International Centre for Social Complexity, Econophysics & Sociophysics Studies: A Proposal

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Abstract: In the concluding session of the Joint International Conference titled ‘Econophys-2017 & Asia Pacific Econophysics Conference (APEC)-2017’, held in Jawaharlal Nehru University and Delhi University during November 15-18, 2017, a brief version of this Proposal was presented. Several important and enthusiastic comments were received from the participants. This note is based on these comments and discussions.

1. Introduction

More than twenty years have passed since the formal coining of the term and hence the launch of econophysics as a research topic (since 1995; see the entry by Barkley Rosser on Econophysics in ‘The New Palgrave Dictionary of Economics’ [1]: “Econophysics: According to Bikas Chakrabarti (2005), the term ‘econophysics’ was neologized in 1995 at the second Statphys-Kolkata conference in Kolkata (formerly Calcutta, India) by the physicist H. Eugene Stanley ...”). Soon, econophysics had been assigned the Physics and Astronomy Classification Scheme (PACS) number 89.65Gh by the American Institute of Physics. According to Google Scholar, typically today more than thousand papers and documents, containing the term ‘econophysics’, are published each year (many more research papers are, in fact, published today on the topic without ever calling it econophysics) in almost all physics journals covering statistical physics, general science journals and a few economics journals. More than fifteen books on econophysics (with the word econophysics in the title of the book), including some textbooks and monographs written by pioneers and active researchers in the field, have al-
already been published by Cambridge University Press, Oxford University Press, Springer and Wiley. Many more edited books and conference proceedings are published (search of ‘econophysics’ titles in the ‘amazon.com:books’ today gives more than 140 entries; with some double counting of course!). Similar has been the story for ‘sociophysics’.

Regular interactions and collaborations between the communities of natural scientists and social scientists, however, are rare even today! Though, as mentioned already, interdisciplinary research papers on econophysics and sociophysics are regularly being published at a steady and healthy rate, and a number of universities (including Universities of Bern, Leiden, London, Paris and Tufts University) are offering the interdisciplinary courses on econophysics and sociophysics, not many clearly designated professor positions, or other faculty positions for that matter, are available yet (except for econophysics in Universities of Leiden and London). Neither there are designated institutions on these interdisciplinary fields, nor separate departments or centres of studies for instance. We note however, happily in passing, a recently published highly acclaimed (‘landmark’ and ‘masterful’) economics book [2] by Martin Shubik (Seymour Knox Professor Emeritus of Mathematical Institutional Economics, Yale University) and Eric Smith (Santa Fe Institute) discusses extensively on econophysics approaches and in general on the potential of interdisciplinary researches inspired by the developments in natural sciences. Indeed, this massive 580-page book can also serve as an outstanding ‘white-paper’ document in favor of our intended Proposal.

Though the inter-disciplinary interactions have not grown much, some sure signs of positive impact for the research achievements in econophysics and sociophysics have been documented in the literature. The precise characterizations of stock market fluctuations by Mantegna and Stanley [3] has already made a decisive mark in financial economics and all the related subjects (with more than 4000 citations already for the book [3]; Google scholar). In the section on ‘The position of econophysics in the disciplinary space’ in the book ‘Econophysics and Financial Economics’ [4], the authors write (pp. 83, 178): “To analyze the position of econophysics in the disciplinary space, the most influential authors in econophysics were identified. Then their papers in the literature were tracked by using the Web of Science database of Thomson-Reuters ... The sample is composed of Eugene Stanley, Rosario Mantegna, Joseph McCauley, Jean Philippe Bouchaud, Mauro Gallegati, Benoît Mandelbrot, Didier Sornette, Thomas Lux, Bikas Chakrabarti, and Doyne Farmer.” The book [2] by Shubik and Smith noted (pp. 75-76) that while simple kinetic exchange market model (see e.g., [5]) leads
to exponentially decaying distributions, “it was shown in [6] that uniform saving propensity of the agents constrains the entropy maximizing dynamics in such a way that the distribution becomes gamma-like, while (quenched) nonuniform saving propensity of the agents leads to a steady state distribution with a Pareto-like power-law tail [7]. A detailed discussions of such steady state distributions for these and related kinetic exchange models is provided in [8]”. Shubik and Smith [2] also noted the important contributions by physicists in the study of multi-agent iterative (and collective) learning game models for efficient resource sharing ([9] for binary choice iterative learning games and [10] for multi-choice iterative learning games1). This book [2] also discusses in details on the impact of the pioneering work by physicist Per Bak and collaborators in the context of self-organizing dynamics of complex markets. The Econophysics course offered by Diego Garlaschelli in the Physics department of the Leiden University, where the first economics Nobel laureate (statistical physicist Jan Tinbergen) came from, follows exclusively the book ‘Econophysics: An Introduction’ [11] since its inception in 2011 (see e.g., [12] for the 2017-2018 and 2018-2019 e-prospectuses). Discussions on some more impact of econophysics [3, 4, 13, 14] and sociophysics [15-18] researches will be continued later.

2. Proposal in Brief and Some Earlier Attempts

In view of all these, it seems it is time to try for an international centre for in-

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1Important developments have taken place in such many-player, multi-choice iterative learning games for limited resource utilizations, since publication of The Kolkata Paise Restaurant Problem & Resource Utilization, A. S. Chakrabarti, B. K. Chakrabarti, A. Chatterjee and M. Mitra, Physica A, 388, pp. 2420-2426 (2009). For applications to quantum cryptography physics, computer job scheduling, on-line car hire, etc., see e.g., Strategies in Symmetric Quantum Kolkata Restaurant Problem, P. Sharif & H. Heydari, Quantum Theory: Reconsideration of Foundations 6: AIP Conf. Proc. 1508, pp. 492-496 (2012); Econophysics of the Kolkata Restaurant Problem & Related Games; B. K. Chakrabarti, A. Chatterjee, A. Ghosh, S. Mukherjee & B. Tamir, Springer (2017); Econophysics & the Kolkata Paise Restaurant Problem: More is Different, B. Tamir, Science & Culture, 84, pp. 37-47 (2018); The Vehicle for Hire Problem: A Generalized Kolkata Paise Restaurant Problem, L. Martin & P. Karaenke, https://mediatum.ub.tum.de/doc/1437330/1437330.pdf (2018); Kolkata Paise Restaurant Game for Resource Allocation in the Internet of Things, T. Park & W Saad, IEEE Xplore, DOI: 10.1109/ACSSC.2017.8335666, https://ieeexplore.ieee.org/abstract/document/8335666/ (2018)
interdisciplinary studies on complexity in social and natural sciences; specifically on econophysics and sociophysics. The model of the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste (funded by UNESCO and IAEA), could surely be helpful to guide us here. We are contemplating, if an ICTP-type interdisciplinary research institute could be initiated for researches on econophysics and sociophysics (see also [19]).

We note that Dirk Helbing (ETH, Zurich) and colleagues have been trying for an European Union funded ‘Complex Techno-Socio-Economic Analysis Center’ or ‘Economic and Social Observatory’ for the last six years (see Ref. [20] containing the White Papers arguing for the proposed centre). We are also aware that Indian Statistical Institute had taken a decision to initiate a similar centre in India (see ‘Concluding Remarks’ in [21]). Siew Ann Cheong (Nanyang Technological University, Singapore) had tried for a similar Asian Centre in Singapore [22]. In view of some recent enthusiasms at the Japan-India Heads of States or Prime Minister level, and signing of various agreements (predominantly for business deals, infrastructure development, technical science and also cultural exchanges) by them, possibility of an Indo-Japan Centre for studies on Complex Systems is also being explored, including the possibility of a centre in Tokyo with private support [23]. There are several other similar initiatives (e.g., [24]).

These proposals are, or had been, for regular research centres on such interdisciplinary fields, where regular researchers are expected to investigate such systems. In view of the extreme interdisciplinary nature of econophysics and sociophysics, such efforts may be complemented by another visiting centre model.

Unlike the above-mentioned kind of intended centres, this proposed centre may be just a visiting centre where natural and social scientists from different universities and institutions of the world can meet for extended periods to discuss and interact on various interdisciplinary issues and collaborate for such researches, following the original ICTP model. Here, as in ICTP, apart from a few (say, about ten to start-with) promising young researchers on econophysics and sociophysics as permanent faculty who will continue active research and active visiting scientist programs (in physics, economics and sociology) etc. can be pursued, The faculty members, in consultation with the advisers from different countries, can choose the invited visitors and workshops or courses, on economics and sociological complexity issues, can be organized on a regular basis (as for basic theoretical sciences in ICTP or in Newton Centre, Cambridge, etc.). In two short communications [25], Martin Shubik (Yale University, New Haven) supported the idea very enthusiastically and encouraged us with some very precise
suggestions. He also noted that such a centre can play a much more inclusive role for the whole world (as is being done by the ICTP), compared to what the Santa Fe Institute has been successful to do for the US. Gene Stanley (Boston University, Massachusetts) supported enthusiastically such a proposal (“... you already thought of all the ideas I might have had ... I will continue to think ... congratulations on your ambitious idea ... ” [26]).

3. Some Responses Received From the Participants

After my brief presentation of this proposal in the Concluding session of our Conferences, there were several appreciative comments made by the participants and a number of precise suggestions mailed to me later by many participants including Frederic Abergel (Centrale Supelec, Chatenay-Malabry Cedex), Bruce Boghosian (Tufts University, Massachusetts), Anirban Chakraborti (Jawaharlal Nehru University, Delhi), Siew Ann Cheong (Nanyang Technological University, Singapore), Acep Purqon (Institute for Technology, Bandung) and Irena Vodenska (Boston University, Massachusetts). I append below parts of a few detailed comments, summarizing the past achievements and some suggestions for possible structural organisation, received from them:

A) Regarding the “discoveries of important economics and finance phenomena that were unknown to economists and financial economists before, the following few come to my mind:

a) The distribution of wealth and income. While Pareto was the first to examine the tail end of the wealth distribution, and found it to be a power law, little was known and understood about the full distribution until you and Victor Yakovenko came along, to (i) examine empirical distributions of wealth and income [27], and (ii) build kinetic theory/agent-based models to show that the full distribution is an exponential distribution crossing over to a power-law tail [6, 28] and this arise because for rich people, they can gain from return on investment or through interests generated by savings, whereas the rest of us, repeated random exchange of income/wealth shape the exponential part of the distribution. During Econophys APEC 2017, we heard Bruce talking about his further results showing that if wealth is inadequately redistributed through taxation, oligarchs emerge, leading to the most extreme form of wealth inequality that we can possibly imagine [29, 30].

b) Home prices and property bubbles. Following your lead, and more recently
the work by Ohnishi et al. [31], my students and I have started looking into the distribution of home prices around various markets. Interestingly, the equilibrium distribution of home prices is similar to the income/wealth distribution, consisting of an exponential body and a power-law tail [32]. We see this in Singapore, Hong Kong, Taiwan, UK, and Japan so far, and believe this result is universal. We also found that in bubble years, the home price distribution develops dragon kings, which are strong positive deviations from the equilibrium distribution. We have evidence to suggest that such dragon kings are the results of speculation, but have yet to test regulations that can help defuse them in agent-based models that we are currently building. More alarmingly, we have seen from the historical home price data of London and Tokyo that their distributions once contained an exponential body, but after experiencing a couple of property bubbles, have become asymptotic power laws with no exponential body. This is another manifestation of economic inequality, in that for cities like London and Tokyo, homes are priced out of the reach of the middle class. From the historical data for UK, we see this trend repeating itself for cities like Birmingham and Manchester. This calls for action on the part of government, but they cannot act until we understand the processes that drive this trend.

c) Louis Bachelier was the first to propose that stock returns perform Brownian motion, and laid the mathematical foundation for finance. However, for a long time, it has not occurred to financial economists to check the validity of Bachelier’s assumptions. Benoit Mandelbrot did so in 1967, and found that the tail of the return distribution is a power law [33]. Rosario and Gene then demonstrated more convincingly using a large data set of returns for the S&P 500 in their 1995 Nature paper that the return distributions for different time horizons follow a scaling form, and this scaling form can be fitted better to a Levy distribution than to a Gaussian distribution [34]. Since then, many different agent-based models have been developed to explain the emergence of fat tails in the return distribution. More recently, Hideki and Misako Takayasu examined high-frequency order data, and demonstrated convincingly that stock price is an invisible particle performing stochastic motion as a result of it being bombarded on either side by bid and ask orders [35]. For regular Brownian motion, this noise is uncorrelated in time, and therefore we end up with long autocorrelations in the velocity of the Brownian particle. For stock returns, we know from many previous works that they are nearly uncorrelated in time. The Takayasus explained that this is the consequence of the noise being strongly correlated in time, pointing to what they observe in the
order book data. This duality is surprising!

d) Economists Ricardo Hausmann and Cesar Hidalgo became world famous for publishing their Atlas of Economic Complexity [36], visualising the network of international trade over time. Not convinced that the economists have extracted the most important insights from the data, Luciano Pietronero went in to the data set to plot the economic performances of countries on a two-dimensional plot, with capabilities on the x-axis, and GDP on the y-axis [37]. Luciano found that he could classify countries into undeveloped, developing, and developed economies by where they appear on the plot. Undeveloped countries are problematic, and are mostly African, because their GDPs are low, and their capabilities are also low. These countries can potentially be stuck in a poverty trap, because they earn so little that they cannot reinvest into their education system to increase their capabilities. Developing countries like China, India, and Vietnam are countries that have invested heavily into education and are therefore ranked highly in terms of their capabilities. China has already started to benefit from its past investment, to see a steady rise in its GDP. India can be seen to be following suit, and Vietnam will likely take off soon. When Luciano produced such plots using data from different years, he found that the developing countries are in a region where economic trajectories are fairly deterministic, and therefore we can have confidence in the economic futures of India and Vietnam, for example. On the other hand, the undeveloped countries are in a region of the plot where economic trajectories appear to be chaotic and turbulent, where countries can experience periods of enhanced GDP because of exploitation of resources (like Brazil), but can also fall from grace just as quickly because of political turmoil.

In creating this list, I am leaving out interesting results obtained by people working on urban complexity, because they rarely attend econophysics conferences. Besides the most important scaling work done by Geoffrey West and Luis Bettencourt, showing that there are urban variables that scale sub linearly with the size of cities, and other urban variables (like GDP, patents, crime, etc.) that scale super linearly with size [38]. Hyejin Youn and her collaborators have also found that cities are not equally diverse in terms of job opportunities [39]. Small cities tend to have fewer types of jobs, and more people working on the same type of jobs. Large cities tend to have more types of jobs, and fewer people working on each type of job. More importantly, they have discovered that wealth is unequally concentrated in large cities, and that large cities tend to have a better educated populace, and because of this, is more resilient against the ongoing economic re-
structuring due to automation.

Finally, besides telling success stories, we also need to frame a few key questions that we hope the international centre can address. Here, we should be ambitious, and go for questions that individual investigators, or even individual universities would not have the capability, resource, or correct composition of different experts to address.”

B) In this connection, it may be worthy to note that “the German Physical Society has a working group on Physics of Socio-Economic Systems since 2009 (see e.g., [40]: ... This dedicated scientific community is rapidly growing and involves, besides sociologist and economists, also physicists, mathematicians, computer scientists, biologists, engineers, and the communities working on complex systems and operations research ...). Apart from supporting researches and recognising regularly active young researchers (with ‘Young Scientist Award for Socio- and Econophysics’) in such interdisciplinary fields, they organise many conferences within Germany with participants from all over Europe.”.

C) Regarding a possible financial structure, “I note, following Shubik, we want to raise funds for it to be endowed in perpetuity and cost of the regular activities can be met from the (fixed deposit) interests. As we discussed in Delhi after the Conference, this is not easy but I am hopeful. Also, I agree with Shubik, it is worth trying. ... Presumably, to begin with, the founding faculty members would need only a fraction of their salary, and the bulk of the interest money could be used for postdocs, graduate student support, visitor travel, etc. For a different institutional model, have a look at the web page of ICERM at Brown University (https://icerm.brown.edu/home/index.php ). From our conversations in New Delhi, I understand that you would like to see a more extensive and inclusive model for this purpose, located somewhere in Eurasia, and I am very supportive of this idea.

To raise funds for this kind of thing, it will be necessary to create a clear proposal that addresses – at the very minimum – the following items:

a) First, we need a list of names and bios of international faculty who would be willing lend their names to such a Centre. In fact, it would be better to partition this list into categories: Some more senior faculty with administrative experience could serve on an Advisory Board. Other faculty would be willing to visit the Centre from time to time, and perhaps organize conferences there. Some would send their graduate students during the summer, etc.
b) Second, we need a clear business model for the Centre, along with a governance model and sample budget. Again, we might learn from the models of ICERM, ICTP and SFI, but we probably want something that is unique to what we have in mind.

c) Third, we need a list of benefits from this proposed Centre that would accrue to the hosting institution and the hosting country.”

4. Concluding Remarks

We think, it is an appropriate time to initiate such a project for the healthy growth of this ‘Fusion of Natural and Social Sciences’, through active dialogue among the students and experts from different disciplines (e.g., physics, computer science, mathematics, economics and sciology), engaged in researches in their respective disciplines and institutions, from all over the world. We find, both the experts in the related disciplines as well as the researchers already initiated in such interdisciplinary researchers have deep feelings about the urgent need for such a Centre, where short and long term visits would be possible and enable them to participate in interdisciplinary schools, workshops, and research collaborations.

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