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Where do we stand on econophysics?

Abstract

This issue contains papers selected from the contributions presented at the 5th International Conference on *"Applications of Physics in Financial Analysis"* (APFA5) held in Torino from June 29th to July 1st, 2006 (http://www.polito.it/apfa5). The issue collects recent applications of models and methods of statistical physics to economic problems. This interdisciplinary field of research, known as Econophysics, has seen intensive growth over the last decade. The challenge for econophysicists will be to go beyond the traditional views of economics and physics unifying the separate lines of development followed by the two disciplines over great part of the 20th century.

"*The conventional view serves to protect us from the painful job of thinking*", John Kenneth Galbraith (1908–2006).

Keywords: Social and economic systems; Complex systems; Systems obeying scaling laws

A characteristic feature of the economics was the richness of interaction with natural sciences since its origin. The *Wealth of the Nations*, published by Adam Smith (1723–90), is usually considered to mark the beginning of classical economics. One century later, Adolphe Quetelet (1796–1874) corroborated the idea that physical laws could govern human behavior and also economics. His contemporary philosopher, Auguste Comte (1798–1857), first envisaged the *social physics* as a scientific discipline alongside astrophysics, geophysics and chemical physics. It is not by chance that these concepts raised in an intellectual climate permeated by the Newtonian ideas. The basic assumptions of neoclassical economics span a wide range of applications and concepts (utility maximization, market supply and demand, equilibrium) and are still influential.

The attempt to understand economical phenomena in terms of statistical behavior of individual agents inspired James Clerk Maxwell (1831–79) and Ludwig Boltzmann (1844–1906), that posed the basis for the foundation of statistical mechanics. Hence, several economists, like Alfred Marshall (1842–1924) and Francis Edgeworth (1845–1926), starting from the work of these physicists, elaborated the concept that an economical system could achieve equilibrium like a physical system does.

Fruitful exchanges of ideas between economics and biology also led to important breakthroughs. For instance, the concept of *"invisible hand"* of Adam Smith led Charles Darwin (1809–82) to argue that competition is the hidden force acting behind biological adaptation and natural selection. A further example is the work of Louis Bachelier (1870–1946) that, borrowing from the ideas of the biologist Robert Brown (1773–1858), in 1900 introduced the concept of *random walk* in finance. These are only a few representative examples of the many advances resulted by the dialogue between economics and natural sciences [1–11].

Nonetheless, it is a fact that such skilled interaction came to an almost complete stop around 1930 lasting about up to 1980. Apart from rare exceptions, during these decades economics and social sciences lived isolated from the other disciplines. Several reasons might have caused this seclusion. During the first decades of the 20th century, the theories of relativity and quantum mechanics, the thermodynamics of nonequilibrium and the deterministic chaos revolutionized the physical sciences. The same decades were characterized by a

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huge number of scientific discoveries and technological advances. For example, these were the earliest days of radio; prototype semiconductor devices were designed, leading to the invention of the transistor and ultimately to the electronics revolution of the past century; the first antibiotic was discovered; the DNA was isolated.

The socio-cultural scenario and the geopolitical struggles following from the Second World Conflict might have played a rôle. The development of alternative energy sources, biochemistry and cryptography were considered more strategic and urgent investigation areas than economics and social sciences by the research policy makers. Strong impulses were thus given, for example, to research in particle and solid state physics, in pharmacology, in information communication and in space technology.

The prodigious developments of new physical theories, the discoveries of drugs, the electronic revolution embedded in the war and postwar context might have all together worked in the direction to deviate the interest of physicists and natural scientists far from social sciences. Therefore, while physicists, chemists and biologists were developing tools to investigate relativistic and quantum many-body systems in far from equilibrium conditions, economists continued to parameterize their models of the economy as equilibrium systems whose inhabitants were perfectly informed, rational and unbiased *homines oeconomici* and whose dynamic behavior simply resulted from exogenous sources. According to the conventional view, the *homo oeconomicus* is the agent making complicated deductive calculations, taking unbiased decisions always perfectly and completely informed. In a few words, he is *rational*.

Meanwhile, natural scientists theorized the existence of *complex adaptive systems* in the 1970s. Such systems are constituted by many parts whose microscopic interactions determine the emergence of macroscopic patterns of behavior. The relevant difference between a traditional dynamical system and *complex adaptive system* is that, in the latter, the dynamic behavior is *self-generated* as a result of the internal structure through the microscopic dynamic of the single agents. In the last decades of 20th century, a pioneering fringe of economists began thus to experiment with models of economic phenomena that were radically different from traditional ones [12–16]. Rational agents were recognized as a platonic oversimplified idealization of economic humankind. Elementary *agents* having the ability to exchange information, learning and adapting their behavior, thus started their migration from physics to populate economical systems. The introduction of the concept of *complex adaptive system*—where the macroscopic behavior *emerges* from the microscopic interactions—implies a literal revolution in the socio-economical thought: the *microeconomics* and *macroeconomics*, traditionally considered as separate disciplines, are intimately related according to the new economic views.

The increasing awareness of the inadequacy of the traditional methods of analysis has stimulated need for confrontation and interest towards the new paradigms of thought even within the most traditional and conservative fringes of the economical and physical disciplines. New views and approaches are being tested and established allowing for interdisciplinary models of the economical human behavior, having as common denominator the fundamental dissatisfaction with rational agents and equilibrium [17–23]. Consequently, new disciplines as *Econophysics, Behavioral Economics, Evolutionary Economics, Neuroeconomics* were born and are growing within the most traditional schools of thought [24–26]. The affirmation of these ideas is an unequivocal signal of the need to go beyond the limits of the neoclassical economics using concepts, methods and tools matured in different scientific contexts. In this scenario, the *Econophysics* is intended as an interdisciplinary research field applying theories and methods originally developed by statistical physicists to solve problems in economics. Its scholars apply concepts and models such as scaling, universality, phase transitions and percolation to explain the features of the stock market and socio-economic systems as well as self-organized criticality to describe emergent phenomena in aggregate behaviors. In addition to the traditional economic notions of coordination via the price system, models of collective phenomena are now making their appearance in many branches of economics. One peculiar driving force of this new discipline arises from the huge amounts of available data significantly contributing to the foundation of an *experimental complexity economics*. New models of growth are tested against real data. The analysis of time series, distributions of asset prices and price returns with attendant phenomena, such as scaling and universality, is leading to radically new insights.

The official birth of the name *Econophysics* can be dated to the appearance of this term in a paper published in this journal in 1996 [27]. In the past decades, an increasing interest has flourished around this new discipline as confirmed by the huge number of papers published in leading international journals of physics and economics. A significant index of the attention and curiosity of the scientific community towards the *Econophysics* is the number of papers having this discipline itself as their main purpose [28–35]. Both economists and physicists, active in this new area of research, are trying to unravel mission and challenge, limits and potentialities of the new discipline.

The first Conferences on Econophysics were organized in 1997 (*International Workshop on Econophysics*, Budapest, 21–27 July 1997) and in 1998 (*International Workshop on Econophysics and Statistical Finance* Palermo, 28–30 September 1998), whose proceedings were published in Refs. [36,37]. The first officially recognized Conference by a professional society on *Econophysics*, the International Conference on *''Application of Physics in Financial Analysis''* (APFA), was held in Dublin, 15–17 July 1999. The positive feedback, the richness of results and the increasing interest of the next editions, organized in Liege (2001), London (2002) and Warsaw (2003), are well documented by the works collected in Refs. [38–41]. The 5th edition has been held in Torino from 29th June to 1st July, 2006. Over 160 participants coming from 30 different countries attended the meeting. There were 120 presentations: 30 invited plenary talks, 45 contributed talks in two parallel sessions, 45 posters. A panel and many informal discussions have given strong impulse to the reinforcement of existing ties and to the creation of new ones among economists and physicists, addressing future directions of scientific thought in this field.

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