NEW ECONOMIC WINDOWS

Banasri Basu
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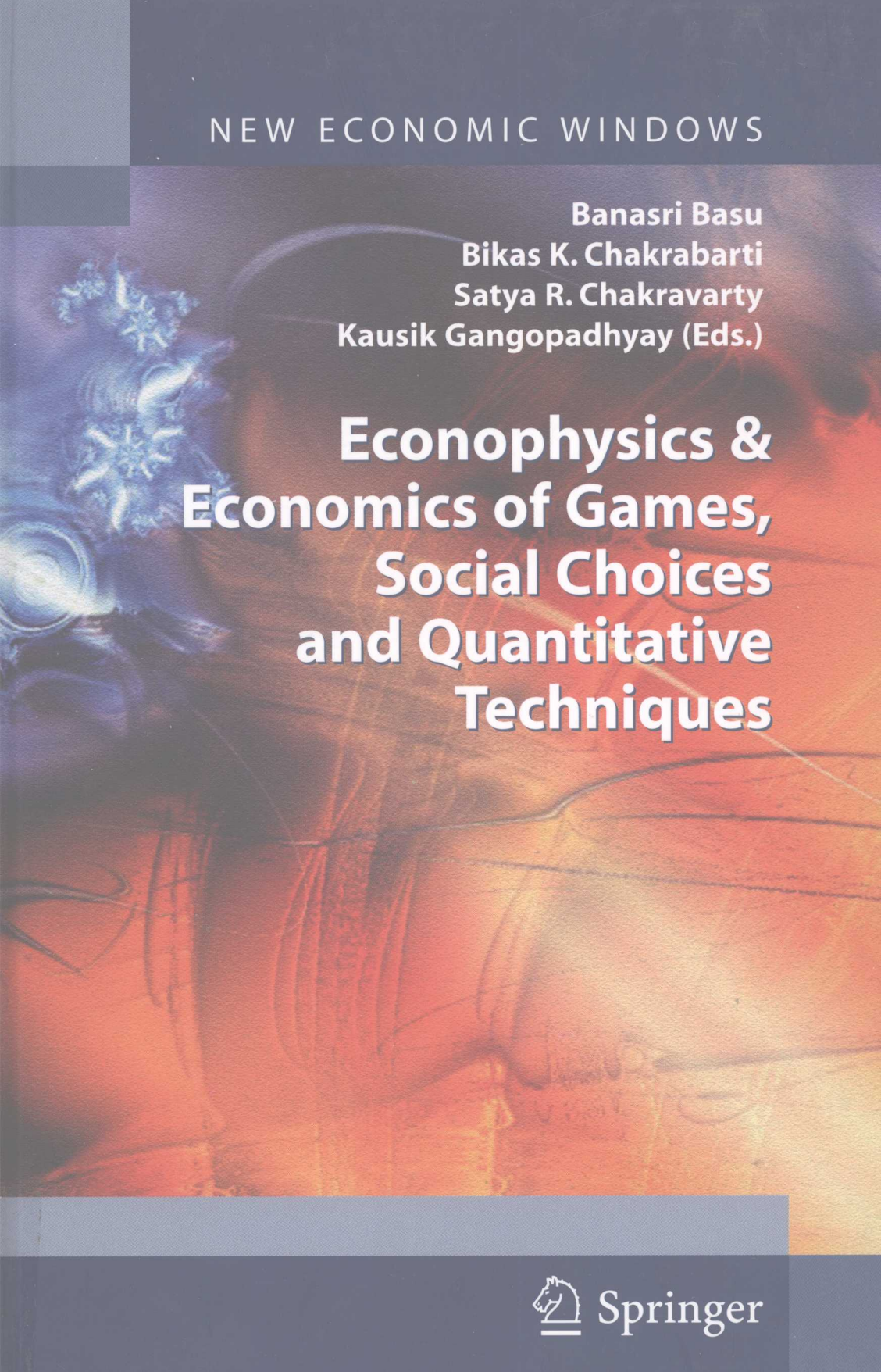
Satya R. Chakravarty
Kausik Gangopadhyay (Eds.)

Econophysics & Economics of Games, Social Choices and Quantitative Techniques



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Banasri Basu · Bikas K. Chakrabarti
Satya R. Chakravarty · Kausik Gangopadhyay
Editors

Econophysics and Economics of Games, Social Choices and Quantitative Techniques

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New Economic Windows

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Preface

The combined efforts of the Physicists and the Economists in recent years in analyzing and modeling various dynamic phenomena in monetary and social systems have led to encouraging developments, generally classified under the title of Econophysics. These developments share a common ambition with the already established field of Quantitative Economics. This volume intends to offer the reader a glimpse of these two parallel initiatives by collecting review papers written by well-known experts in the respective research frontiers in one cover.

This massive book presents a unique combination of research papers contributed almost equally by Physicists and Economists. Additional contributions from Computer Scientists and Mathematicians are also included in this volume. It consists of two parts: The first part concentrates on econophysics of games and social choices and is the proceedings of the Econophys-Kolkata IV workshop held at the Indian Statistical Institute and the Saha Institute of Nuclear Physics, both in Kolkata, during March 9-13, 2009. The second part consists of contributions to quantitative economics by experts in connection with the Platinum Jubilee celebration of the Indian Statistical Institute. In this connection a Foreword for the volume, written by Sankar K. Pal, Director of the Indian Statistical Institute, is put forth. Both parts specialize mostly on frontier problems in games and social choices.

The first part of the book deals with several recent developments in econophysics. Game theory is integral to the formulation of modern economic analysis. Often games display a situation where the social optimal could not be reached as a result of non co-operation between different agents. The Kolkata Paise Restaurant problem is an example of such a game, where the outcome of a non-dictatorial allocation, is far inferior compared to the social optimum. Asim Ghosh, Anindya Sundar Chakrabarti, and Bikas K. Chakrabarti study this problem under some homogenous learning strategies, when the agents are symmetric in nature. Debasis Mishra and Manipushpak Mitra characterize the optimal rules to allocate a set of jobs to set of heterogenous machines. Edward W. Piotrowski, Jan Sładkowski, and Anna Szczypińska studies how investors facing different games, gather information and form the decision despite being unaware of the complete structure of the game. They apply reinforced learning methods to study the market. Prisoner's Dilemma is

a classic game. There are mechanisms to implement co-operation in this game and ensure the socially optimal outcome. György Szabó, Attila Szolnoki and Jeromos Vukov show how the efficiency of such a mechanism can be improved.

The applications of the theory of quantum mechanics is pervasive. Recently, a new interdisciplinary stream of quantum game investigates into any possible improvement in strategy to apply to classical games. Tad Hogg, David A. Fattal, Kay-Yut Chen, and Saikat Guha applies the theory of quantum information to the field of an economic system. They show that quantum information technology offers a new paradigm for various economic applications and provides new ways to construct and formulate economic protocols, particularly in the context of auctions. In another article, Sudhakar Yarlagadda uses the many-body entangled states to ensure coordination in some games, where otherwise coordination could not be obtained.

Another pertinent contribution of Econophysics is the distributional analysis of different social phenomena. Starting with simple processes, researchers have matched the complicated empirically observed distributions with remarkable success. One recurring distribution in this literature is named after Pareto. Jun-ichi Inoue and Jun Ohkubo investigate equilibrium properties of disordered urn model and discuss the conditions for the heavy tailed power-law (Pareto) in the occupation probability by using statistical physics of disordered spin systems. In the next article, Davide Fiaschi and Matteo Marsili forms an economic environment, in which large number of firms and households interact through the capital and the labor markets. In that model economy, the top tail of the equilibrium wealth distribution is well-represented by a Pareto distribution. A kinetic model for wealth distribution including taxation and redistribution is put forward by Giuseppe Toscani and Carlo Brugna. The impact of the model parameters on the Pareto exponent is numerically analyzed. Bertram Düring's article is concerned with the formation of bimodal income and wealth distribution in a society along with opinion formation in a heterogenous society.

Pareto law is omnipresent in nature. Besides wealth and income distribution, it is also observed in the contexts of city-size distribution and behavior in financial markets. Kausik Gangopadhyay and Banasri Basu investigate the relationship between two well-accepted empirical propositions regarding the distribution of population in cities, namely, Gibrat's law and Zipf's law, using the Chinese census data. They also build a relevant theoretical framework imbibing the formation of special economic zones. A mean-field model of financial markets is proposed by Vikram S. V. and Sitabhra Sinha. This model reproduces the long tailed distributions and volatility correlations without explicit agent-agent interaction or prior assumptions about individual strategies. Prasanta K. Panigrahi, Sayantan Ghosh, P. Manimaran, and Dilip P. Ahalpara analyze the Bombay stock exchange price data using recently developed wavelet based methods. Comparison of this method with the Fourier power spectrum analysis characterize the periodic nature and correlation properties of the time series. A dynamic nonlinear modeling on industrial growth data is performed by Arnab K. Ray.

In any social discipline, the measurement of inequality and welfare is fundamental for quantitative analysis. John Angle, François Nielsen, and Enrico Scalas

proposes Kuznets curve for the measurement of income inequality in a society comprising of two types of workers - the poor unskilled and the rich skilled. An entropy based performance index is suggested by Vijay A. Singh, Praveen Pathak, and Pratyush Pandey for monitoring the teaching-learning process. They elucidate their proposition through a survey-based empirical analysis. Jisnu Basu, Bijan Sarkar, and Ardhendu Bhattacharya's article uses the concept of thermodynamics to evaluate the technology level in an industrial supply chain with empirical illustrations. In the concluding session of Econophys Kolkata IV workshop, there have been many stimulating discussions on the course the discipline of Econophysics. Some of them are noted in the last section of Part I.

The papers in Part II span both emerging and classical areas in both theoretical and applied economics. They involve applications of mathematical and econometric techniques. Some papers argue about feasibilities and implementation of new economic policies arising from changes in a country over the past half-century.

Recently the literature on multi-utility representation of binary relations has received a significant attention. The article of Kuntal Banerjee and Ram Sewak Dubey demonstrates the impossibility of representation of intergenerational preferences in the multi-utility framework under certain restrictions on the cardinality of the set of utilities. A reformulation of public policies like expenditure on public health and education and the design of social security systems may be necessary when the standard of living and the composition of the population change. This problem receives attention from S. Subramanian, who investigates a particular approach to ethical aspects of population change in the context of inequality measurement. Generation of income and its distribution are often explained by stochastic processes. The contribution of Satya R. Chakravarty and Subir Ghosh uses an "economics approach" to derive a size distribution of income.

The Indian economy, as well as the discipline of development economics, has undergone substantial changes over the past half-century. Consequently, many new areas of economic policy require better information; new theories and empirical research methodologies need surveys to be designed and implemented in different ways. Also there exist problems with coordination across different sources of data, and with respect to under-utilization of existing information. An account by Dilip Mookherjee provides the need for a comprehensive reassessment of the Indian Statistical System, with a view to proposing vital changes and amendments. Sudeshna Maitra's contribution in the important area of health economics examines the role of parental education in influencing child health care using recent Indian data. A paper by V. K. Ramachandran, Madhura Swaminathan and Aparajita Bakshi attempts to assess whether it is possible to achieve simultaneously the objectives of food security in rice production and large-scale diversification in crop production in an Indian state. Estimation of equivalence scale is an important topic of research in applied economics. Amita Majumder and Manisha Chakrabarty's contribution provides a concise account of a two-step estimation procedure using Engel curve analysis based on a single cross section data on household consumer expenditure. It is accompanied by an illustration using Indian consumer expenditure data. One of the major issues of recent empirical growth literature is 'convergence'. In their con-

tribution Samarjit Das and Manisha Chakrabarty develop a new test for 'absolute convergence'. The proposed methodology is applied to check if there is absolute convergence in terms of real per capita income in different OECD countries.

Economic growth has always been an important area of research in Economics. Soumya Datta and Anjan Mukherji examine the robustness of results in Goodwin's growth cycles and demonstrate that if the equation determining the rate of change of the real wages depends only on employment rate, Goodwin's conclusions follow. But the Goodwin cycles disappear if the share of wages is admitted into this equation. Bidisha Chakraborty and Manash Ranjan Gupta's article develops policy implications of a redistributive tax on the incomes of the rich to finance an education subsidy to the poor in a less developed economy.

Two contributions on the theory of international trade deal with two different issues. Sajal Lahiri's paper on trade and conflict resolution examines the effect of foreign aid and a tax on arms exports of countries involved in war efforts. It is demonstrated that while foreign aid to the countries engaged in war is likely to increase war efforts, the opposite effect is likely to arise because of a tax on exports of arms. Brati Sankar Chakraborty and Abhirup Sarkar's contribution traces the effect of trade on the skill premium in the trading countries and shows that even under full factor equalization skill premium rises all over the trading world. Moreover, the wage inequality in each country keeps on rising gradually over time as more countries participate in trade.

The next set of papers takes the readers to different issues on game theory and industrial organization. Manipushpak Mitra and Arunava Sen analyze allocation problems and look for a mechanism in which truth telling is a dominant strategy for each agent and outcome in every state is efficient. It is shown that in the homogeneous good case an impossibility arises with diverse preferences. However, a possibility result emerges if a package assignment problem is considered. Anirban Kar examines the problem of allocating costs associated with a project among the set of individuals who derive benefit from the project. A class of cost allocation rules over the efficient network is constructed and their fairness properties are investigated. In their contribution, Chirantan Ganguly and Indrajit Ray consider the Battle of Sexes game with private information and allow cheap talk before the game is played. It is shown that if the best fully revealing symmetric cheap talk equilibrium exists then it has a desirable property. The paper of Anirban Kar, Manipushpak Mitra and Suresh Muthuswami analytically identifies a situation in which two solution concepts in cooperative game theory, the Pre-nucleolus and the Shapley value, coincide. Sonali Roy's paper provides an understanding of the measurement of voting power. It is shown that if the voters can be ranked in terms of their influence over a decision making process, then the Johnston index can be a useful indicator of voting power. Conditions for the Johnston index for ranking the voters in the same order as the Banzhaf-Coleman and Shapley-Shubik voting power indices are also identified. Krishnendu Ghosh Dastidar's paper examines the effects of increase in market size and entry of additional firms on equilibrium configurations in a homogeneous good market. It is demonstrated that the conventional wisdom regarding the effects of in-

crease in market size may not hold unambiguously. However, existing results on the effects of additional entry are reconfirmed.

We extend our sincere gratitude to the participants of the workshop, Econophys-Kolkata IV, as well as to the other contributors of this volume. Our thanks are specially for Mauro Gallegati of the editorial board of **New Economic Windows** series; his encouragement and support enabled us to publish this volume in this esteemed series once again. It may here be mentioned that the proceedings of previous sessions of Econophys-Kolkata (I, II, and III) have been published in this very series respectively under the titles of *Econophysics of Wealth Distributions* (Springer, Milan, 2005), *Econophysics of Stock and other Markets* (Springer, Milan, 2006), and *Econophysics of Markets and Business Networks* (Springer, Milan, 2007). We appreciate very much the prompt and cordial support from Marina Forlizzi (Springer, Milan) regarding these publications. We are also grateful for the support from the Collaboration Project "ISI-ERU & SINP-CAMCS", funded by Centre for Applied Mathematics and Computational Science, Saha Institute of Nuclear Physics, Kolkata, and for the infrastructure provided by the Indian Statistical Institute, Kolkata.

We sincerely hope, the readers will enjoy the novelty and richness of the recent research ideas in both economics and econophysics of various game theoretic and social choice models as well as the quantitative techniques (even some quantum mechanical techniques!) developed to handle them. We also hope, these papers will inspire new researchers to make ventures and contribute in these rapidly growing fields.

Banasri Basu
Bikas K. Chakrabarti
Satya Ranjan Chakravarty
Kausik Gangopadhyay

Kolkata,
June 2009

Foreword

The Indian Statistical Institute (ISI) was established on 17th December, 1931 by a great visionary Prof. Prasanta Chandra Mahalanobis to promote research in the theory and applications of statistics as a new scientific discipline in India. In 1959, Pandit Jawaharlal Nehru, the then Prime Minister of India introduced the ISI Act in the parliament and designated it as an Institution of National Importance because of its remarkable achievements in statistical work as well as its contribution to economic planning.

Today, the Indian Statistical Institute occupies a prestigious position in the academic firmament. It has been a haven for bright and talented academics working in a number of disciplines. Its research faculty has done India proud in the arenas of Statistics, Mathematics, Economics, Computer Science, among others. Over seventy five years, it has grown into a massive banyan tree, like the institute emblem. The Institute now serves the nation as a unified and monolithic organization from different places, namely Kolkata, the Headquarters, Delhi, Bangalore, and Chennai, three centers, a network of five SQC-OR Units located at Mumbai, Pune, Baroda, Hyderabad and Coimbatore, and a branch (field station) at Giridih.

The platinum jubilee celebrations of ISI have been launched by Honorable Prime Minister Prof. Manmohan Singh on December 24, 2006, and the Govt. of India has declared 29th June as the "Statistics Day" to commemorate the birthday of Prof. Mahalanobis nationally.

Prof. Mahalanobis, was a great believer in interdisciplinary research, because he thought that this will promote the development of not only Statistics, but also the other natural and social sciences. To promote interdisciplinary research, major strides were made in the areas of computer science, statistical quality control, economics, biological and social sciences, physical and earth sciences.

The Institute's motto of 'unity in diversity' has been the guiding principle of all its activities since its inception. It highlights the unifying role of statistics in relation to various scientific activities.

In tune with this hallowed tradition, a comprehensive academic programme, involving Nobel Laureates, Fellows of the Royal Society, Abel prize winner and other dignitaries, has been implemented throughout the Platinum Jubilee year, highlight-

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ing the emerging areas of ongoing frontline research in its various scientific divisions, centers, and outlying units. It includes international and national-level seminars, symposia, conferences and workshops, as well as series of special lectures. As an outcome of these events, the Institute is bringing out a series of comprehensive volumes in different subjects including those published under the title Statistical Science and Interdisciplinary Research of the World Scientific Press, Singapore.

The present volume titled "Econophysics and Economics of Games, Social Choices and Quantitative Techniques" is one such outcome published by Springer Verlag. It deals with frontier problems in games and social choices, and has thirty six chapters written by eminent physicists and economists from different parts of the world. The chapters are divided in two parts. The first part consisting of eighteen articles discusses on the development of econophysics of games and social choices. The remaining eighteen articles in part two concentrate on recent advances in quantitative economics ranging from classical to modern areas, both theoretical and applied, using mathematical and econometric techniques. I believe the state-of-the art studies presented in this book will be very useful to researchers as well as practioners.

Thanks to the contributors for their excellent research contributions, and to the volume editors Dr. Banasri Basu, Prof. Bikas K. Chakrabarti, Prof. Satya R. Chakravarty and Dr. Kausik Gangopadhyay for their sincere effort in bringing out the volume nicely in time. Thanks are also due to Springer Verlag for their initiative in publishing the book and being a part of the Platinum Jubilee endeavor of the Institute.

Kolkata,
June 2009

Sankar K. Pal
Director, Indian Statistical Institute

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Part I
Econophysics of Games and Social Choices

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