

Complexity and Emergence:
ideas, methods, with a special attention to economics and finance
Villa del Grumello, 22-27 July 2018

LIST OF ABSTRACT
(in alphabetical order)

Blanchard, P. - *Mathematical Analysis of Complex Networks and Database*

Contents:

1. Brief overview
2. Exploring graphs by random walks
3. Embedding graphs in probabilistic \mathbf{R}^N using statistical and spectral properties
4. Classical and generalized epidemic processes using percolation theory
5. Applications to real world problems

References:

- Mathematical Modeling on Random Graphs of AIDS-Epidemics

- 1) Lecture Notes in Physics 355, Springer 1990
- 2) Lecture Notes in Biomathematics 86, Springer 1990

Ph. Blanchard, G. Bolz, T. Krüger

- Emergenz in und jenseits Physik

Philippe Blanchard

Emergenz: zur Analyse und Erklärung komplexer Strukturen
Suhrkamp (2010)

- Mathematical Analysis of Urban Spatial Networks

Ph. Blanchard, D. Volchenkov

Springer Complexity (2009)

- Random Walks and Diffusion on Graphs and Databases

Ph. Blanchard, D. Volchenkov

Springer (2011)

Boi, L.

- 1) Introduction to the geometry of complexity: methods, ideas, and perspectives
- 2) The link between topological plasticity and functional complexity in living systems
- 3) On self-organization and emergence in complex living systems: from the embryo to the brain.

Capelli, I. - *Law and Complexity*.

The relationship between Law and complexity. The aim of the Law: regulation, social order and social progress promotion. Regulation and complexity. Two different trends: regulatory complexity and the attempts at

simplification by the Lawmaker. Regulation and complex systems: the role of the State and democracy in regulating complex systems. The role of the Legislatures and the need for competence. The role of the State as a Lawmaker after the global crisis. The financial market's example. The recent attempts of an effective financial regulation between the need of stability and the need of fair information and rapid technological innovations: the equity crowdfunding example.

Ekeland, I. and McIsaac, F.

Lecture 1 (IE) ***The emergence problem in economics***

Economic indices: GNP, unemployment rate, cost of living, Dow Jones, etc...

The 2008 crash. Why did no one see it coming?

Is prediction possible? Why should the economic indices be related?

Lecture 2 (FMI) ***The 2008 crisis***

Originates in the financial sector and morphs into an economic crisis.

Is money important per se or is it just a veil thrown over the real economy?

Following the money, from Northern Rock to the Greek debt

The laws of economics are man-made and can be changed

Lecture 3 (IE) ***Microfoundations***

The hope: there are microfoundations to macroeconomics (Schelling)

Microfoundations do not favour any global outcome: Sonnenschein-Mantel-Debreu, and Chiappori-Ekeland.

Microfoundations prevent any kind of prediction: the Lucas critique

The market as a blind regulator: the market for lemons.

Lecture 4 (FMI) ***The phenomenological approach***

The hope: there are statistical relations between suitably chosen economic indices

Putting money back into the picture: GEMMES

Agent-based models

Critical self-organization

Guerra, F. - ***The challenge of complexity in modern physics***

We show how complexity arises in modern physics, by considering simple examples taken from hard optimisation, thermodynamic properties of spin glasses and neural networks. A central role is played by frustration, defined in precise physical and mathematical terms. Both static aspects and dynamical aspects will be considered. We show that the simplest naive procedures to control these problems are insufficient. Complexity is a real challenge. We give a complete outline of the techniques developed in recent times to efficiently attack the problems. Exotic terminology, such as replica symmetry and replica symmetry breaking, is explained in simple, precise terms. The emerging structures are synthetically outlined. The lectures will be directed to a general audience. Technical aspects will be kept at a minimum.

Yet we hope to convey the flavour of the new ideas involved.

Jost, J. - ***Information theory and complexity measures***

Information theory is a basic tool for studying complex systems, and in particular, it provides us with systematic tools to construct and evaluate complexity measures.

Also, the new theory of information decompositions offers new perspectives on the interaction of various sources in determining or influencing a target.

Patras, F.

Lecture 1. ***Simplicity, complexity.***

In this first lecture we will analyze the historical process of building of science, from the Greeks onwards, featuring its philosophical implications and background. Realizing that many phenomena had a simple and universal structure, obey simple universal laws, has been a great achievement on which science could grow. The various meanings of “complexity” and their philosophical implications will then (start to) be analyzed.

Lecture 2. ***Complexity in finance: a case study.***

In this second lecture, we will analyze several key features of complexity on a concrete example: RMBS (residential mortgage-backed securities). RMBS were the main cause of the 2008 financial crisis. We will analyze why and how (obviously) oversimplifying hypothesis were applied to device and price these financial products that have in practice an extremely complex behavior. Some of these hypothesis originate in a wrong financial analysis, but some others, more interestingly, originate in some sort of naive faith in mathematical models.

Lecture 3. ***Neural networks and related topics.***

In this last lecture, we will investigate the phenomenon of deep learning. A new paradigm is emerging: computational structures capture features of reality, classify phenomena, play and win over human beings in complex games, but through purely algorithmic and spontaneous auto-organization. These phenomena go against many of our spontaneous ideas and conceptions of science and challenge our humanistic ideals -for example the ones expressed by Husserl in the 1930's. Do we face a new “crisis of European sciences”?

Riedel, F. ***Knightian Uncertainty in Finance and Economics***

The distinction of “uncertainty” from “risk” is about to change the way economists think about financial markets and markets under time and uncertainty. In these lectures, we introduce the basic models and concepts that allow to model different perceptions of uncertainty - that cannot be described by exact probabilities - and risk - that can be described by objective probability distributions. We then reconsider the microeconomic foundations of financial economics under Knightian Uncertainty. In a general framework, we discuss the absence of arbitrage, its relation to economic viability, and the existence of suitable nonlinear pricing expectations. Classical financial markets under risk and no ambiguity are contained as special cases, including various forms of the Efficient Market Hypothesis. For Knightian uncertainty, our approach unifies recent versions of the Fundamental Theorem of Asset Pricing under a common framework. In equilibrium, Knightian uncertainty can lead to inefficiencies and explain “market breakdowns” in a sense to be explained.

Semboloni, F.

The three lectures concern

- 1) ***the self-organization of a system of cities,***
- 2) ***the functional organization of a city***
- 3) ***the control of the spontaneous development of a city.***

1. The power law distribution of the population among the cities is usually considered a signature of the complex behavior of a system of cities. The explanations of the distribution, distinguishing between interconnected and independent behavior of the cities, are shown. The interconnected behavior is based on migration between cities and on the asymmetric exchange of goods and services between cities. This second case is shown with a simulation with variable transportation costs.

2. The functional organization of a city and the spontaneous growth of the urban fabric. The functional organization of a city is the result of the land market. The location of different functions (rich and poor housing, services, and firms) is the result of the equilibrium in the land market where the distance from central services and segregation play a crucial role. The interaction between heterogeneous agents that bid for dwellings spontaneously generates a spatial organization. By varying preferences in terms of distance from services and segregation, different patterns are obtained. The spontaneous growth of the urban fabric depends on the spatial aggregation of the buildings along roads that generate other more or less perpendicular roads. A random factor is able to generate different urban models.

3. The planning of spontaneous growth of a city. Planning is considered as the maximization of the global utility of a spatial organization of different functions or land uses. Planning can be compared to spontaneous growth in which each function seeks to maximize its utility. The problem is: what happens if one wants to establish a series of tipping points in which the land use is established, and what is the minimum number of tipping points able to control a spontaneous growth.

Seri, R. - *Emergence and Causation in Computational Models in Social Sciences*

The aim of the lecture is to give an introduction to some computational/simulation methods used in social sciences. We start from the early implementations of simulated systems in analog and digital computers. We then consider some macrosimulation techniques, namely system dynamics and discrete-event simulation. We pass to microsimulation techniques introduced in economics and political science. At last we consider cellular automata and agent-based models. Throughout the lecture, we will stress some common features of these models that have become important over time, namely emergence and causation.