 2021.
Instructor: Azarakhsh Malekian, azarakhsh.malekian@rotman.utoronto.ca
Course Requirements

- Homeworks, 50%.
- Final Projects, 50 %.

Homeworks

- There will be biweekly homeworks.

Final Projects: Final projects will be on a topic of your choice that overlaps with the course. More details will be circulated during the semester.
Textbooks:

- David Easley and Jon Kleinberg (EK), "Networks, Crowds, and Markets: Reasoning about a Highly Connected World", Cambridge University Press.

- Matthew Jackson, "Social and Economic Networks", Princeton University Press.

The analysis of economic and social networks heavily relies on game theory. Of course, the course does not presume any game theoretic background and we will cover all of the game theory that you need as we go along.

- **Lecture 1:** Introduction to economic, social and communication networks.Reading: EK, Chapter, 1 (also skim Chapters 3-5); Jackson, Chapter 1. Graph theory and social networks.Reading: EK, Chapters 2 and 13; Jackson, Chapters 2 and 3.

- **Lecture 2:** Branching processes and random graph models.Reading: Jackson, Sections 4.1.1, 4.2.1-4.2.5, and 4.3.

- **Lecture 3:** Rich get richer phenomena, power laws, small worlds. Preferential attachment, degree distributions, clustering. Applications: firm size distributions, link analysis and web search, PageRank, decentralized search and navigation. Reading: EK, Chapters 18, 20, and 14; Jackson, Chapter 5 and Section 7.3.

- **Lecture 4:** Epidemics: SIR and SIS models of diffusion. Applications: spread of information and disease, genetic inheritance. Reading: EK, Chapter 21; Jackson, Section 7.2.

- **Lecture 5:** Game Theory review: Games, strategies, payoffs, extensive and normal forms, Nash Equilibrium. Applications: tragedy of the commons, coordination games.

- **Lecture 6:** Modeling network traffic and strategic network formation, Negative externalities, congestion, Braess' paradox, potential games. Application: congestion tax in London. Reading: EK, Chapter 8; Jackson Chapter 6.

- **Lecture 7:** Network effects, innovation, tipping, and contagion Positive externalities, strategic complements, path dependence, diffusion of innovation, tipping in technology, financial, and product markets. Application: the rise of Microsoft and contagion phenomena. Reading: EK, Chapters 17 and 19, Jackson, Section 9.6-9.7.

- **Lecture 8:** Wisdom of the crowds, information aggregation over networks. Review of Markov Chains, law of large numbers, Condorcet jury theorem, imitation and social influence, consensus and gossip algorithms. Application: prediction markets. Reading: Jackson, Section 8.3.

- **Lecture 9:** Herding and informational cascades Bayesian learning, benefits of copying, herd behavior, informational cascades. Applications: consumer behavior, financial markets. Reading: EK, Chapter 16, Jackson, Sections 8.1-8.2.

- **Lecture 10-11-12:** Student Presentations.