

Physics 250

Econophysics

Statistical Physics of the Financial Markets

John Rundle
Professor of Physics and Geology

Econophysics is the application of ideas from statistical mechanics to the financial markets. In turn, markets are complex systems that are observed to undergo sudden transitions such as “booms” or “bubbles” and “busts” or “crashes”. Transitions in system dynamics are associated with the nucleation and growth of fluctuations, together with a threshold in the state space of the system. Markets are also observed to obey scaling dynamics, an interesting example being the existence of the Pareto distribution of wealth among populations. In this course, we will introduce the dynamics of markets from a physics and systems perspective. We will discuss the statistical distributions of returns, the phase dynamics of prices, and models for the markets. We will discuss specific markets such as the equity stock markets (NYSE/Euronext, NASDAQ), the fixed income (bond) markets (Govt and Munis), and the commodities markets (CME and Futures). We will discuss time-dependent models for equity valuations such as the Black-Scholes equation that are used in options pricing. Students will be expected to contribute actively to discussions, as well as complete a project using financial data and analysis. Familiarity with some form of computer programming is mandatory.

Structure of Classes

Classes will involve both lectures and seminar-type discussions. Grades will be based on:

| | |
|----------------------|-----|
| Class Participation | 50% |
| Project | 30% |
| Homework assignments | 20% |

Texts and Readings:

1. Rosario N. Mantegna and H. Eugene Stanley, *An Introduction to Econophysics, Correlations and Complexity in Finance*, Cambridge University Press, Cambridge, UK
2. Philip R. Bevington and D. Keith Robinson, *Data Reduction and Error Analysis for the Physical Sciences*, McGraw-Hill, NY.
3. Dietrich Stauffer and Amnon Aharony, *Introduction to Percolation Theory*, CRC Press, NY

Approximate Course Plan (10 weeks - 20 lectures)

- | | |
|--|------------|
| • Introduction, administrivia | 1 lecture |
| • Complex systems and markets | 1 lecture |
| • Fat tails, scaling, and simple models of markets | 5 lectures |
| • Statistics and distributions | 3 lectures |
| • Stochastic processes and complex dynamics | 4 lectures |
| • Time series analysis | 2 lectures |
| • Financial data | 1 lecture |
| • Options and the Black-Scholes model | 2 lectures |
| • Risk management and the Kelly criterion | 1 lecture |