ECONOPHYSICS OF INCOME AND WEALTH DISTRIBUTIONS

The distribution of wealth and income is never uniform, and philosophers and economists have tried for years to understand the reasons and formulate remedies for such inequalities. This book introduces the elegant and intriguing kinetic exchange models that physicists have developed to tackle these issues.

This is the first monograph in econophysics focused on the analyses and modelling of these distributions, and is ideal for physicists and economists. It explores the origin of economic inequality. It is written in simple, lucid language, with plenty of illustrations and in-depth analyses, making it suitable for researchers new to this field as well as more specialized readers.

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Preface

> An imbalance between rich and poor is the oldest and most fatal ailment of all republics.
>
> *Plutarch, ancient Greek biographer (c. 46–120 CE)*

Why does this imbalance exist in the first place? Why are a few rich and many poor? For centuries we have borne the effects of this inequality. We know neither the cause nor the solution to this elusive problem. From philosophers to economists, many have vehemently tried for ages to understand the reasons and formulate remedies for such inequalities. No doubt, great efforts have been made to tackle this multifaceted problem, but the situation has been analogous to fighting the Greek mythological monster Hydra, who grows two heads in place of an injured one. Overcoming this problem, indeed, seems to be a Herculean task!

Heraclitus[1] said, 'change is the only constant'. Putting our faith in him, one might have expected things to change drastically, and the inequality to even disappear at some point in time! Strangely, this has not been the case. We find that inequality has been a universal and robust phenomenon – not bound by either time or geography. Fortunately for scholars, it has a few statistical regularities, most of which have been recorded in the past 115 years or so. Owing to the seminal works of Pareto (1897) and Gibrat (1931), one can now identify certain regularities in the income and wealth distributions over a wide range of societies and time periods. Physicists have come up with some very elegant and intriguing kinetic exchange models in recent times to shed some light on these observations. Our intention is to describe these developments in this book.

Standard economic theory would like to consider that the activities of individual agents are driven by the utility maximization principle. The alternative picture proposed by physicists is that the agents can be simply viewed as gas particles exchanging 'money', in the place of energy, and trades as money (energy)

[1] Ancient Greek philosopher (*c.* 535–475 BCE).

conserving two-body scatterings, as in the entropy maximization-based kinetic theory of gases. This qualitative analogy seems to be quite old, and both economists and natural scientists had already noted it earlier in various contexts. However, this equivalence between the two maximization principles has gained firmer ground only recently.

When tested with empirical data from various countries, just pure kinetic exchange models fall short of accommodating the Pareto tail. However, the introduction of 'saving propensity' (in various forms) in such kinetic exchange models enables one to successfully explain several of the observed features, including the much desired Pareto tail. A direct link between the saving propensity distribution and the inequality can also be established. The subsequent developments in the analysis of these models further established many intriguing features in the observed data. The mathematical structures of these models and their economic implications are now being investigated extensively. As mentioned above, the discovery of the equivalence of the physical entropy and the utility or psychological satisfaction, and their corresponding maximization principles, marks the entry of the kinetic exchange models of market in the domain of macroeconomics.

Interestingly, the economic inequality is a natural outcome of this framework of stochastic kinetics of trading processes in the market, independent of any exogenous factors. Thus, the kinetic exchange models described in this book demonstrate how inequality may arise. They also indicate how its effects may be partially reduced by modifying the saving habits.

The book is organized as follows: the first chapter introduces the topic to the readers. In Chapter 2, a detailed presentation of the recorded data and analyses of the income and wealth distributions across various countries in different time periods is given. In Chapter 3, some of the major recent attempts to set up the physics-inspired many-body dynamical models for income or wealth exchanges, amongst the agents in the market or network, are discussed. In Chapter 4, the details of the numerical results for the kinetic exchange models for asset or income among the agents in the market are presented. Then, Chapter 5 gives the detailed analytical structure of such kinetic exchange models for the income and wealth distributions. Chapter 6 shows how, in two-person, two-commodity trading dynamics, the Cobb–Douglas utility maximization leads to the same kinetic exchange dynamics with uniform saving propensity, discussed in the earlier chapters. In Chapter 7, these kinetic exchange modelling approaches for income and wealth distributions leading to the economic inequalities are reviewed in terms of economics of income generation and development. Finally, we present an outlook with a brief summary of the chapters, a few discussions on new directions and open problems in the last chapter.

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We hope that researchers, especially the younger ones, will find the ideas described in this book intriguing enough to inspire them to do further research and take up the Herculean challenge of solving this chronic problem, which is one of the pertinent sources of tragedy for human civilization.

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