Quantum Mechanics_Econophysics

Econophysics is an interdisciplinary research field, applying theories and methods originally developed by physicists in order to solve problems ineconomics, usually those including uncertainty or stochastic processes andnonlinear dynamics. Its application to the study of financial markets has also been termed statistical finance referring to its roots in statistical physics.

History

Physicists' interest in the social sciences is not new; Daniel Bernoulli, as an example, was the originator of utility-based preferences. One of the founders ofneoclassical economic theory, former Yale University Professor of EconomicsIrving Fisher, was originally trained under the renowned Yale physicist, Josiah Willard Gibbs.[1] Likewise, Jan Tinbergen, who won the first Nobel Prize in economics in 1969 for having developed and applied dynamic models for the analysis of economic processes, studied physics with Paul Ehrenfest at Leiden University.

Econophysics was started in the mid-1990s by several physicists working in the subfield of statistical mechanics. Unsatisfied with the traditional explanations and approaches of economists – which usually prioritized simplified approaches for the sake of soluble theoretical models over agreement with empirical data – they applied tools and methods from physics, first to try to match financial data sets, and then to explain more general economic phenomena.

One driving force behind econophysics arising at this time was the sudden availability of large amounts of financial data, starting in the 1980s. It became apparent that traditional methods of analysis were insufficient – standard economic methods dealt with homogeneous agents and equilibrium, while many of the more interesting phenomena in financial markets fundamentally depended on heterogeneous agents and far-from-equilibrium situations.

The term "econophysics" was coined by H. Eugene Stanley, to describe the large number of papers written by physicists in the problems of (stock and other) markets, in a conference on statistical physics in Kolkata (erstwhile Calcutta) in 1995 and first appeared in its proceedings publication in Physica A 1996.[2][3] The inaugural meeting on Econophysics was organised 1998 in Budapest by János Kertész and Imre Kondor.

Currently, the almost regular meeting series on the topic include: APFA, ECONOPHYS-KOLKATA,[4] Econophysics Colloquium, ESHIA/ WEHIA.

In recent years network science, heavily reliant on analogies from statistical mechanics, has been applied to the study of productive systems. That is the case with the works done at the Santa Fe Institute in European Funded Research Projects as Forecasting Financial Crises and the Harvard-MIT Observatory of Economic Complexity

If "econophysics" is taken to denote the principle of applying statistical mechanics to economic analysis, as opposed to a particular literature or network, priority of innovation is probably due to Emmanuel Farjoun and Moshé Machover (1983). Their book *Laws of Chaos: A Probabilistic Approach to Political Economy*proposes *dis*solving (their words) the transformation problem in Marx's political economy by re-conceptualising the relevant quantities as random variables.[5]

If, on the other side, "econophysics" is taken to denote the application of physics to economics, one can already consider the works of Léon Walras and Vilfredo Pareto as part of it. Indeed, as shown by Ingrao and Israel, general equilibrium theory in economics is based on the physical concept of mechanical equilibrium.

Econophysics has nothing to do with the "physical quantities approach" to economics, advocated by Ian Steedman and others associated with Neo-Ricardianism. Notable econophysicists are Jean-Philippe Bouchaud, Bikas K Chakrabarti, J. Doyne Farmer, Dirk Helbing, János Kertész, Matteo Marsili, Joseph L. McCauley, Enrico Scalas, Didier Sornette, H. Eugene Stanley, Victor Yakovenko and Yi-Cheng Zhang. Particularly noteworthy among the formal courses on Econophysics is the one offered by the Physics Department of the Leiden University,[6] from where the first Nobel-laureate in economics Jan Tinbergencame.

Basic tools

Basic tools of econophysics are probabilistic and statistical methods often taken from statistical physics.

Physics models that have been applied in economics include the kinetic theory of gas (called the Kinetic exchange models of markets [7]), percolation models,chaotic models developed to study cardiac arrest, and models with self-organizing criticality as well as other models developed for earthquake prediction.[8] Moreover, there have been attempts to use the mathematical theory of complexity and information theory, as developed by many scientists among whom are Murray Gell-Mann and Claude E. Shannon, respectively.

Since economic phenomena are the result of the interaction among many heterogeneous agents, there is an analogy with statistical mechanics, where many particles interact; but it must be taken into account that the properties of human beings and particles significantly differ.

Another good example is random matrix theory, which can be used to identify the noise in financial correlation matrices. It has been shown that this technique can significantly improve the performance of portfolios, e.g., in applied in portfolio optimization.[9] Thus, this practice is commonly encountered in the praxis of quantitative finance.

There are, however, various other tools from physics that have so far been used with mixed success, such as fluid dynamics, classical mechanics and quantum mechanics (including so-called classical economy, quantum economy andquantum finance), and the path integral formulation of statistical mechanics.

The concept of economic complexity index, introduced by the Harvard economistRicardo Hausmann and the MIT physicist Cesar Hidalgo, has been further developed at the Harvard-MIT Observatory of Economic Complexity, has been devised as a predictive tool for economic growth. According to the estimates of Hausmann and Hidalgo, the ECI is far more accurate in predicting GDP growth than the traditional governance measures of the World Bank.[10]

There are also analogies between finance theory and diffusion theory. For instance, the Black-Scholes equation for option pricing is a diffusion-advectionequation (see however [11][12] for a critique of the Black-Scholes methodology).

Influence

Papers on econophysics have been published primarily in journals devoted to physics and statistical mechanics, rather than in leading economics journals.Mainstream economists have generally been unimpressed by this work.[13] SomeHeterodox economists, including Mauro Gallegati, Steve Keen and Paul Ormerod, have shown more interest, but also criticized trends in econophysics.

In contrast, econophysics is having some impact on the more applied field ofquantitative finance, whose scope and aims significantly differ from those of economic theory. Various econophysicists have introduced models for price fluctuations in financial markets or original points of view on established models.[11][14] Also several scaling laws have been found in various economic data.[15][16][17]

Main results

Presently, the main results of econophysics comprise the explanation of the "fat tails" in the distribution of many kinds of financial data as a universal self-similarscaling property (i.e. scale invariant over many orders of magnitude in the data),[18] 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 neglegible 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". [19] 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. [19] The "fat tails" are also observed incommodity markets.

As in quantum field theory the "fat tails" can only be obtained by complicated "nonperturbative" methods, mainly by numerical ones, since they contain the deviations from the usual Gaussian approximations, e.g. the Black-Scholes theory.

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(1995), however the "fat tails"- phenomenon itself was discovered already earlier by economists.

19. ^ a b See for example Preis, Mantegna, 2003.

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