

Timeline of Econophysics

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I. DEVELOPMENTS UP TO 2000

1931: M. N. Saha & B. N. Srivastava in their textbook “A Treatise on Heat” [Indian Press, Allahabad (1931), pp. 104-105], in the section on Maxwell-Boltzmann velocity distribution in ideal gases, suggested the use of statistical physics to explain the (assumed) Gamma-like income/wealth distribution in any country. (see Fig. 1, where two pages from the section are reproduced). M. N. Saha published several articles on scientific study of social problems in his founded and edited journal Science & Culture [see, e.g., B. K. Chakrabarti, “Econophysics as Conceived by Meghnad Saha”, Science & Culture, Vol. 84 (2018), pp. 365-369] and was the founder of Saha Institute of Nuclear Physics, Kolkata (named after his death).

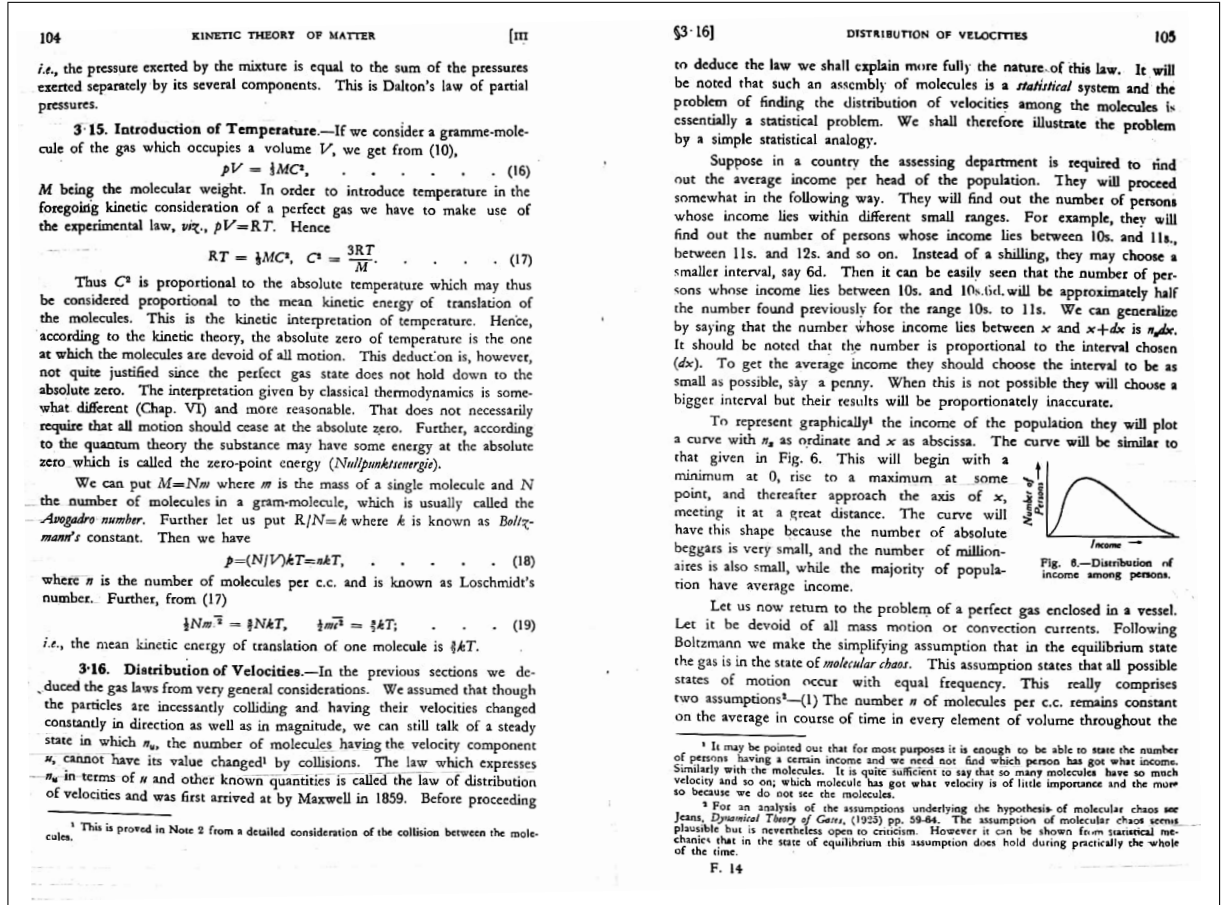


FIG. 1: Image of the pages 104 and 105 of the book “A Treatise on Heat” (1931) by Saha and Srivastava.

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The number density of particles $P(\epsilon)$ having energy between ϵ to $\epsilon + d\epsilon$ is given by $P(\epsilon)d\epsilon = g(\epsilon)f(\epsilon)d\epsilon$. In three dimension momentum counting gives the density of states $g(\epsilon) \sim \sqrt{\epsilon}$. Energy conservation during the scattering process suggests $f(\epsilon_1)f(\epsilon_2) = f(\epsilon_1 + \epsilon_2)$ for arbitrary values of ϵ_1, ϵ_2 . This leads to the energy distribution $f(\epsilon) \sim \exp(-\epsilon/\Delta)$; Δ is a constant. Together these lead to $P(\epsilon) \sim \sqrt{\epsilon} \exp(-\epsilon/\Delta)$. In a market where each two-agent (two-body) trade/scattering keeps total money conserved the money distribution should also satisfy $f(m_1)f(m_2) = f(m_1 + m_2)$, leading to $f(m) \sim \exp(-m/\delta)$, where δ is constant. In absence of any momentum equivalent, the $g(m)$ is constant here, leading $P(m)$ to be an exponentially decaying function. Saha and Srivastava (1935) asked students to think how this exponential $P(m)$ becomes more like Gamma distribution.

1942: E. Majorana wrote a detailed Note emphasizing on “The Value of Statistical Laws in Physics & in Social Science”, published in 1942 after he went missing in 1938 [translated in to English in 2005, from Italian, by R. N. Mantegna, published in Quantitative Finance, Vol. 5, p. 135-140 (2005); see also R. N. Mantegna, in Proceedings of the XXXIII Congress of the Italian Society for the History of Physics and Astronomy (SISFA 2013); <https://arxiv.org/pdf/1409.0789> and T. Gianfranco, “From Galileo to Modern Economics: The Italian Origins of Econophysics”, Palgrave Macmillan, (2018)].

1960: B. Mandelbrot published “The Pareto-Levy Law & the Distribution of Income”, International Economic Review, Vol. 1 (1960), pp. 79-106, arguing for statistical mechanical modelling of markets.

1963: B. Mandelbrot published “The Variation of Certain Speculative Prices”, Journal of Business, Vol. 36 (1963), pp. 394-419, indicating the failure of the Random walk statistics in capturing the Stock price fluctuations.

1971: L. P. Kadanoff published the paper “From Simulation Model to Public Policy: An Examination of Forrester’s “Urban Dynamics””, Transactions of the Society for Computer Simulation, Vol. 16 (1971), pp. 261-268, arguing for statistical physical analysis of social dynamics.

1974: E. W. Montroll & W. W. Badger published the book titled “Introduction to Quantitative Aspects of Social Phenomena”, Gordon and Breach, Washington (1974). Later, E. W. Montroll also published “On the Dynamics & Evolution of Some Sociotechnical Systems”, Bulletin of the American Mathematical Society, Vol. 16 (1987), pp. 1-46, again emphasizing the importance of statistical physics in modelling of social dynamics.

1995: B. K. Chakrabarti & S. Marjit published “Self- Organization & Complexity in Simple Model Systems: Game of Life & Economics”, Indian Journal of Physics B, Vol. 69 (1995), pp. 681-698, discussing in particular the classical (and quantum-like) statistical mechanics of market models and the consequent nature of income or wealth distributions [this paper being the first Indian one with both physicist and economist coauthors]. H. E. Stanley coined the term ‘Econophysics’ in the Statphys-Kolkata II Conference 1995 [Series initiated by the Saha Institute of Nuclear Physics & S. N. Bose National Centre for Basic Sciences; X-th Conference held in 2019] and published (see Fig. 2) in its Proceedings [H. E. Stanley et al., “Anomalous Fluctuations in the Dynamics of Complex Systems: From DNA & Physiology to Econophysics”, Physica A: Statistical Mechanics and its Applications, Vol. 224 (1996), pp. 302-321].

1999: R. Mantegna & H. E. Stanley published “Scaling Behaviour in the Dynamics of an Economic Index”, Nature, Vol. 376 (1999), pp. 46-49. Also, R. Mantegna & H. E. Stanley “An Introduction to Econophysics”, Cambridge University Press, Cambridge (1999).

2000: A. Dragulescu & V. M. Yakovenko published “Statistical Mechanics of Money”, European Physical Journal B, Vol. 17 (2000), pp. 723-729; A. Chakraborti and B. K. Chakrabarti published “Statistical Mechanics of Money: How Saving Propensity Affects its Distribution” European Physics Journal B, Vol. 17 (2000), pp. 167-170; and J.-P. Bouchaud and M. Mzard published “Wealth Condensation in a Simple Model of Economy”, Physica A: Statistical Mechanics and its Applications, Vol. 282 (2000), pp. 536-545. All these three papers employed ideal gas-like model in which each agent is represented by a gas molecule in a trading (modeled as collision) with money (modeled as energy) to investigate the emerging features of income & wealth distributions.

II. DEVELOPMENTS BEYOND 2000

Reviews

2007: A. Chatterjee & B. K. Chakrabarti (2007), “Colloquium: Kinetic Exchange Models for Income & Wealth Distributions”, European Physical Journal B, Vol. 60, pp. 135-149.

2009: V. M. Yakovenko & J. Barkley Rosser Jr. (2009), “Colloquium: Statistical Mechanics of Money, Wealth, and Income”, Reviews of Modern Physics, Vol. 81, pp. 1703-172.

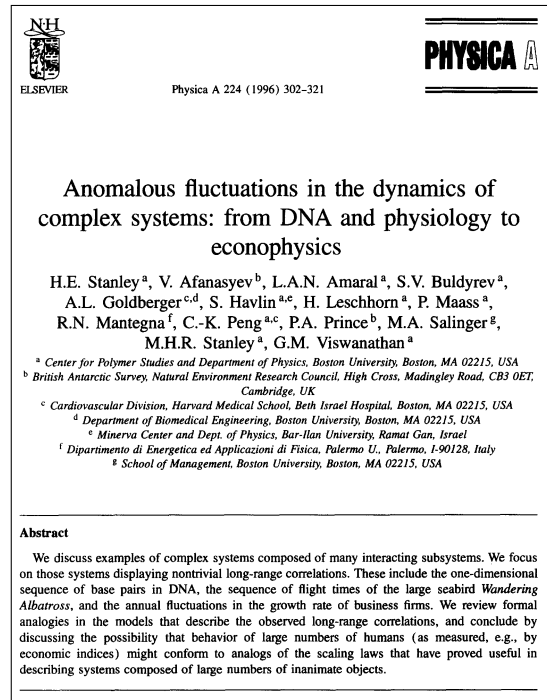


FIG. 2: The title and abstract of the article *Physica A: Statistical Mechanics and its Applications*, Vol. 224 (1996), pp. 302-321.

2011: A. Chakraborti, I. Muni Toke, M. Patriarca & F. Abergel (2011), “Econophysics Review I: Empirical Facts”, *Quantitative Finance*, Vol. 11, pp. 991-1012; “Econophysics Review II: Agent-based Models”, *Quantitative Finance*, Vol. 11, pp. 1013-1041.

Books

2005: D. Challet, M. Marsili & Y.-C. Zhang (2005), *Minority Games*, Oxford University Press, Oxford.

2010: S. Sinha, A. Chatterjee, A. Chakraborti & B. K. Chakrabarti (2010) *Econophysics: An Introduction*, Wiley-VCH, Weinheim.

2013: B. K. Chakrabarti, A. Chakraborti, S. R. Chakravarty & A. Chatterjee (2013), *Econophysics of Income & Wealth Distributions*, Cambridge University Press, Cambridge.

2013: F. Slanina (2013), *Essentials of Econophysics Modelling*, Oxford University Press, Oxford.

2013: P. Richmond, J. Mimkes & S. Hutzler (2013), *Econophysics & Physical Economics*, Oxford University Press, Oxford.

2014: Pareschi & Toscani (2014), *Interacting Multiagent Systems*, Oxford Univ. Press, Oxford.

2016: M. Shubik & E. Smith (2016), *The Guidance of an Enterprise Economy*, MIT Press, Massachusetts.

2017: H. Aoyama, Y. Fujiwara, Y. Ikeda, H. Iyetomi, W. Souma & H. Yoshikawa (2017), *Macro-Econophysics*, Cambridge University Press, Cambridge.

2017: F. Jovanovic & C. Schinckus (2017), *Econophysics and Financial Economics*, Oxford Univ. Press, New York.

2017: B. K. Chakrabarti, A. Chatterjee, A. Ghosh, S. Mukherjee, & B. Tamir (2017), *Econophysics of the Kolkata Restaurant Problem and Related Games: Classical and Quantum Strategies for Multi-agent, Multi-choice Repetitive Games*, New Economic Windows, Springer, Cham.

Thesis

2018: C. Schinckus (2018), Thesis entitled “When Physics Became Undisciplined: An Essay on Econophysics”, Department of History and Philosophy of Science, University of Cambridge (Freely available online).

Popular Reports and Writings

2002: B. Hayes (2002), “Follow the Money”, American Scientist, Vol. 90, pp. 400-405.

2005: J. Hogan (2005), “Why it is hard to share the wealth?”, New Scientist, 12 March 2005, p. 6.

2007: A. Chatterjee, S. Sinha & B. K. Chakrabarti (2007), “Economic inequality: Is it natural?”, Current Science, Vol. 92 (2007) pp. 1383-1389.

2007: M. Buchanan (2007), “The Socail Atom”, Bloomsbury, New York.

2012: S. Battersby (2012), “Physics of our Finances”, New Scientist, 28 July 2012, p. 41.

2012: S. Sinha & B. K. Chakrabarti (2012), “Econophysics: An Emerging Discipline”, Economic & Political Weekly, Vol. 46 (2012), pp. 44-65.

2019: K. C. Dash (2019), “The Story of Econophysics”, Cambridge Scholars Publishing, Newcastle upon Tyne.

2019: B. M. Boghosian (2019), “Is Inequality Inevitable?”, Scientific American, Vol. 321, pp. 70-77.

In Fig. 3 we show the plot of the yearly citation frequency of the publications which contain the term econophysics.

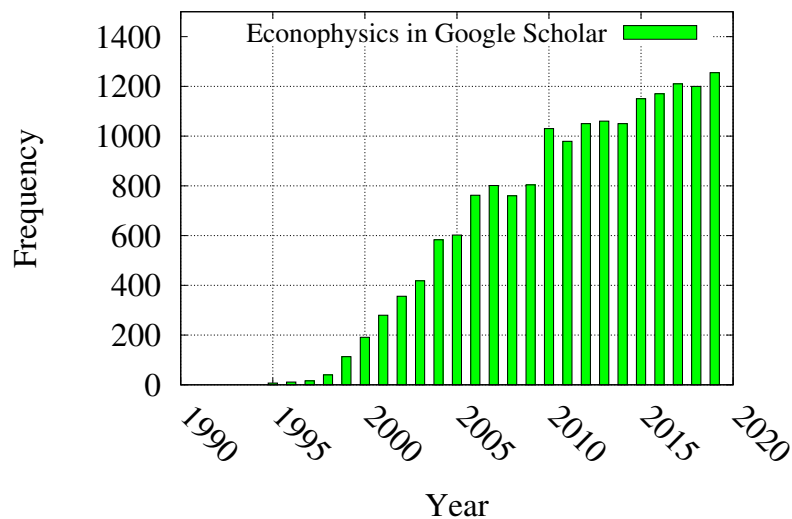


FIG. 3: Histogram plot of numbers of entries per year containing the term econophysics versus the corresponding year. The data are taken from Google Scholar (dated: 31 December, 2019). It may also be noted from Google Scholar that while this 24-year old econophysics has today typical yearly citation frequency of order 1.2×10^3 , more than 100-year old subjects like astrophysics (Meghnad Saha published his ionization equation for solar chromosphere in 1920), biophysics (Karl Pearson coined the term in his 1892 book ‘Grammar of Science’) and geophysics (Issac Newton explained planetary motion, origin of tides, etc in ‘Principia Mathematica’, 1687) today have typical yearly citation frequencies of order 36.6×10^3 , 40.2×10^3 and 45.4×10^3 respectively.