The economics of networks—Basic models and recent developments

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Economics is concerned with the allocation of scarce resources to meet desired ends. For decisions to be correct, it is important that the appropriate information is available in a timely manner to the decision makers. Firms located in production and supply networks combine labour, knowledge and material inputs to produce goods and services. Production and consumption rests on the movement of goods and services and of people on infrastructure networks like roads, trains, airlines and the internet. The flow of information take place in networks of social interactions. Individuals build friendships and social ties that give them access to information, shape their values, and ultimately determine who they become. Economic exchange rests on trust but, trust, combining elements of beliefs and behaviour, is a feature of personal ties and kinship relations.

Lecture 1-3 will cover three fundamental questions:

- 1. How should we measure networks?
- 2. What are the incentives of individuals to create links and shape networks?
- 3. How do networks affect the incentives of individuals to choose actions?

In lectures 2 and 3, we will discuss the relation between equilibrium or strategically stable outcomes and socially optimal outcomes. This will lead us to study optimal interventions in networks.

Lectures 4-5 will apply the theory to the study of two sets of substantive questions:

- 1. Conflict and Conquest
- 2. Trust, Social Structure, and State Capacity.

Textbook: Sanjeev Goyal (2023), Networks: An economics approach. MIT Press.

Every lecture will last 3 hours and will have a problem set. Students are encouraged to work through these problem sets.

Lecture 1: Concepts and Measurement

A network consists of points and the lines that connect these points: this parsimony and abstraction allows us to represent a wide variety of important economic systems as networks. The advances in data collection methods and in our computational capacity over the past three decades allows us to collect progressively richer data on networks and the different processes that take place on networks. In this lecture, we define concepts and propose measurements of aspects of networks that play an important role in economics such as *degrees, distance, clustering, centrality, cohesiveness, and homophily.* The lecture also illustrates the concepts by presenting computations on simple examples and then applies them to measure a range of real world networks.

Reading: Goyal (2023) Chapter 1

Lecture 2: Network formation

This lecture introduces the basic elements of the theory of network formation. Individuals use links to create networks in order to achieve their different objectives. This leads us to discuss different motivations for forming links. We distinguish between directed and undirected links. We present the role of externalities and of strategic considerations in the process of linking. This leads us to draw attention to a fundamental tension between strategically stable networks and collectively desirable (or efficient) networks. We discuss theoretical models and applications. Concepts covered will include *pairwise stable networks* (and their many refinements), *Nash equilibrium networks*, and *efficient networks*. We also present experimental evidence on these models.

Reading: Goyal (2023) Chapters 2, 3. Recent Papers.

Lecture 3: Individual choice in networks

This lecture presents a model in which individuals interact locally with neighbours embedded in broader chains of interaction. This lecture offers us an approach to thinking of how behaviour is scaled from small groups to large populations, through a sequence of overlapping neighbourhoods. We discuss a number of applications and use them to motivate the concepts of positive and negative externalities and strategic substitutes and strategic complements. We study how these factors interact with the topology of networks to shape behaviour. We discuss welfare implications of strategic behaviour and propose methods to welfare enhancing design interventions. This lecture will introduce concepts such as *maximal independent sets, q-core, Bonacich centrality,* and *principal components.* We will also present experimental evidence on the theoretical models.

Reading: Goyal (2023) Chapter 4. Recent Papers.

Lecture 4: Conflict and Conquest

This lecture studies the question of conflict and network resilience. It draws attention to the versatility of networks: we may think of links as reflecting defence alliances or physical contiguity or as technologies that enable movement from one physical space to another. We study how links affect the investments in conflict and we then study the factors that shape the creation of links. The lecture will draw attention to *Harary graphs, separators/transversals, network centrality*. The models will help us better understand a number of empirical phenomena – resilience of hub-spoke networks, structure of attack and defence networks in early societies, the dynamics of conquest, and the rise and fall of empires in history.

Reading: Goyal (2023) Chapters 6, 10. Recent Papers.

Lecture 5: Trust, Social Structure, and State Capacity

This lecture studies the foundations of trust -- an essential precondition for social and economic exchange. We discuss trust in the small (as in repeated interaction within small groups) and trust in

the large (as among strangers). We then propose networks as a conceptual approach to help scale up from small groups to trust at a societal level. We study the effects of social capital on the nature of the state. Finally, we consider the co-determination of social ties and state capacity and we examine stable configurations of society and state. The lecture will draw attention to *WEIRD vs NON-WEIRD societies, universalism, bridging and bonding social capital, nested split graphs.*

Reading: Goyal (2023) Chapters 18, 19. Recent papers.

Textbook Networks: An Economics Approach

https://uniandes.primo.exlibrisgroup.com/permalink/57U_UDLA/1I16f7l/alma991005759428407681

Bogotá Summer School – Network Analysis for Economics

Week 2: Prof. Pau Milán (BSE)

SUMMARY. This is the second part of a two-week course on the analysis of social and economic networks. We will leverage some of the concepts introduced in week one to explore what networks can teach us about five different topics related to information economics, development economics, management, and macroeconomics. In this part of the course, we will take the network structure as given and explore how networks shape the propagation of information and the formation of opinions over time; how village networks distribute income risk; how firms structure their workforce; and how supply chains shape macroeconomic fluctuations. The course combines theoretical/mathematical modelling and manipulation/analysis of social network data.

PREREQUISITES. A reasonable command of the following: (i) multivariate optimization, (ii) linear algebra, (iii) probability and statistics, (iv) game theory, (v) intermediate micro. We will also learn to manipulate data in R/python using the *igraph* package. Knowing how to use these languages is a plus.

TEXTBOOK. Sanjeev Goyal (2023) *Networks: an economics approach*. MIT Press. Chapters 5, 13, 14.

1. Diffusion and Optimal Seeding

- a. Simple diffusion: SIS, SIR, Independent Cascades
- b. Complex diffusion: Linear Threshold model
- c. Optimal vs. Random Seeding

2. Opinion Dynamics

- a. DeGroot Model
- b. Convergence and Consensus
- c. Platform Design

3. Risk Sharing and Informal Insurance

- a. Basic Insurance Model with 2 Households
- b. Insurance Frictions
- c. Consumption Risk Sharing in Village Networks

4. Incentives and Organizational Design

- a. Centralization, Coordination, and Adaptation in multidivisional firms
- b. Organizations and information flows
- c. Wage contracts and incentive design

5. Supply Chains

- a. Amplification of idiosyncratic shocks
- b. Fragility and Resilience

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