Towards High-resolution Simulation of Post-Disaster Economies Utilizing Firm-level Data

Joshua PANGANIBAN[1], Amit GILL[2], Lalith MADDEGEDARA[3,4], Yoshiki OGAWA[5], Muneo HORI[6], Tsuyoshi ICHIMURA[7], and Kohei FUJITA[8]

[1] M. Eng. Graduate, Department of Civil Engineering, The University of Tokyo, Tokyo, Japan, jlpanganiban.ce@gmail.com

[2] Ph.D., Researcher, Sumitomo Mitsui Construction Company, Ltd., Tokyo, Japan, amitgill@smcon.co.jp

[3] Ph.D., Assoc. Professor, Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, lalith@eri.u-tokyo.ac.jp

[4] Visiting Researcher, Center for Spatial Information Science, The University of Tokyo

[5] Ph.D., Assis. Professor, Center for Spatial Information Science, The University of Tokyo, Tokyo, Japan, ogawa@csis.u-tokyo.ac.jp

[6] Ph.D., Director-General, Research Institute for Value-Added-Information Generation, JAMSTEC, Yokohama, Japan, horimune@jamstec.go.jp

[7] Ph.D., Professor, Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, ichimura@eri.u-tokyo.ac.jp

[8] Ph.D., Assoc. Professor, Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, fujita@eri.u-tokyo.ac.jp

Abstract

Major disasters affect economies in highly complex ways due to the strong interrelationship of economic entities to each other and their heavy dependence on infrastructures. As an example, damages to the lifeline and transportation networks, accessed by firms and their suppliers and consumers, brought upon by disasters are highly heterogeneous, causing extremely varied impacts on different firms even if they are located within the same geographical region. Moreover, the interdependence of economic entities makes these disaster impacts ripple through the regional and national economies in another highly complex manner. For this reason, accurate assessment of the short-term and long-term economic impacts of disasters and the economic performance of their corresponding candidate recovery plans calls for an approach that considers individual economic entities, their complex interdependence, and other real-world constraints such as access to lifelines, transportation, and changes in the government policies during the post-disaster recovery period. Achieving this level of analysis requires high-resolution modeling of the economy and the infrastructure as an integrated system. Going towards this objective, we developed a high-performance computing (HPC) extension for an agent-based economic model that is capable of efficiently simulating large economies with hundreds of millions of economic entities at a 1:1 scale. In our most recent works, we further advanced this model by integrating it with the historical business data of around 1.4 million firms provided by Teikoku Databank, Ltd., such that the firm agents in the model are initialized with the data of their real-world counterparts. Validation tests show that the model is capable of reproducing the past observed indices of the Japanese economy at three levels of resolution: national (e.g., national GDP), industrial (e.g., sectoral production) and firm-level (e.g., sales records of major firms). To demonstrate the application of the developed system in a disaster case and policy use, we estimated the economic impacts of a hypothetical disaster scenario and simulated a simple recovery plan. This research contributes to the understanding of disaster consequences and highlights the use of firm-level data in the field of disaster risk analysis and management.

Keywords: Agent-based economic models, Post-disaster economic simulation, High-Performance Computing