

Economic Analysis of Resilience to Natural Hazards in Industrial Sectors

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Abstract

The increasing trend in disaster occurrence frequency, expanding impacts on society and economic system, and substantial economic losses caused by disasters have provided a grim reminder to the whole world. Less resilient economic systems tend to face more significant difficulties in absorbing and recovering from disaster impacts, leading to higher consequences and economic losses. Therefore, building resilience provides an opportunity to combine adaptation, risk transfer, disaster preparedness, and resilient reconstruction. Thus, understanding, recognizing, and strengthen resilience is essential to reduce damages caused by disasters and achieve the Sendai framework for disaster risk reduction 2015-2030. Meanwhile, firms may face business disruptions when disasters occurred, and critical lifeline service disruptions could extend the impacts of disasters across space and time. Although various approaches have incrementally developed to enhance system resilience against disaster risks, it is often difficult for government and individual firms to prioritize trade-offs before disasters and take responsibility and actions after disasters due to limited evidence-based supports.

This research aims to understand, model, and estimate resilience to natural hazards in industrial sectors and calculate the economic impacts caused by disasters with empirical evidence from post-disaster cases. With the aid of this, lifeline resilience factors for estimating business resistance immediately after the disaster and the recovery function for estimating the post-disaster recovery process are modeled and assessed based on the questionnaire survey data collected in the aftermath of disaster. Then, the production capacity loss rate is calculated with an adaptation of the proposed lifeline resilience factor and recovery function model. The validation is conducted by comparing the estimated result to the index of industrial production.

According to this research, some findings are derived. Firstly, findings suggest the varying importance of different lifeline services among sectors and consistent with existing studies. Results also provide empirical evidence to businesses for allocating resources and building resilience towards disasters. Secondly, the proposed model can evaluate the recovery probability at any post-disaster time conditional on the initial production capacity rate and lifeline service availability in different industrial sectors. The proposed model is integrated into the firms'

recovery process after the 2016 Kumamoto earthquakes, and the estimated results are consistent with the actual observed dataset and recovery tendency. Results suggest that the recovery process is highly dependent on the initial damage rates and lifeline service restoration, which emphasize the importance of preparedness and reconstruction in the aftermath of disasters. Thirdly, to estimate the overall economic impact due to disasters and validate the proposed resilience analysis methodology, the production capacity loss rates in the disaster area are evaluated with an adaption of the proposed lifeline resilience factor model and recovery function. A validation is conducted between the estimated production capacity rate and the observed index of industrial production. Results indicate that the proposed resilience estimation methodology is reasonable and promising in assessing the economic impacts due to disaster.

This research concludes with suggestions regarding response, recovery, and reconstruction to disasters in order to continue or quickly resume business operations. These findings make a significant contribution in confirming lifeline services' reliability and stability for post-disaster economic impact analysis. Such a model can also contribute by estimating the economic impacts caused by natural hazards, providing empirical evidence to decision-makers and business managers about the systematization of recovery strategies, and predicting business recovery processes for disaster mitigation in case of future incidents.