IJASRM
International Journal of Advanced Scientific Research and Management, Volume 3 Issue 10, Oct 2018
www.ijasrm.com
ISSN 2455-6378

The Past and Future Trends of Econophysics

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Abstract

The historical development of econophysics as an interdisciplinary field of study is discussed briefly with a note that there should be a paradigm shift to the approach of econophysics in order to formulate a new set of laws in physics for social sciences that may go beyond the limit of the Copenhagen interpretation of quantum mechanics. Complex systems that seem unpredictable have been understood by breaking the complex system into simpler ones with the methods and laws established in science. The same concept may be utilized to solve the complex problems of econophysics.

Keywords: *Economics; Econophysics; Physics; Quantum Mechanics; Social Science*

1. Introduction

Education was interdisciplinary in nature before the advent of formal education. The concept of different field of studies and subjects evolved with the advancement of formal education. The division of knowledge into various specialized subjects has made our studies more systematic and comprehensive which made a rapid progress in enhancing human's knowledge. There was a time when it was considered more as a taboo for scholars to intrude into another field of studies. This trend led to stagnation of various discoveries and inventions that were vital to mankind. As scholars have become more aware of these facts in the last few decades, there is now a reverse process of embracing back the interdisciplinary approach to various fields of studies. This can be understood more extensively from the field of studies where scientist have started a multidisciplinary approach in the studies of various crucial issues like cancer, acquired immune deficiency syndrome(AIDS), climate change etc. The same is true for econophysics.

Physics can be utilized as a proper tool for investigating questions posed by various field of studies ranging from social science to commerce and management. The interactions between the sub-systems in a complex system are not neglected in physics which is very important to understand the fundamental rules governing a system. This concept can be applied for the study of complex systems in econophysics which involves the interaction between physical and social sciences.

2. What is Econophysics?

Conventionally, econophysics is an emerging inter disciplinary field of study to investigate the problems of economics by applying the theories and methods of physics (Mantegna R. N. and Stanley E. H., 2004). In the contemporary world, econophysics should be an interdisciplinary field of study where economists study the theories of economics by using physics as a tool. Similarly, econophysics should be just an interdisciplinary field of study where physicist studies economics as a subject by using the methods and theories of physics but econophysics should be a branch where the field of economics can be considered as a way to formulate more universal laws in physics that go beyond the boundary of conventional physics. Econophysics should be a subject to investigate the existence of a relationship between the physical laws of with social science.

3. Econophysics: The Past

The field of formal econophysics was developed a little more than two decades back. It is understood from the historical development of econophysics that the subject evolved due to the interest shown by physicist more than the economist.

In the past, there has been a lot of debate whether there can be physics laws of social sciences. In other words, the scholars were divided on the issue of a general law in social science as formulated in physics. The social sciences were considered to be lagging behind the physical science due to its inability to formulate a universal law. There has been discussion to consider economics as an empirical

science (Leontief W., 1993).With the inputs of modern science and technology, the world progressed rapidly with the explosion of knowledge and wealth. The market started blooming with the heavy increase in volume of trade and commerce. The financial market expanded by leap and bounds which increases the chances of more unpredictability in stock and share market.

The conventional subject of economics became handicapped in many ways to handle the huge flow of data with the abrupt jump in quantity and complexity of the economic sector. The traditional concept that social science deals only with the external manifestations of human behavior and can be evaluated only up to a certain extend in the form of an empirical science based on experience made it more difficult to intrude into the conventional field of economics by deploying the tools of physics in solving the problems of economics. The majority of the concerned scholars were made to believe that the inner psychological experiences and events of humans cannot be observed directly and often tend to ignore the inner subjective experience of human beings. A particular section of scholars were partly reluctant to accommodate the use of the established laws and methods of physics as a tool to evaluate the problems faced in economics as they feel that most of the physical laws do not incorporate the inner psychological feelings of human beings.

However, some of the scholars were of the view that statistical finance has its root in statistical physics and statistics. The established laws and methods of physics were employed for the development of neoclassical economic theory. Eugene Stanley in mid 1990s (Mantegna R. N. and Stanley E. H., 2000) attempted to describe the application of the methods and laws of physics in economics as 'econophysics'. There were instances when physicist tried to explain problems of stocks, shares and financial transactions of markets with the use of physical laws and statistical physics. A conference on statistical physics at Calcutta (1995) in the above cited topics and its subsequent publications made an impact on the realization of econophysics as a specialized field of study. The meeting on econophysics was initially arranged at Budapest by Janos Kertesz and Imre Kondor in the year 1998. The Saha Institute of Nuclear Physics, Kolkata is one of the pioneering institutes in the world to study econophysics as a formal research subject. It then gradually started in different universities and Institutes around the whole world.

The studies on 'econophysics' have started even before the term was coined. In the pre classical era, there was no boundary between different subjects and the scientist was free to propagate their ideas without the limit and boundary of distinct subject. Thus, there was always a blend of physics and economics in the pre classical era. The classical era was a period that gives birth into many branches of studies but the philosophers were liberal to intrude into any subjects or topic. For instance, Nicole Oresme (1320-1382) worked in all topics including economics, mathematics, physics, astronomy, philosophy and theology. Isaac Newton (1642-1727) was a noted physicist but contributed a good amount of time in economics. James Dodson (1705 -1757) tried to apply mathematics and statistical methods in the field of insurance and finance. Daniel Bernoulli (1687- 1759) said that the 'betting preference' in any kind of gambling can be expressed as a function of its payout, risk aversion, utility factor and personal preference. This theory is termed as the 'theory of utility'. François Quesnay (1694 -1774) tried to explain the economic circulation with the help of blood circulation in human body. Simon Laplace (1749 -1827) came with the idea that the so called random and unpredictable events obey simple rules and are actually predictable. Lambert Adolphe Quetelet (1796 -1874) started using statistical methods to the social sciences. Comte (1798 – 1857) classified various branch of studies and introduced the concept of interdisciplinary studies like socio-physics, geophysics, biophysics etc. Augustin cournot (1801-1877) introduced the theories on monopolies and duopolies along with the concept of modern economic analysis. Jules Regnault (1834-1894) used the idea of random quantum walk and statistical method to explain the complexity of the stock market. The work of Josiah Willard Gibbs (1839 - 1903) in statistical mechanics influenced many future scientists working in econophysics. Alfred Marshall (1842 -1924) formulation of new economic theories like the marginal utility law and diminishing returns law supplemented the ideas of combining statistical physics and statistical methods with economics. Louis Bachelier (1870 -1946) in his thesis described stock market with the help of Brownian motion giving birth to the concept of stochastic process in the study of economics. The idea of time series analysis in economics by George Udny Yule (1871 -1951) and the Yule process help the growth of econophysics. Scientists like Osborne, Mantegna R. N. and William Smith used the Albert Einstein's (1879 -1955) work on Brownian motion (Einstein A, 1905) to evaluate various issues in economics. Meghnad Saha (1893- 1956) suggested to classify the income distribution in societies with the help of Maxwell Boltzmann velocity distribution of an ideal gas. Scholars like Clausius, William Stanley Jevons, Vilfredo Pareto, Jan Tinbergen, Ettore Majorana, Tjalling Charles Koopmans and Paul Anthony Samuelson also work in topics related with econophysics. Jan Tinbergen got his Ph.D in Statistical physics from Leiden University and afterwards won the first Nobel Prize in Economics in 1969 for his work on dynamic models of economic processes. The deviation from the Gaussian statistics (Bikas K. Chakrabarti,2010) have been understood

more precisely with the works initiated by Mandelbrot B. B.(1963), Fama E. F. (1965), Mantegna R. N. and Stanley E. H. (2004), Bouchaud J. P. (2008), Farmers J. D. (1997) and others in mid 1990s. This is discussed by Bikas K. Chakrabarti et al. (2010) in his research work. Network models, characterization of market correlations and complex business networks (Aoyama H., 2010) have been studied extensively by many scholars. Chatterjee A. et al., (2007) explained that the concept of Gibbs distribution of energy in an ideal gas can be used for analyzing the income and wealth distribution in various societies.

With the recognition of econophysics as an interdisciplinary subject, many universities across the globe have started studies related with econophysics. Universities and Institutes like Leiden University, Saha Institute of Nuclear Physics, University of Houston, Calcutta University, Boston University, University of Paris, University of Silesia, University of Wroclaw, Tata Institute of Fundamental Research Mumbai, Santa Fe Institute, Kyoto University, Delhi University, Ecole Centrale Paris, University of Maryland, Indian Institute of Management Kozhikode, University of Palermo etc. are some of the institutes that are involved in research activities related with econophysics or offers econophysics in their curriculum.

4. The Future Trends in Econophysics

Scholars from various fields are now trying to work on the field of econophysics. There are now specialized institutes or centers that are trying to promote interaction of natural science and social science. Many reputed Institutes and Universities are involved in research work of econophysics. However, the actual breakthrough in econophysics may take place only when certain fundamental issues are addressed properly.

Classical economics are basically built on strong assumptions which may not be always true for all conditions, as it deals with the behavior of human beings. The behaviors and the nature of decisions made by humans are not always static and have ample chances to vary from person to person. These unpredictable events make the study of economics related with the human nature more difficult in applying the physical laws that are established without any emotional attachments. There is still little framework in classical economics to comprehend the extremeness of a wild market. But the past experience shows us that problems that seem to be random are actually predictable. A new set of ideas that can change the fundamental relationship of social science with physical laws should be initiated in order to incorporate social science into the realms of the laws of physical and natural science. The natural and physical science should be related fundamentally with the social sciences.

The chaotic behavior in dynamical systems, studies on self-organized criticality, cellular automata and neural network should be implemented as economic tools to solve the mystery of economics. The chaos theory teaches us that unpredictable time series can arise from deterministic nonlinear system (Mantegna R. N. and Stanley E. H., 2000).The non linear dynamics can be applied for a chaotic market in economics (Sharma B. G. et al., 2009). The time evolution of asset price in economics may be related to non linear deterministic dynamics in the near future with the help of biological and physical systems. The chaos theories in physics have to be utilized to answer the long pending questions in economics.

Statistical Physics may be applied to describe the potential moves in financial markets, derivative pricing and risk control. The processing of data on financial markets can open the path to new methodologies where systematic comparison between theories and real data will become possible (Bouchad J. P. and Potters M., 2000).The tools of statistical physics and non linear dynamics will be useful to understand the dynamical behavior of the economic market that consists of a large number of agents interacting non linearly and will replace the static assumptions of the conventional approach of the classical economics (Sharma B. G.,2012).The multi scale entropy analysis can be applied in economic (Sharma B. G.,2010). The concept of scaling, universality disordered frustrated systems and self organized systems will help in the modeling of economic systems. There will be statistical characterization of the stochastic process in the field of economics. The studies on the stochastic nature of biochemical reactions in a cell will make events more predictable and will help in the growth of econophysics. Capital allocation model equivalent to the standard model in population biology will help us to understand more accurately the internal dynamics of the markets that leads to excess volatility (Farmer J. D., 1997). The detrended fluctuation analysis used for the detection of long range autocorrelations in time-series can be further extended for various business studies (Balgopal Sharma, 2010).

5. Conclusion

There has been debate on whether econophysics should be dealt by physicist or economist. There have been issues raised by certain economist about the inability of the law of physics to solve the problems of economics. We should not be confined to the past schools of thoughts where interdisciplinary approach was very rare. Rather, we should consider this as a challenge where the

problems in economics are not only solved by the use of the laws of physics but more general theories are developed in physics by traversing beyond the boundary of conventional physical laws.

The progress of science lies on the simple fact that the scientists were able to find the fundamental rules governing a complex process. A real system will appear apparently like a complex quantity until science is able to decompose into simpler components. Statistical patterns of large populations should be modeled in economics as done with the ideal gases in physics by proper treatment of the concept equations and empirical data (Bouchad J. P., 2008). Buchanan M. (2009) discussed about empirical research done in the study of economics. There should be proper scientific coordination between economist and physicist. The physicist should try to learn the essence of the progress of economics based on the classical theory of economics which actually implies that theories can be evolved with proper assumptions as the subject dwells more with the behavior of human beings. The physicist need to be convinced that there might underlay a science behind the classical theory of economics which science is not able to explain at this particular stage and juncture. Likewise, economist needs to learn from the past success of physicist who were able to transcend from classical to quantum physics and likewise, from non relativistic to relativistic physics. The social science should collaborate with physics to go beyond the boundary of conventional quantum mechanics in formulating a new physics law of social sciences that may fundamentally deviate from the Copenhagen interpretation of quantum mechanics.

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