It has been recognized for a long time that non-market interactions, i.e. interactions between agents that are not mediated by the market, are crucial to explain different economic phenomena such as stock market crashes, growth, education, religion, crime, etc. In these models, the marginal utility to one person of undertaking an action is a function of the average amount of the action taken by her peers. Peer effects are an intragroup externality, homogeneous across group members, that captures the average influence that members exert on each other. We would like to go further by explicitly providing the particular structure of this dependence on group behavior. In particular, if one considers a network of links between agents, then the peer influence varies across agents in the network, and the intra-group externality we obtain is heterogeneous across agents. This heterogeneity reflects asymmetries in network locations across group members. Networks and peer effects are in the heart of most non-market relationships.

The aim of this course is to present the relatively recent literature on social networks by exposing the economics, sociological and physics/applied mathematics approaches, showing their similarities and differences. We will expose, in particular, the two main ways of modeling network formation. While the physics/applied mathematics approach is capable of reproducing most observed networks, it does not explain why they emerge. On the contrary, the economics approach is very precise in explaining why networks emerge but does a poor job in matching real-world networks. We also analyze behaviors on networks, which take networks as given and focus on the impact of their structure on individuals’ outcomes. Using a game-theoretical framework, we then compare the results with those obtained in sociology. We will then focus on some applications of social networks: labor-market networks, R&D networks, crime networks and homophily and networks.

The main reference for this course is:


All students are required to buy this book because most of our exercises and problem sets will be based on this book.
1) Lecture 1: Motivation, Definitions and Descriptive Evidence

We will present here some key characteristics of real-world social, economic and technology networks. In terms of structure, real-world networks are characterised by:

(i) A small average shortest path length between any pairs of agents.

(ii) A high clustering, which means that the neighbors of an agent are likely to be connected.

(iii) An inverse relationship between the clustering coefficient of an agent and her degree. The neighbors of a high degree agent are less likely to be connected among each other than the neighbors of an agent with low degree. This means that empirical networks are characterized by a negative clustering-degree correlation.

(iv) A highly skewed degree distribution. While some authors find power law degree distributions, others find deviations from power-laws in empirical networks, or exponential distributions.

(v) Degree-degree correlations for economic and social networks. In this case the network is said to be assortative. On the other hand, technological networks such as the internet display negative correlations. In this case the network is said to be dissortative. Others, however, find also negative correlations in social networks such as in the Ham radio network of interactions between amateur radio operators or the affiliation network in a Karate club. Networks in economic contexts may have features of both technological and social relationships and so there exist examples with positive degree correlations such as in the network between venture capitalists as well as negative degree correlations as it can be found in the world trade web, online social communities and in networks of banks.

We will also introduce some definitions and notations.

References:


2) Lecture 2: Theories of Network Formation

One of the main goals of the analysis of social networks is to shed some light on the mechanisms explaining how and why networks form. If social networks are relevant, we need to understand how networks emerge and the forces determining their shape. There are basically two main approaches of network formation. One possible reason why a link is formed is pure chance. Two individuals randomly meet and create a link between them, which can represent friendship or a stable working relationship. A set of different models have arisen based on this assumption. They are called random models of network formation. Another possible reason for the formation of a link is strategic interactions. Individuals carefully decide with whom to interact and this decision entails some consent by both parts in a given relationship. Strategic network formation models are, precisely, grounded on this premise.

2.1. Random Models of Network Formation

We will expose the following models:
Erdős-Rényi (Bernoulli) Random Graphs;
Rewired Lattices and Clustering (Watts and Strogatz, 1998);
Preferential Attachment and Scale-Free Degree Distributions;

2.2. Strategic Models of Network Formation

We will define the equilibrium concept of pairwise stability (which is the most prominent equilibrium concept used in network formation games) introduced by Jackson and Wolinsky (1996) and illustrate it using two well-known examples: The “Connections Model” and the “Co-Author Model”.
We will show that there is a tension between a pairwise stable network and an efficient network (from an overall society perspective). In particular, plenty of pairwise stable networks are not efficient (see, in particular, the surveys by Jackson (2007, 2008)).

The Connections Model: We will expose the results in both of equilibrium (pairwise stability) and efficiency.

Extensions of the “Connections Model”:

The spatial connection models explaining small world phenomena.

The Co-Author Model. We will expose the results in both of equilibrium (pairwise stability) and efficiency.
Another approach to network formation is the non-cooperative game introduced by Myerson (1977) and analyzed, for instance, by Bala and Goyal (2000) for the case of directed networks. We will expose and discuss this game for the case of un-directed networks, where link formation required mutual consent, using the paper by Calvó-Armengol and Ilkiliç (2009). This paper has also a very nice example for which the empty network, which happens to be a trembling-hand equilibrium network for the Myerson game, is not pairwise stable. This paper shows than one needs to resort to equilibrium notion of properness to reconcile the non-cooperative and cooperative approaches.

2.3. Hybrid models: mixing random networks and strategic network formation

We will mainly expose the paper by Jackson and Rogers (2007).

References:


Lecture 3: Games on Networks

The network structure of social interactions influences a variety of behaviors and economic outcomes, including the formation of opinions, decisions on which products to buy, investment in education, access to jobs, and social mobility, just to name a few.

In this lecture, we take networks as given (thus we leave aside the issue of network formation) and analyze the consequence of network structures on economic outcomes. The starting point of this analysis will be the paper by Ballester, Calvó-Armengol and Zenou (2006). They use a linear-quadratic utility function that exhibits both strategic substituabilities and complementarities between agents and each agent chooses the optimal amount of an action by maximizing this utility function. They show that, if the largest eigenvalue of the adjacency matrix (the matrix that represents the graph of the network) is bounded above, then there is a unique Nash equilibrium and each action is proportional to the Bonacich centrality (in the network) of each agent.

We develop further this approach by using the paper of Ballester and Calvó-Armengol (2010), who show the robustness of the first paper by reformulating the model as a linear-complementarity problem, a well-known issue in applied mathematics. One interesting result is to show that, using a suitable linear transformation of the interaction matrix (the one that gives the cross-derivatives), a linear-quadratic utility function that does not initially exhibit strategic complementarities can have complementarities in the induced game. This is referred to as hidden complementarities.
One example of a model that exhibits hidden complementarities is that of Bramoullé and Kranton (2007), which a model of public goods in networks. We will expose the model, and analyze the case with hidden complementarities as well as that with pure substitutabilities. A recent work on games on networks with incomplete information about the network structure is Galeotti et al. (2010).

References:


4) Lecture 4: Games on Networks and Network Formation

We will endogeneize the network formation in the previous network games. In particular, we will expose the recent paper by Galeotti and Goyal (2010) who introduce network formation in the strategic experimentation game of Bramoullé and Kranton (2007).

We will also expose the model of König, Tessone and Zenou (2010) which extends the model of Ballester, Calvo-Armengol and Zenou (2006) by introducing network formation in a dynamic framework.

References:


5) Lecture 5: Imperfect information and social learning in networks

Social networks are primary conduits of information, opinions, and behaviors. They carry news about products, jobs, and various social programs; influence decisions to become educated, to smoke, and to commit crimes; and drive political opinions and attitudes toward other groups. In view of this, it is important to understand how beliefs and behaviors evolve over time, how this depends on the network structure, and whether or not the resulting outcomes are efficient.

We will first expose the static models of Calvó-Armengol, A. and J. De Marti (2009) and Zenou and De Marti (2010) where agents are all uncertain about a common value (for example, how much synergies they obtain in a relationship) but receive private signals about the state of the world. We will take the network as given and characterize the Bayesian-Nash equilibrium of this type of game. We will, in particular, show how the structure of the network affects the outcome. In these games, agents cannot communicate with each other about the signals they receive.

In a recent paper, Calvó-Armengol, De Marti and Prat (2010) extend this framework to allow for “local” communication, i.e. agents can communicate only with other agents they are directly linked to.

We will then examine dynamic models of social learning. We will start with the naïve model of DeGroot (1974) and its recent developments made by Golub and Jackson (2009). In this model, there is no Bayesian updating. Agents start with some initial beliefs and in steady-state all agents converge to the same beliefs which have been naively updated. One interesting aspect developed in Golub and Jackson (2009) is: for which social network structures will a society of agents who communicate and update naively come to aggregate decentralized information completely and correctly?

We will then expose more complicated models of social learning. We will start with the standard model of information cascades by Bikhchandani, Hirshleifer, and Welch (1992) and then expose the social network of learning by Bala and Goyal (1998). There are also other more complicated papers on social learning on networks with Bayesian updating such as Gale and Kariv (2003) and more recently Acemoglu et al. (2008).

In the books by Goyal (2007) and Jackson (2008), these models are very well exposed. Also, on the web page of Daron Acemoglu at MIT (http://econ-www.mit.edu/faculty/acemoglu/courses), you can find a nice exposition of the recent development of social learning on networks with Bayesian updating.


6) Lecture 6: Applications to Labor Economics

The exchange and diffusion of information is critical to the functioning of most labor markets, where individuals seeking jobs mobilize their local networks of friends and relatives. Networks of personal contacts mediate employment opportunities that flow through word-of-mouth and, in many cases, constitute a valid alternative source of employment information to more formal methods. The empirical evidences indeed suggest that about half of all jobs are filled through contacts (Holzer, 1988).

We will use the tools learned in Lectures 2 and 3 to deal with these labor network issues. Direct applications are made in the papers by Calvó-Armengol (2004) and Calvó-Armengol and Zenou (2005). We will expose these papers and show how they explain the role of networks in the labor market, in particular how people transmit job information to their friends.
Another approach, which is dynamic and has a more explicit structure (though there is no network formation) is that of Calvó-Armengol and Jackson (2004). This is a beautiful model that has very strong implications. In particular, it explains unemployment duration dependence.

A nice survey of this literature can be found in Ioannides and Loury (2004).

References:


7) Lecture 7: Applications Crime

Crime is a “social” activity. Peers and friends have an important impact on crime decisions and crime activities. Indeed, most offenders belong to a network of friends that help them in their deeds. In their seminal study, Shaw and McKay (1942) show that delinquent boys in certain areas of US cities have contact not only with other delinquents who are their contemporaries but also with older offenders, who in turn had contact with delinquents preceding them, and so on ... This contact means that the traditions of delinquency can be and are transmitted down through successive generations of boys and across members of the same generation, in much the same way that language and other social forms are transmitted. In economics, the empirical evidence collected so far suggests that peer effects are, indeed, very strong in criminal decisions (Ludwig et al. 2001).

However, few theoretical models have investigated this issue. The first paper on this issue is the one by Glaeser, Sacerdote and Scheinkman (1996), where agents are located on the circumference of a circle and decide criminal activities by looking at their neighbors. They show that there are multiplier effects in the sense that the variance of crime is much higher when there are social interactions.
Calvó-Armengol and Zenou (2004) develop another explicit network model where any network structure (and not only the circle) is studied. They also analyze the network formation of criminals (using the pairwise-stability equilibrium concept) and show how social interactions affect crime decisions.

Another interesting approach is to differentiate between weak and strong ties in crime and to see how they affect both crime and labor activities. For that, we will expose the paper by Calvó-Armengol, Verdier and Zenou (2007).

We finally study the policy implications of crime networks using the paper by Ballester, Calvó-Armengol and Zenou (2010). Instead of punishing randomly criminals, they study the key-player policy, which consists in getting rid of the criminal whose removal results in the maximal decrease in overall activity.

References:


Lecture 8: Homophily or the tendency of individuals to associate with people with the same traits

The extent to which a society is segregated across different groups can be critical in determining things like how quickly information diffuses and the extent to which there is underinvestment in human capital, among other things.

In this lecture, we examine a fundamental and pervasive phenomenon of social networks which is known as “homophily.” This term refers to a tendency of various types of individuals to associate with others who are similar to themselves. Homophily has been documented quite broadly, across characteristics such as age, race, gender, religion, and profession, and is generally a quite strong and robust observation (see McPherson, Smith-Lovin, and Cook (2001) for an overview of research on homophily).

Given the importance of social networks, developing models that help us to understand homophily is essential. We will mostly focus on racial homophily. We will mainly expose the papers by Currarini et al. (2009, 2010) and De Marti and Zenou (2009).

We will also deal with issues related to ethnic identity (Akerlof and Kranton, 2000, 2010, Bisin et al., 2010) since choosing racial friends can also be a measure of ethnic identity.

References


9) Lecture 9: Empirical Aspects of Social Networks

In this last lecture, we will explore the empirical studies of some of the theoretical papers mentioned above. In particular, we will study how peer effects and social networks affect labor and crime activities.

We will start by the econometric problems that plague this literature. Indeed, empirical tests of models of social interactions are quite problematic because of well-known issues that render the identification and measurement of peer effects quite difficult: (i) reflection, which is a particular case of simultaneity (Manski, 1993) and (ii) endogeneity, which may arise for both peer self-selection and unobserved common (group) correlated effects.

We will first expose the paper by Bramoulle, Djebbari and Fortin (2009) who give some answers to these problems by exploiting the architecture of social networks to overcome this set of problems and to achieve the identification of endogenous peer effects.

We will also expose the paper by Calvó-Armengol, Patacchini and Zenou (2009) who apply the methodology of Bramoulle, Djebbari and Fortin (2009) to test peer effects in educations.

Other important papers that have test social network effects will be also exposed. Among others, we will expose Topa (2001) for unemployment rates in the US, Conley and Udry (2005), who investigate the role of social learning in the diffusion of a new agricultural technology in Ghana, Fafchamps and Lund (2003) who study risk-sharing networks in rural Philippines, Munshi (2003) who studies the social networks of Mexican Migrants in the U.S, and Wahba and Zenou (2005) who test labor-market networks in Egypt.

References:


