Summary

In recent years, there has been increasing attention and analysis of the tremendous impact of "compound disasters." Compound disasters consist of multiple hazards so that complexity amplifies the damage. The Great East Japan Earthquake (GEJE) in 2011 is the most recent example of a compound disaster; it was triggered by an earthquake, tsunami, and nuclear disaster. In 1999, an earthquake of local magnitude (ML) 7.3 hit central Taiwan. Known as the 921 Earthquake, it was a similar type of compound disaster to the GEJE as it was triggered by an earthquake and electricity shortage. Because Taiwan is ranked as having the highest exposure to multiple natural hazards, with all four of its nuclear power plants built on risk areas, more comprehensive disaster risk management plans are needed. The GEJE highlighted the risk of nuclear disaster in Taiwan and implied the need for a comprehensive analysis of a compound disaster.

This dissertation undertakes a review of the existing literature on compound disasters and finds there is a need to develop a framework to analyze economically the urgent impact of a compound disaster on key industries, wherein their recovery process is described and the effectiveness of policy intervention is examined. The framework can be used to demonstrate the usefulness of simulation studies for disaster risk management as follows.

In the first simulation study, we develop a framework to examine the impact of a short-run disaster on major industries. We use a static single-country computable general equilibrium (CGE) model to simulate a compound disaster involving an earthquake and a power crisis. To estimate the earthquake impacts, we use building collapse rates estimated by the Taiwan Earthquake Estimate Loss System (TELES); and for the power crisis, we assume that all the nuclear power plants are shut down while the power supply gap is substituted by other power generation sources, namely, coal, natural gas, petroleum, and town gas. The simulation results show that Taiwan's major industries, like the semiconductor sector, have high capital intensity and, thus, would be damaged severely in an earthquake. In a power crisis scenario, power prices would rise by 27% and output prices would rise by around 1–2% in each sector. In terms of social welfare, the compound disaster would incur costs of

75,590 TWD per household and add 17% to the damage costs of a single disaster case with only the earthquake.

In the second simulation study, we investigate the impacts of the compound disaster and effects of recovery policies in the long run. We develop and use a dynamic model to describe the recovery process over 30 years. We examine policy interventions in Taiwan's major industries with variations of the recovery program duration and type of subsidy. The simulation results show whether one major sector could achieve sustainable recovery and the extent of fiscal and social costs that would be needed. We examine the effects of production and capital-use subsidies for recovery of the semiconductor, electronic equipment, chemical, and electric power sectors 10 years after the compound disaster, with the subsidies provided for 3, 5, or 7 years. By comparing their fiscal and social costs, it is found that a capital-use subsidy would be more cost effective than a production subsidy. We find that for the semiconductor sector, the annual costs of the recovery program are comparable to 30% of Taiwan's government expenditure. The chemical sector, however, could not achieve any sustainable recovery owing to its heavy dependence on petroleum inputs, which are used more heavily to make up for nuclear power losses. In addition, economy would bear an additional 7% of social losses for the recovery of the semiconductor sector, which equates to 37,411 TWD per household or 3.4% of household income.

Compared with conventional disaster studies from engineering viewpoints of physical losses, the framework developed in this dissertation uses CGE models to focus on quantitative analysis of economic impacts in Taiwan's key sectors and the recovery process under policy interventions. This framework can assist policymakers to manage disaster risks better and develop firm recovery plans based on the results of quantitative assessments. For policy implications, it is suggested that while this framework should be developed regularly and systematically and be used as part of government operations for disaster risk management, more types of disaster databases and micro-level surveys should be conducted in order to enlarge the scope of the framework and improve its accuracy and usefulness. Finally, research limitations of model scope are specified while an annex shows the whole model system developed in this dissertation.