

Physics of Society: Econophysics and Sociophysics

Macro-Econophysics

New Studies on Economic Networks
and Synchronization

Hideaki Aoyama | Yoshi Fujiwara | Yuichi Ikeda
Hiroshi Iyetomi | Wataru Souma | Hiroshi Yoshikawa



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Big data on heterogeneity and synchronization of economic networks provides opportunities to study macroeconomy from micro and mesoscopic perspectives in terms of heterogeneous interacting agents. This book discusses economic networks and synchronization from the perspectives of statistical physics and complex networks. It also discusses applications of big data in macroeconomy, specifically business cycles, systemic risks, inflation and deflation, productivity dispersion and innovation and related topics. Offering detailed discussion on macroeconomics and new insights found by using new methodologies, each topic is elaborated by exploiting recently available big data and by employing new tools. It covers most of the recent research that is based on empirical and large scale data in Japan as well as in Europe and the US using tools and concepts in nonequilibrium statistical physics, complex networks and statistical science. The book also provides new methods based on complex network and statistical physics to macroeconomics, especially for an understanding of interactions and aggregate dynamics in economic systems. The book will be of interest to a wide range of readers in economics, complex systems, complex network science and related disciplines of research.

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Cover image source: Shutterstock

CAMBRIDGE
UNIVERSITY PRESS
www.cambridge.org

ISBN 978-1-107-19895-1



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University Printing House, Cambridge CB2 8BS, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, vic 3207, Australia
4843/24, 2nd Floor, Ansari Road, Daryaganj, Delhi - 110002, India
79 Anson Road, #06-04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107198951

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First published 2017

Printed in India by Nutech Print Services, New Delhi

A catalogue record for this publication is available from the British Library

ISBN 978-1-107-19895-1 Hardback

Additional resources for this publication at www.cambridge.org/9781107198951

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Macro-Econophysics

Recent availability of big data on heterogeneity and synchronization of economic networks provides a good opportunity to study macro-economy from micro and mesoscopic perspectives in terms of heterogeneous interacting agents. Through collaborations between physicists and economists, we find that the key to understand macro-economy is economic networks, on which a large-number of economic agents are interacting with others in heterogeneity, and synchronization, that is, spatial or temporal regularities that emerge from the heterogeneity and interaction. In tandem with the growing necessity of studying macro-economy through such a new perspective and methodology, there is a surge of interest among researchers and students in the subject. This book is tailor-made to meet the needs of a wide range of readers in economics, complex systems, complex network science and related disciplines of research.

This book discusses economic networks and synchronization from the perspectives of statistical physics and complex networks. It aims at discussing application of big data in macro-economy, specifically, business cycles, systemic risks, inflation and deflation, productivity dispersion and innovation, and related topics. It offers detailed discussion on previous studies in macroeconomics and new insights found by using new methodologies. Each topic is elaborated by exploiting recently available big data and by employing new tools. It covers most of the recent research that is based on empirical and large-scale data in Japan as well as in Europe and the US carried out using tools and concepts in non-equilibrium statistical physics, complex networks and statistical science. The text offers new methods based on complex network and statistical physics to macroeconomics, especially for the understanding of interactions and aggregate dynamics in economic systems.

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Physics of Society: Econophysics and Sociophysics

This book series is aimed at introducing readers to the recent developments in physics inspired modelling of economic and social systems. Socio-economic systems are increasingly being identified as ‘interacting many-body dynamical systems’ very much similar to the physical systems, studied over several centuries now. Econophysics and sociophysics as interdisciplinary subjects view the dynamics of markets and society in general as those of physical systems. This will be a series of books written by eminent academicians, researchers and subject experts in the field of physics, mathematics, finance, sociology, management and economics.

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We are at the very beginning of time for the human race. It is not unreasonable that we grapple with problems. But there are tens of thousands of years in the future. Our responsibility is to do what we can, learn what we can, improve the solutions, and pass them on.

– Richard Feynman

Foreword

Economics has emerged as a major discipline today of interest to all because of its impact on our day-to-day life. What has been achieved so far has been truly impressive, although the discipline is not as successful as one would expect. Notwithstanding what mainstream economics does or strives for, it does not really meet the criteria to be called a natural science yet. This book is an attempt to steer it in that direction.

Although natural sciences, such as physics, chemistry, biology, or geology employ logic and mathematics (as a condensed form of logic), it is never the sole ingredient. Stepwise observations are organized in a logical fashion, often with the help of tentative or approximate hypotheses, and both the existing observations and predicted outcomes are carefully compared. The understanding of the next level or of similar but different systems grows progressively, based on the successful ideas or an understanding developed earlier. Naturally, there is interdependence in natural sciences as a consequence of this kind of development. In general, precise knowledge, successful ideas, or techniques developed in one area of the natural sciences become easily translated into another.

This interdependent structure of research in the natural sciences also gets reflected in the graduate level course structure for students in their respective disciplines. Students of one major discipline of the natural sciences have to learn the basic and established concepts in other disciplines: Physics majors learn concepts of chemistry, biology, or geology; biology majors learn basic concepts of physics and chemistry, along with others. This practice is somehow not there yet for the social sciences; the graduate students here do learn mathematics and statistics but not the basic concepts of physics, chemistry, or biology. Personal interests are, of course, exceptions and are not counted here!

To many, this is the main reason why economics, which also started becoming formalized much later compared with most other branches of the natural sciences, could not boast of the spectacular successes achieved by other disciplines. Among others, econophysicists believe in the need for a similar mutation of ideas from economics and physics, for the healthy evolutionary growth in both.

MACRO-ECONOPHYSICS is an attempt by an internationally renowned group of (econo-) physicists and economists to recast macroeconomics in the mold of physics. The subject deals with collective or evolving economic or financial dynamics of a cluster of companies, firms, banking and other networks, where the healthy or sick status of the dynamics of individual agents or companies may not imply the same for the collective society or the nation. Successful ideas, models, and techniques developed in statistical physics over the past century or so can indeed lead to a very satisfactory understanding in macroeconomics and is shown in this book. This attempt is indeed pioneering and balanced. Most of its authors, sometimes with other collaborators, had earlier indicated similar possibilities in their well-known books published earlier by CUP. In that sense, this book details the latest developments in this attempt and in a very comprehensive way. The book should be of immense value to graduate students and researchers in economics and physics interested in exploring the natural science frontier of (macro) economics.

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Acknowledgments

We wish to express our sincere thanks to Bikas Chakrabarti for giving us an opportunity to publish this work. We would like to thank our collaborators and other researchers in this and other related fields. With them, we enjoyed discussions over many years of study that led to this book. We cannot list them all, but some of them are: Masanao Aoki, Yuta Arai, Yoshiyuki Arata, Yuji Aruka, Stefano Battiston, Guido Caldarelli, Giulia De Masi, Corrado Di Guilmi, Yuji Fujita, Yudai Fujiwara, Mauro Gallegati, Bruce Greenwald, Takashi Iino, Hiroyasu Inoue, the late Jun-ichi Inoue, Taisei Kaizoji, Yuichi Kichikawa, Eliza Olivia Lungu, Thomas Lux, Luca Marotta, Rasario Mantegna, Salvatore Micciché, Kazuo Minami, Takayuki Mizuno, Makoto Nirei, Takaaki Ohnishi, Bertrand M. Roehner, Yohei Sakamoto, Yukiko Saito, Katunori Shimohara, Fumiyoshi Shoji, Robert M. Solow, Didier Sornette, Gene Stanley, Joe Stiglitz, Masaaki Terai, Ken-ichi Ueda, Irena Vodenska, Tsutomu Watanabe, Yoshihiro Yajima, Hiwon Yoon, Takeo Yoshikawa, Kikuo Yuta, and Leon Suematsu Yutaka.

This manuscript is written by researchers who are members of a research project supported by the Research Institute of Economy, Trade and Industry (RIETI), Tokyo. We would like to thank RIETI for support in preparing this book.

This work is also partially supported by *Grant-in-Aid for Scientific Research (KAKENHI) Grant Numbers 22300080, 24243027, 25282094, 25400393, and 26350422* by JSPS, the *Kyoto University Supporting Program for Interaction-based Initiative Team Studies: SPIRITS*, as part of the Program for Promoting the Enhancement of Research Universities, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, *Nihon University College of Science and Technology Grants-in-Aid*,

Japan Center of Economic Research, and ISHII Memorial Securities Research Promotion Foundation Research Fund (ISHII-2015-329).

The authors thank the Yukawa Institute for Theoretical Physics at Kyoto University. Discussions during the YITP workshop YITP-W-15-15 on “Econophysics 2015” were useful to complete this work.

Part of the results are obtained by using the K computer at the RIKEN Advanced Institute for Computational Science (AICS), Kobe, partially supported by *The Post K Computer Exploratory Challenges* under the Flagship 2020 initiated by MEXT.

Finally, we are grateful to a number of organizations and individuals, who have understood the value of our endeavors and advised or provided us with crucial data for our evidence-based scientific research of economics: The Credit Risk Database Association for small-to-medium firm data in Japan, Tokyo Shoko Research Ltd., K. Itoh, and N. Shinozaki (both at NHK — Japan Broadcasting Corporation).

Prologue

All truths are easy to understand once they are discovered; the point is to discover them.

— Galileo Galilei

SALVIATI: Greetings, Sagredo, and Simplicio, my good friends. Yesterday, we resolved to meet today and discuss as clearly and in as much detail as possible the character and the efficacy of those laws of macro economics, which up to the present, have been put forth by the books of Aoki and Yoshikawa (2006) and Aoyama et al. (2010a), the very same authors of this book.

SAGREDO: Indeed, I am truly glad and honored to meet you and Simplicio on this occasion of the completion of this book.

SIMPLICIO: Indeed, indeed, (with a touch of doubt on his face) what is “macro-econophysics”?

SALV.: You must be familiar with “econophysics”. It is evidence-based economics as a science. You may recall that it has the word “physics” in it as many physicists have devoted their research to this area, guided by the concepts and ideals of physics in their heart.

SAGR.: I see that most of the authors are physicists, except for Prof. Yoshikawa, who I heard is a macro-economist.

SALV.: They both have put forth the same ideals of revolutionizing the way real economy is studied in their respective books before. Now they have joined forces to introduce the term **Macro-econophysics**.

SAGR.: I have heard that it shares its ideals with “agent-based modelling”, which is yet another great approach.

SIMP.: That is good. But isn't this book a mere collection of the respective topics from each of the authors?

SALV.: Absolutely not. They have been working together for the last few years, combining the best of physics and economics and publishing papers. They have spent many days and nights discussing all things big and small included in this book.

SAGR.: And look... they have Professor Richard Feynman's very hopeful words on the front cover.

SALV.: This book is one of the latest efforts to construct a science of economics, which forms a part of the basis of this new development and will be improved and passed on to the next generation of academics.

SAGR.: And look at this photograph taken by the first author (who, by the way, is the first author because of the names being listed in alphabetical order) on December 1, 1979, at UC Irvine, California. He and his famous van!



SIMP.: These words must have been uttered in the 1960s or 1970s, when the human race was very positive and hopeful about its future. Now, with singularity facing them, it is no longer appropriate. Besides, this van was burned down by *Sheldon Cooper* and his company.

SAGR.: No, no, no! Come to your senses, Simplicio. I am more hopeful of the future of the human race than ever and you know well that the van was burned down only on *The Big Bang Theory*!

SALV.: Speaking of the Big Bang, they say this is the age of the **Information Big Bang**.