

# Economic Network Analysis

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“... each of the people who pass each other as apparently unconnected strangers in the street is tied by invisible chains to other people, whether they are chains of work and property or of instincts and affects. Functions of the most disparate kinds have made him dependent on others and others on him. He lives, and has lived since a child, in a network of dependencies, that he cannot change or break simply by turning a magic ring, but only as far as their structure itself allows; he lives in a tissue of mobile relationships, which have by now been precipitated in him as his personal character. And this where the real problem lies: in each association of human beings this functional context has a very specific structure. It is different in a tribe of cattle-rearing nomads than in a tribal of farmers; it is different in a feudal warrior society than in the industrial society of our day, and over and above this it is different in different national communities of industrial society itself. However, this basic framework of interdependent functions, the structure and pattern of which gives a society its specific character, is not a creation of particular individuals; for each individual, even the most powerful, even a tribal chief, an absolutist monarch or a dictator, is a part of it, the representative of a function which is formed and maintained only in relation to other functions, which can only be understood in terms of the specific structure and the specific tensions of this total context.”

— Nobeert Elias, *A Society of Individuals* (1991)

# 1 Overview

Economic systems—and their subsystems—involve people who either individually or in groups are in quasi-stable relations with other individuals or groups. Firms for instance buy inputs from and sell output to other firms. Some of these buyer-seller relations last for months and years. Similarly banks enter into relations with borrowers and lenders, with relations lasting for long periods of time. The economy is not a well mixed system in which everyone interacts with everyone else with equal probability, rather there are particularly structures of local interactions. These structures are quasi-stable in the sense that while some relations last for years, others change in matter of days. The economic network therefore is dynamic in the sense that nodes (individuals, households, and firms) and links (buyer-seller relations, borrower-lender relations) evolve over time. Despite these microeconomic changes in nodes and links, the economic network itself can exhibit some stable properties much like how a firm can remain stable though the employees who constitute the firm are forever changing.

A network-view of the economic system brings to the foreground numerous problems that do not appear through the reductionist lens. Not the least of which is the problem of knowledge and rationality. Each economic entity is likely to possess some knowledge about the behavior of those with whom it has direct links. It would not be unreasonable to postulate that economic actors use this knowledge to form expectations about the behavior of those on whom their own plans directly dependent. Nonetheless, such a conception of economic actors is a far cry from viewing economic agents as gathering, possessing, or using knowledge about all actors and all relations in the economic system. Knowledge and rationality therefore are more ecological than logical, in these sense that agents' knowledge gathering and using procedures will relate to their niche in the ecology of inter-relations between agents.

Note that the field of network economics is young and emerging, therefore exciting but experimental. I have therefore attempted to introduce you to various thematic areas, including games on fixed networks, the emergence of networks topologies from economic interactions, measuring economic networks and outcomes that emerge from networks, studying networks using field experiments, and the macroeconomic dynamics that emerge from firm interactions on buyer-seller networks. In some senses, each of these areas mark the intersection between network science and another field. For instance, 'network games' lies at the intersection between game theory and network science. The empirics of networks presumes a reasonable grasp over standard econometrics. Laboratory and field experiments with networks involve using well established experimental procedures within a network setting. Agent-based computational experiments with networks build on the agent-based computational modelling paradigm. Macroeconomic and monetary dynamics that emerge from networks are at times characterized using results from Random Matrix Theory. All these areas directly and indirectly rely on Graph Theory and Combinatorics. And ultimately, much of the applied work on network economies solves domain specific problems that call for reasonable familiarity with specific terrains. In some senses the 'network way' calls for a bouquet of courses spanning over a period of two years. Perhaps some of you will embark on such a journey after the completion of this course.

## 1.1 “Level” of the course

Some time ago, a colleague of mine asked me if his wife could ‘sit in’ on a course I was teaching over the summer, to which I consented. I must admit that she was far more punctual than most undergraduate and graduate students who had enrolled in the course. Nonetheless, there was something about the course which appeared to bother her. In fourth, perhaps fifth, lecture she brought up the issue, she asked me “Vipin, but what is the level of the course?” I was somewhat lost with the question, I suppose I had never thought in those terms. And I do not think in those terms even today. I assign levels neither to the courses I teach, nor the students I meet. Each of you comes to this course with unique histories, life experiences, expectations, goals, and dreams. And each of you therefore will interact with the material at hand in idiosyncratic ways. I have no desire to dampen such idiosyncrasies. After all there is little more to life than the particularities of people, places, and times.

## 2 Textbooks

Jackson, Matthew O. 2009. *Social and Economic Networks*. Princeton University Press. (Referred to as “Jackson”)

*The Oxford Handbook of The Economics of Network*. 2016. Edited by Yann Bramouille, Andrea Galeotti, and Brian W Rogers. (Referred to as “Handbook”)

### 2.1 Supplementary textbooks

Bona, Miklos. 2006. *A Walk Through Combinatorics: An Introduction to Enumeration and Graph Theory*. World Scientific.

Livan, Giacomo, Marcel Novaes, and Pierpaolo Vivo. 2017. *Introduction to Random Matrices: Theory and Practice*. Springer.

# 3 Modules

## I. Introduction

- Elias, Nobert. 1991. *A Society of Individuals*. Continuum, pp: 3-66.
- Kirman, Alan. “Networks: A paradigm shift for economics”. Handbook Chapter 2.
- Wagner, Richard E. 2012. “A macro economy as an ecology of plans.” *Journal of Economic Behavior & Organization*, 82(2-3): 433-444.

## II. Motivating examples

- Axtell, Robert L, and Joshua M. Epstein. 1999. “Coordination in transient social networks: An agent-based computational model of the timing of retirement”. Center on Social and Economics Dynamics Working Paper No.1. Brookings Institution.
- Mandel, Antoine, Davoud Taghawi-Nejad, and Vipin P. Veetil. 2019. “The price effects of monetary shocks in a network economy”. *Journal of Economic Behavior & Organisation*, 164(1):300–316.

## III. Basic properties of fixed networks

- Jackson Chapters 1 - 4.

## IV. Growing networks

- Jackson Chapters 5 - 6.

## V. Networked Markets

- Axtell, Robert L, Omar A. Guerrero, and Eduardo Lopez. 2019. “Frictional unemployment on labor flow networks”. *Journal of Economic Behavior & Organization*, 160: 184–201.
- Jackson Chapter 10.
- Vignes, Annick, and Jean-Michel Etienne. 2011. “Price formation on the Marseille fish market: Evidence from a network analysis”. *Journal of Economic Behavior & Organization*, 80: 50–67.

## VI. Games and networks

- Bramoulle, Yann, and Rachel Kranton. “Games played on networks”. Handbook Chapter 5.
- Jackson Chapters 11 and 12.

- Mauleson, Ana, and Vincent Vannetelbosch. “Network formation games”. Handbook Chapter 8.
- Vega-Redonodo, Fernando. “Links and actions in interplay”. Handbook Chapter 9.

## **VII. International trade networks**

- Chaney, Thomas. “Networks in international trade”. Handbook Chapter 28.
- Hausmann, Ricardo, and Cesar A. Hidalgo. 2011. “The network structure of economic output.” *Journal of Economic Growth*, 16(4): 309-342.
- Grief, Avner. 1989. “Reputation and coalitions in medieval trade: Evidence on the Maghribi trades”. *Journal of Economic History*, 49(4): 857–882.

## **VIII. Financial networks**

- Battiston, Stefano, Guido Caldarelli, Robert M. May, Tarik Roukny, and Joseph E. Stiglitz. 2016. “The price of complexity in financial networks.” *Proceedings of the National Academy of Sciences*, 113(36): 10031-10036.
- Boginski, Vladimir, Sergiy Butenko, and Panos M. Pardalos. 2005. “Statistical analysis of financial networks.” *Computational Statistics & Data Analysis*, 48(2): 431-443.
- Glasserman, Paul, and H. Peyton Young. 2016. “Contagion in financial networks.” *Journal of Economic Literature*, 54(3): 779-831.
- Kinnan, Cynthia, and Robert Townsend. 2012. “Kinship and financial networks, formal financial access, and risk reduction.” *American Economic Review*, 102(3): 289-93.

## **IX. Macroeconomic dynamics and production networks**

- Acemoglu, Daron and Carvalho, Vasco M and Ozdaglar, Asuman and Tahbaz-Salehi, Alireza. 2012. The network origins of aggregate fluctuations. *Econometrica*, 80(5): 1977–2016
- Carvalho, Vasco M and Tahbaz-Salehi, Alireza. 2018. “Production networks: A primer”. *Annual Reviews*, 11.
- Mizuno, Takayuki and Souma, Wataru and Watanabe, Tsutomu. 2014. The Structure and Evolution of Buyer-Supplier Networks. *Plos One*.

## **X. Monetary dynamics and production networks**

- Gualdi, Stanislao and Mandel, Antoine. 2016. On the emergence of scale-free production networks. *Journal of Economic Dynamics and Control*, 73: 61–77
- Mandel, Antoine, and Vipin P. Veetil. “Price dynamics in a network economy”.

## **XI. Empirics of networks**

- Boucher, Vincent, and Bernard Fortin. “Some challenges in the empirics of the effects of networks”. Handbook Chapter 12.
- Chandrasekhar, Arun G. “Econometrics of network formation”. Handbook Chapter 13.
- Jackson Chapter 13.

## **XII. Networks in field and laboratory experiments**

- Aral, Sinan. “Networked experiments”. Handbook Chapter 15.
- Breza, Emily. “Field experiments, social networks, and development”. Handbook Chapter 16.
- Kosfeld, Michael. “Economic networks in the laboratory: A survey”.
- Syngjoo, Choi, and Edoardo Gallo, and Shachar Kariv. “Networks in laboratory”. Handbook Chapter 17.