論 文 の 内 容 の 要 旨

論文題目　A Study on Crises in an Agent-Based Socioeconomic System
（エージェントベースの社会経済システムの危機に関する研究）

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Our socioeconomic system, like the natural system, can also experience “disaster”, i.e. crisis, which greatly threatens the sustainability of an economy. The study on crisis can be traced back to Malthus 200 years ago, who conducted the first scientific investigation on the potential crisis of food production shortage caused by population explosion. After Malthus’ preliminary study, his student Keynes improved his study and conceived dynamic processes of crises with multiple phases, and warned another type of potential crisis of economic recession triggered by population decline. Nowadays, both the population growth on our planet and the population decline in aging societies such as in Japan have created many problems and exerted great pressure on our socioeconomic system. On the other hand, despite these warnings relating to population, the economic crises always emerge unexpectedly along with economic development. A few examples include recent Asia financial crisis in 1997, bankruptcy of Lehman Brothers in 2008, and the default of Greece around 2017. The emergence of all these socioeconomic crises indicate that our socioeconomic system is a complex system, in which the problems of instability and vulnerability could be induced easily and unexpectedly. The surprising crisis phenomenon arises from the interactions of huge amount of agents in an economy, which imposes systematic investigations on the causes of crises, both for academic interests and sustainability practice.

Unfortunately, even though Keynes had already realized the incapability of the mainstream macroeconomic general equilibrium theory on crisis after the unexpected happening of the Great Depression, the mechanism of crisis still remains undiscovered even with the recent development of modern macroeconomics. As a result, the mainstream macroeconomics struggles to provide any effective recommendations relating to crisis occurrence from its models, and we are not in a capable position to deploy policies to avoid or mitigate the unexpected crises. To address the issue, a new transdisciplinary econophysics-oriented agent-based model of a socioeconomic system has been engaged to systematically analyze the crisis phenomenon in a modeled socioeconomic system. The main advantages of this approach are the bottom-up emergent mechanism of crisis occurrence through interaction of massive agents, and the theoretical insights from complex physical models, both of which are important to understand the happenings of crises in complex systems which are lacking in the traditional approach of mainstream macroeconomics. This study is the first in-depth crisis study with a transdisciplinary agent-based

model, with both the theoretical and key factor analysis .

In this study, two main objectives are set: to unveil the crisis mechanisms behind complex socioeconomic phenomena theoretically, and to utilize the mechanisms for investigations of key factors to recommend policy in a more practical sense. The theoretical analysis mainly focuses on the phase transition mechanisms, while the key factor analysis focuses on various players in the socioeconomic system such as household, firm, bank, government, and population factor as well. A macroeconomic agent-based model "Mark0" was set up for the basic investigations on the mechanisms of crisis emergence and instability issues in a complex economic system. Roles of key parameters, modifications of economic rules and extensions of population dynamics to Mark0 are studied in a systematic way with both simulations and theoretical insights relating to crisis emergence. The simulations focus on identification of the long term instability referring to the endogenous crisis phenomena. The theoretical analyses focus on the relating concepts from physics referring to the non-equilibrium phase transitions. Both the dynamical transition processes in the time space and the phase diagrams in the parameter space are studied. Applying the general insights from the model, several key factors of crisis emergence in the economy are further analyzed and elaborated. In particular, market price, labor wage, demand-supply balance, firm debt, household debt, bank policy, government control, population interaction are studied case by case to demonstrate the applications of systematical factor analysis on crisis in a general modeling approach.

On the outcomes of this study, the theoretical insights on the general model reveal that endogenous crisis state does exist in a modeled economy, which can also be observed in simulations where the sudden unemployment shocks arise in the so-far quiescent economy unexpectedly and repeatedly. The significance of discovery of the endogenous crisis in a general economic system is twofold: it proves that the fundamental crisis mechanisms can root inside the basic settings of our socioeconomic system rather than the previously believed external shocks or behavior of investors. And what is more, its presence cannot be studied in the normal resilience framework, for the presence of shocks can still cause large scale negative effects on the society because of its uncertainty, regardless of the fact that the economy can eventually recover from these shocks. This imposes the necessity of a new explanation for the mechanism of this type of endogenous crisis occurrence. By further exploring the phases of the modeled economy in parameter space and studying the critical values for transitions between the endogenous crisis phase and other phases in the economy, we theoretically prove the mechanism of the endogenous crisis in the modeled economy is a self-organized clustering phenomenon controlled by an economic variable called diminishing debt ratio gap of firms. The covert nature of this self-organization with an irreversible transition process to crisis is embedded in a subgroup of deeply indebted firms, which causes the sudden burst-and-bust effect. Besides, another phase transition mechanism has also been theoretically demonstrated by the demand-supply gap in another subgroup of firms sharing irreversible features. Applying these general insights, we further investigate different key factors in various sectors of a socioeconomic system, such as the precautionary saving behavior of household, the macroeconomic policy by banks, the profit tax control by government etc., which can either trigger new crisis or control the crisis phase from emergence.

Overall, this study shows that theoretically the emergent crisis from the interactions of individuals in a complex socioeconomic system does always exist and occur unexpectedly, which refutes the assumption of the mainstream

macroeconomic theory. Furthermore, practically the transdisciplinary econophysics-oriented agent-based model has the potential to be engaged to shed new lights on the crisis mitigation policy in our economy eventually. One limitation and the important future direction of this work is empirically validation of the phenomena through the indicators and predictions made from this general theoretical model study. A systematic approach to deal with crisis in a complex system is necessary if the sustainable development of our socioeconomic system is imposed.