Masanao Aoki and Hiroshi Yoshikawa, Reconstructing Macroeconomics — A perspective from statistical physics and combinatorial stochastic processes, Cambridge University Press, 2007, 352 pages

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When I had a first chance to talk with Masanao Aoki at an international conference on statistical physics a decade ago, I was actually shocked by his unique approach to macroeconomics, which employed population genetics in biology and random combinatorics in statistics and mathematical physics. He often begins to say, "though I am not a mainstream economist, ..." to me, an alien researcher working in econophysics, during conversations. But after having enjoyed opportunities to talking and collaborating with him since then, and recently with Hiroshi Yoshikawa, I now realized that my first response to and belief in the importance of their approach to macroeconomics was correct. The present book is its proof showing that a new approach to macroeconomics is not only possible but it is *essential*.

This book begins with a phrase in the preface by Hiroshi Yoshikawa, "macroeconomics has gone astray". In the "mainstream" approach, the agenda of having microeconomic foundations for macroeconomics has been taken as building sophisticated optimization of an individual economic agent into a macro model, typically in a representative agent model. Behavior of heterogeneous and interacting agents is simply assumed to be irrelevant. But heterogeneity and interaction are responsible for most phenomena in macroeconomics!

The purpose of this book is to explain the necessity of the new approach for macroeconomics, different from the standard equilibrium theory. The approach is based on Masanao Aoki's research efforts, and a long-term collaboration with Hiroshi Yoshikawa, "to revising the commonly adopted frameworks for modeling and analysis by mainstream macro-economists" (quoted from the preface by Masanao Aoki). For Aoki's previous works and collaborations with Yoshikawa, see Aoki (1996, 2002). Nevertheless, to be significant, the present book has a numerous examples in macroeconomics, to which those new methods are applied to the extent, much further than in the previous books. These examples in macroeconomics constitute a backbone in this book, and are described in the Section 1 of Introduction.

The examples are rather extensive:

- Role of demand in macroeconomics (Section 3)
- Policy ineffectiveness and long stagnation in economy (Section 4)
- Slack dynamics and inflexible prices (Section 5)
- Business cycles (Section 6)
- Labor market (Section 7)
- Demand saturation and economic growth (Section 8)
- Heterogeneous investors in stock markets (Section 9)

- Stock prices and real economy (Section 10)

and are fully treated in each section indicated.

How can one treat the heterogeneity and interaction among economic agents, and model the above phenomena? The answer lies in tools of statistical physics and in a relatively new branch in mathematics. The first component is continuous-time Markov chain models for stochastic interactions among agents. The second is a combination of stochastic processes and new mathematical methods in combinatorics. This is relatively new and is called combinatorial stochastic processes. The two components are explained in Section 2 in a compact way.

Unfortunately, the readers in evolutionary and institutional economics are not usually trained to mathematics of stochastic processes, and may feel uneasy. I suggest that such readers could obtain prerequisite knowledge from the books, Aoki (2002, 2003), and textbooks referred in them. If you are a novice, you have benefit from reading a modern textbook such as Ross (2007) to learn elementary things in stochastic models. For a few methods such as Fokker-Planck equation in statistical physics, which is not popularized outside of physics, one can consult a textbook such as Gardiner (2004). On the other hand, the combinatorial stochastic processes would be quite new to many researchers. With an appropriate knowledge on basics on stochastic models, you can take a look at Pitman (2006). As far as I know, the approach of combinatorial stochastic processes in economics was first taken in Aoki's papers.

Fortunately, however, each of the sections indicated above has a nice description of introduction and background. Even without mastering those mathematical tools, the readers would be able to understand what is the problem, and why the standard approaches fail to explain, or even to describe the problems in macro-economy. So any readers, professional in macroeconomics or not (like me), are suggested to read these introductory parts carefully. These introductory parts in the sections 3 to 10 are actually essential to all the readers, with or without mathematical background. I think that the authors succeeded in avoiding a potential danger of blindly importing tools and concepts from outside economics proper by writing these introductory parts in every sections.

To illustrate their approach, let me take a look at the Section 3.2. This is a relatively short subsection, but important in the sense that the authors claim that the heterogeneity of interacting agents and the existence of microeconomic fluctuations, in general, bring about a distribution in equilibrium, rather than a point of homogeneity in the macro-economy. Specifically in the section, they focus on differences in productivity that are observed to remain in the economy at all times, and explain that the differences in productivity are a necessity in equilibrium.

Since the advent of econophysics, researchers found a number of evidences in personal income, firm size (flows and stocks), number of relationships among firms (ownership, supplier-customer, financing networks), and so on in real economy, which show that distributions and fluctuations are the keys for understanding many phenomena in macro-economy. See Aoyama et al. (2007), a book summarizing present status about this for general audience. In my opinion, a majority of the researchers in econophysics will accept that one has equilibrium as *distribution*. In contrast, equilibrium as *point* is a mere analogy borrowed from the concept of equilibrium in classical mechanics; such viewpoint will be quite inadequate, because it contradicts with empirical observations.

Obviously, a nation-wide economy consists of a large number of agents (persons, firms, etc.). The orders of magnitude are 10^8 for persons, and 10^6 for firms, for example. Although it would be in principle possible to track individual agents, such a record or database of the economy is only useless. Instead, one needs aggregate descriptions such as "how many persons have income from ten million yen to hundred millions", "what is the rate of transition for a firm to change its total-asset from a billion yen to ten billions", and so forth.

Gas in a box consists of a huge number of molecules, typically 10^{23}. Tracking every molecules by classical mechanics is not useful to understand macroscopic behavior of the gas. Instead, statistical physics describes the system by asking "how many molecules have velocity in a range", "what is the transition rate for a molecule to change its velocity from a value to another", and so on. That is, distributions and fluctuations are essential description in the approach of statistical physics, which turned out to be successful.

The success of statistical physics is not trivial at all. It cannot be determined *a priori*, but should be checked empirically. The framework of statistical physics is one of theoretically possible frameworks, so its success is non-trivial. No less trivial is the potential success of statistical-physics framework in the Economy. To proceed, it is necessary to examine phenomena carefully by using real data with exhaustive lists of persons, firms and also relationships among them. This attempt has been and is being done by researchers in econophysics over a decade, as well as by economists for a century.

For example, my colleagues and I used an exhaustive list of high-tax payers in Japan, and tracked the growth of *individual* personal income. We verified (i) that the Pareto's law, a power-law distribution of personal income, holds with precision and in a wide range of income, and (ii) that the Gibrat's law of proportionate effect, statistical independence of growth from the value of income, holds in the power-law region. Because many kinds of proposed scenarios so far since D. G. Champernowne and B. B. Mandelbrot, can predict a power-law distribution as a static snapshot, it has been highly desirable to have direct observation of the dynamical process of growth and fluctuations of personal income. Our work was strengthened by Masanao Aoki and appeared in Fujiwara et al. (2002). Pareto and Gibrat laws are old stuffs, but we found that these laws are related with each other through the so-called detailed balance in a non-trivial way. Detailed balance is a concept in statistical physics, and states that a frequency of the transition from income x_1 to x_2 is statistically equal to that of the reverse transition, from x_2 to x_1. At the epoch of bubble crash, the detailed balance did not hold, and those laws were broken as was verified in the real data.

Going back to the Section 3.2, differences in productivity is shown to be present by using a large dataset of firms in Japan ranging from small and medium-size enterprises to quoted firms. This is being done by researchers in econophysics, Hideaki Aoyama and colleagues in joint collaboration with Hiroshi Yoshikawa. The motivation comes from this Section 3.2, which is actually based on Yoshikawa (2003). The standard economics postulates that the marginal products of a production factor such as labor are all equal across sectors, industries and firms at equilibrium. Otherwise a profit opportunity remains. This contradicts to the notion of equilibrium in "classical mechanics" according to the "mainstream". From the viewpoint of econophysics, this is really a strange situation, because physics does not use such a notion in the description of systems consisting of a large number of molecules, and because of empirical evidence against the validity of the notion.

Molecules are different from economic agents for obvious reasons. Statistical physics as the successful description of the Nature under a certain set of conditions will not be useful for the Economy as it is in its physics context. A bold challenge is necessary to prove it empirically and theoretically that the notion of equilibrium as distributions and fluctuations is essential. This book is the challenge by two professionals. I believe that this approach would be promising and successful, as will be proved by researchers in each community and also in the overlapping communities of economists and physicists quite soon.

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