Econophysics Restart

Chapter 1-8 of Mantegna and Stanley's book

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R. N. Mantegna and H. E. Stanley:
An introduction to econophysics
Correlations and complexity in finance

Authors
Chapter 1-8
New data
New references

Motivation: Wiki on Econophysics

Econophysics

28 languages

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From Wikipedia, the free encyclopedia

Econophysics is a non-orthodox (in economics) interdisciplinary research field, applying theories and methods originally developed by physicists in order to solve problems in economics, usually those including uncertainty or stochastic processes and nonlinear dynamics. Some of its application to the study of financial markets has also been termed statistical finance referring to its roots in statistical physics. Econophysics is closely related to social physics.

Main results [edit]

Econophysics is having some impacts on the more applied field of quantitative finance, whose scope and aims significantly differ from those of economic theory. Various econophysicists have introduced models for price fluctuations in physics of financial markets or original points of view on established models.[23][34][35]

Presently, one of the main results of econophysics comprises the explanation of the "fat tails" in the distribution of many kinds of financial data as a universal self-similar scaling property (i.e. scale invariant over many orders of magnitude in the data),[36] arising from the tendency of individual market competitors, or of aggregates of them, to exploit systematically and optimally the prevailing "microtrends" (e.g., rising or falling prices). These "fat tails" are not only mathematically important, because they comprise the risks, which may be on the one hand, very small such that one may tend to neglect them, but which - on the other hand - are not negligible at all, i.e. they can never be made exponentially tiny, but instead follow a measurable algebraically decreasing power law, for example with a *failure probability* of only $P \propto x^{-4}$, where *x* is an increasingly large variable in the tail region of the distribution considered (i.e. a price statistics with much more than 10^8 data). I.e., the events considered are not simply "outliers" but must really be taken into account and cannot be "insured away".[37] It appears that it also plays a role that near a change of the tendency (e.g. from falling to rising prices) there are typical "panic reactions" of the selling or buying agents with algebraically increasing bargain rapidities and volumes.[37]

Basic problem: small amount of data usually Gaussian or exponential.
Data improve, Gaussians become unsatisfactory, due to heavy tails.
https://en.wikipedia.org/wiki/Econophysics

Authors

Rosario N. Mantegna is Applied Physics professor[1] at Palermo University, Palermo, Italy, and member of the External Faculty of the Complexity Science Hub Vienna[2].

He graduated in Physics at Palermo University in 1984 and did his PhD in Physics at the same University defending his thesis on “Stochastic process at microwave frequency” in 1990. He was postdoc at the Max-Planck Institute for Quantum Optics in Munich where he did experiments on quantum chaos and at Boston University where he worked on complex systems under the mentorship of Gene Stanley. During 2012-2016 he was also professor at the “Center for Network Science” and “Department of Economics” of Central European University, Budapest, Hungary[4]. During 2016-2021 he was honorary professor at University College London, UK. He is an associate of the UCL Centre for Blockchain Technologies[5].

He has been principal investigator or member of several international and national research projects funded by the European Union, the National Science Foundation of USA, The Italian Ministry of Education, The Italian Institute for the Physics of Matter, and by the Institute for New Economic Thinking[6].

Harry Eugene Stanley (born March 28, 1941) is an American physicist and University Professor at Boston University. He has made seminal contributions to statistical physics and is one of the pioneers of interdisciplinary science. His current research focuses on understanding the anomalous behavior of liquid water, but he had made fundamental contributions to complex systems, such as quantifying correlations among the constituents of the Alzheimer brain, and quantifying fluctuations in noncoding and coding DNA sequences, interbeat intervals of the healthy and diseased heart. He is one of the founding fathers of econophysics.

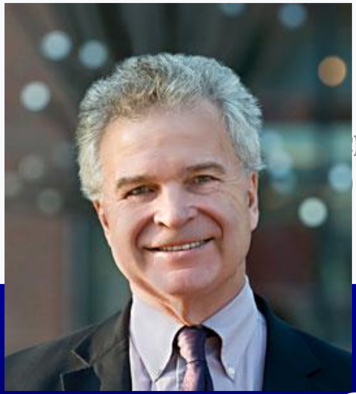
Harry Eugene Stanley

Born

Citizenship

Alma mater

Known for



Top class authors, establishing a new field,
But by now the field has grown up (25+).

Authors

Dr Rosario N. Mantegna is interested in the empirical and theoretical modeling of complex systems. Since 1989, a major focus of his research has been studying financial systems using methods of statistical physics. In particular, he has originated the theoretical model of the truncated Lévy flight and discovered that this process describes several of the statistical properties of the Standard and Poor's 500 stock index. He has also applied concepts of ultrametric spaces and cross-correlations to the modeling of financial markets. Dr Mantegna is a Professor of Physics at the University of Palermo.

Dr H. Eugene Stanley has served for 30 years on the physics faculties of MIT and Boston University. He is the author of the 1971 monograph *Introduction to Phase Transitions and Critical Phenomena* (Oxford University Press, 1971). This book brought to a much wider audience the key ideas of scale invariance that have proved so useful in various fields of scientific endeavor. Recently, Dr Stanley and his collaborators have been exploring the degree to which scaling concepts give insight into economics and various problems of relevance to biology and medicine.

Both focusses on topics interesting for us:
Corrections to Levy flights and scaling.

Chapter 1

AN INTRODUCTION TO ECONOPHYSICS

Correlations and Complexity in Finance

Levy flights: stochastic processes
Chaos: non-linear dynamics
Focus: power-law tails

Feldolgozott fejezetek

Chapter 2: Efficient market hypothesis	Brigi
Chapter 3: Random walk	István
Chapter 4: Lévy stochastic processes	N. Tamás
Chapter 5: Scales and scaling in financial data	Gábor
Chapter 6: Korrelációk 1	Sanyi
Chapter 7: Korrelációk 2	
Chapter 8: Stat. models of price dynamics	Cs. Tamás

Plan for this semester: Chapters 9-13

Chapter 1

1.1 Motivation

Since the 1970s, a series of significant changes has taken place in the world of finance. One key year was 1973, when currencies began to be traded in financial markets and their values determined by the foreign exchange market, a financial market active 24 hours a day all over the world. During that same year, Black and Scholes [18] published the first

A second revolution began in the 1980s when electronic trading, already a part of the environment of the major stock exchanges, was adapted to the foreign exchange market. The electronic storing of data relating to financial contracts – or to prices at which traders are willing to buy (bid quotes) or sell (ask quotes) a financial asset – was put in place at about the same time that electronic trading became widespread. One result is that today a huge amount of electronically stored financial data is readily available. These data are characterized by the property of being high-frequency data – the average time delay between two records can be as short as a few seconds. The enormous expansion of financial markets requires strong investments in money and

Black and Scholes formula: Gauss eloszlást feltételez. Hivatkozás!

1.2 Pioneering approaches

With this background in mind, it may surprise scholars trained in the natural sciences to learn that the first use of a power-law distribution – and the first mathematical formalization of a random walk – took place in the social sciences. Almost exactly 100 years ago, the Italian social economist Pareto investigated the statistical character of the wealth of individuals in a stable economy by modeling them using the distribution

$$y \sim x^{-\nu}, \tag{1.1}$$

where y is the number of people having income x or greater than x and ν is an exponent that Pareto estimated to be 1.5 [132]. Pareto noticed that his result was quite general and applicable to nations 'as different as those of England, of Ireland, of Germany, of the Italian cities, and even of Peru'.

Pareto törvénye: 1897

[132] V. Pareto, *Cours d'Economie Politique* (Lausanne and Paris, 1897).

Section 8.1: Levy stable model

Proposed by B. Mandelbrot in 1963 for modeling cotton ln Y(t).

The Variation of Certain Speculative Prices

Benoit Mandelbrot

The Journal of Business, Vol. 36, No. 4. (Oct., 1963), pp. 394-419.

Stable URL:
http://links.jstor.org/sici?sici=0021-9398%28196310%2936%3A4%3C394%3ATVOCSP%3E2.0.CO%3B2-L

The Journal of Business is currently published by The University of Chicago Press

B. ADDITION OF MORE THAN TWO STABLE RANDOM VARIABLES

Let the independent variables U_n satisfy the condition (PL) with values of α, β, γ, and δ equal for all n. Then, the logarithm of the characteristic function of

$$S_N = U_1 + U_2 + \ldots U_n + \ldots U_N$$

is N times the logarithm of the characteristic function of U_n, and it equals

$$i\,\delta N z - N\gamma|z|^{\alpha}[1 + i\beta(z/|z|)\tan(\alpha\pi/2)]\,,$$

so that S_N is stable with the same α and β as U_n, and with parameters δ and γ multiplied by N. It readily follows that

$$U_n - \delta \text{ and } N^{-1/\alpha}\sum_{n=1}^{N}(U_n - \delta)$$

have identical characteristic functions and thus are identically distributed ran-

Seconded by Fama (1965)
Stable for convolution
Generalized central limit theorems
Infinite second moment for $\alpha < 2$.
Infinite first moment for $\alpha < 1$.
Gaussian is recovered for $\alpha = 2$.
Top cited, paradigm shifting paper.

Section 8.4: Truncated Levy Flights (TLF)

TLF distribution is defined by

$$P(x) \equiv \begin{cases} 0 & x > \ell \\ cP_{\mathrm{L}}(x) & -\ell \le x \le \ell \\ 0 & x < -\ell \end{cases},$$

Not stable for convolution.
It has finite means and variances: asymptotically Gaussian.
But how quickly?

How quickly will it converge? To answer this question, we consider the quantity $S_n \equiv \sum_{i=1}^{n} x_i$, where x_i is a truncated Lévy process, and $\langle x_i x_j \rangle = \text{const}\ \delta_{ij}$. The distribution $P(S_n)$ well approximates $P_{\mathrm{L}}(x)$ in the limit $n \to 1$, while $P(S_n) = P_{\mathrm{G}}(S_n)$ in the limit $n \to \infty$. Hence there exists a crossover value of $n, n_\times$, such that (Fig. 8.3)

$$P(S_n) \approx \begin{cases} P_{\mathrm{L}}(S_n) & \text{when } n \ll n_\times \\ P_{\mathrm{G}}(S_n) & \text{when } n \gg n_\times \end{cases}, \tag{8.5}$$

where $P_{\mathrm{G}}(S_n)$ is a Gaussian distribution. The crossover value $n_\times$ is given by

$$n_\times \simeq A\ell^{\alpha}, \tag{8.6}$$

Very interesting.

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Section 8.4: Truncated Levy Flights (TLF)

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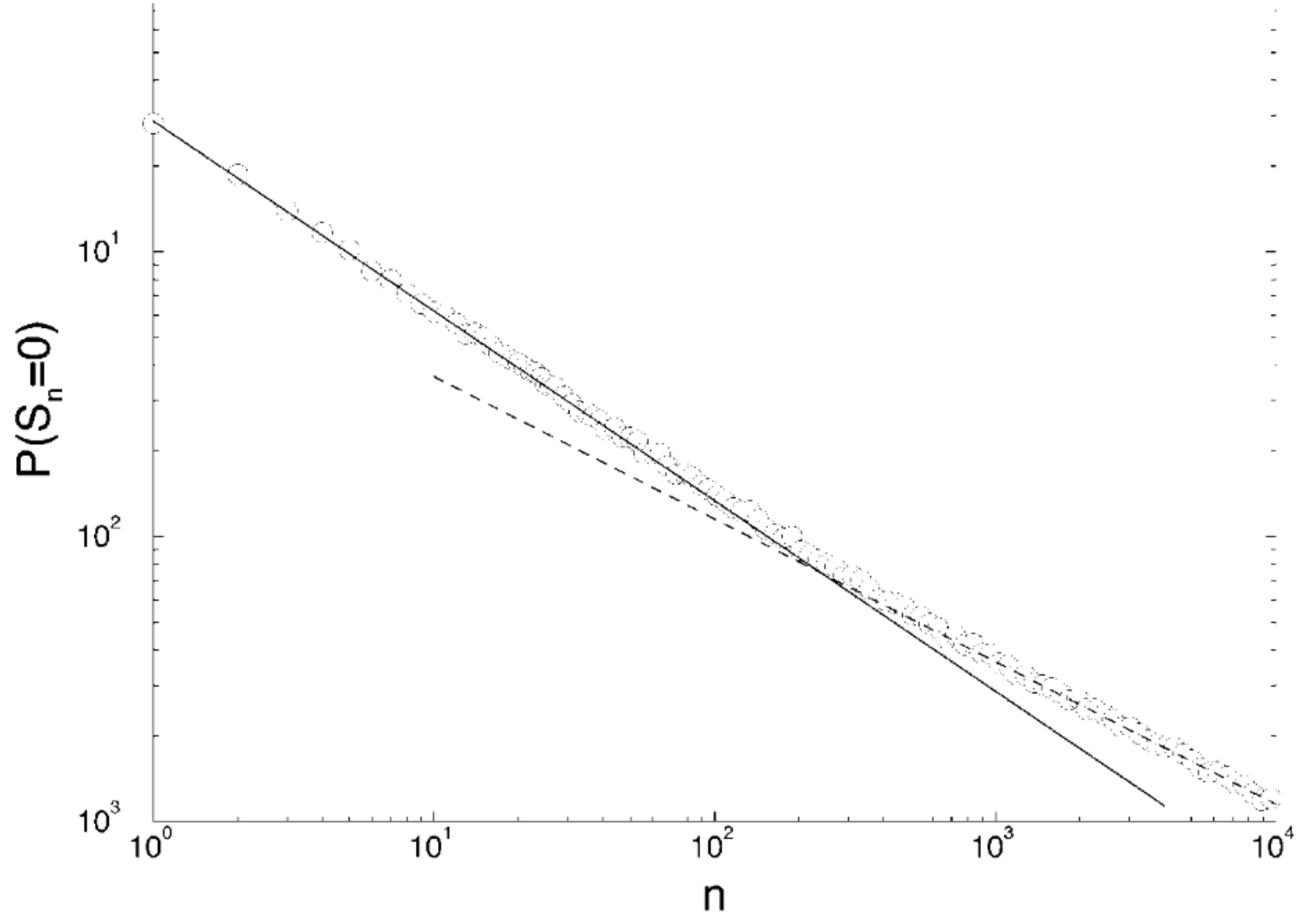

Fig. 8.4. Probability of return to the origin of S_n as a function of n for $\alpha = 1.5$ and $\ell = 100$. The simulations (circles), obtained with 5×10^4 realizations, are compared with the Lévy regime (solid line) and the asymptotic Gaussian regime calculated for $\ell = 100$ (dotted line). Adapted from [114].

[114] R. N. Mantegna and H. N. Stanley, Physics Investigation of Financial Markets *In: The physics of complex systems*. Book issued by IOS Press, (1997) pp. 473-489.

Section 8.4: Truncated Levy Flights (TLF)

Transition from Levy to Gaussian regime. From [114].

Very interesting: effect of truncation dominant for long term.
Similar effects for St. Peterburg Paradox.

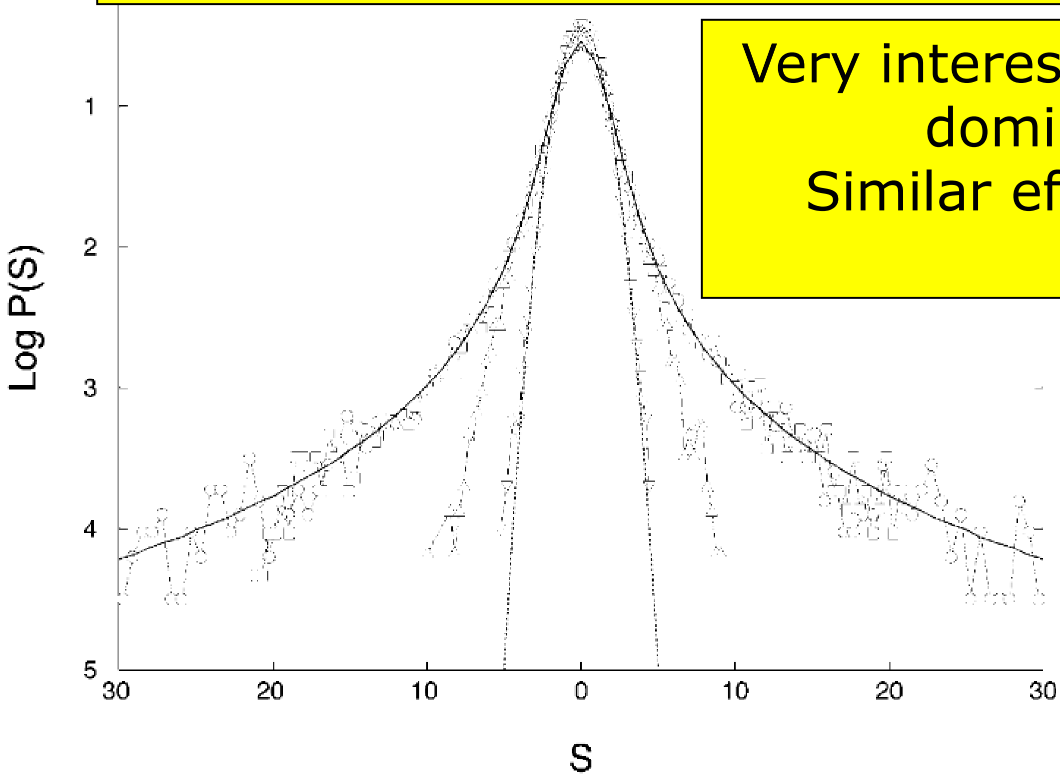

Fig. 8.5. Semi-logarithmic scaled plot of the probability distributions of the TLF process characterized by $\alpha = 1.5$ and $\ell = 100$ for $n = 1$, 10, 100, and 1,000. For low values of n ($n = 1$ (circles) and 10 (squares)) the central part of the distributions is well described by the Lévy stable symmetrical profile associated with $\alpha = 1.5$ and $\gamma = 1$ (solid line). For large values of n ($n = 1{,}000$ (inverted triangles)), the TLF process has already reached the Gaussian regime and the distribution is essentially Gaussian (dotted line). Adapted from [114].

[114] R. N. Mantegna and H. N. Stanley, Physics Investigation of Financial Markets *In: The physics of complex systems*. Book issued by IOS Press, (1997) pp. 473-489.

New references

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Investopedia

New books recommended by T. Novák and by Z. Lakner

Let us restart the study seminar series