E101

Analysis of Resilience to Flood Disasters in Industrial Sectors: Evidence from the Heavy Rain Event of July 2018 in Japan

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Abstract: Industrial sectors are progressively threatened by the risk associated with flood disasters and are increasingly aware that building resilience is critical for their continuity, competitiveness, and survival. However, empirical evidence of industrial resilience to flood disasters are rarely provided, especially the impact of infrastructure disruptions, resourcefulness, and other socioeconomic factors on industry resilience. This paper proposes a parametric methodology to quantitatively estimate the recovery curves in industrial sectors, which measures the dynamic resilience of industrial sectors to flood disasters. Additionally, the presented recovery function integrates the impact of initial production capacity damage, inundation depth, sediment condition, infrastructure disruptions, and financial resources during reconstruction, which can calculate the quantitative changes of production capacity rates under different recovery scenarios. Results could provide empirical evidence and support for decision-makers and business managers to allocate reconstruction resources in the aftermath of disasters and establish the business continuity plan to build back better in case of future shocks.

Keywords: Recovery curves; Flood disasters; Industrial sectors; Semi-Markov model; Impact of infrastructure disruption

1. Introduction

Considerable damages have been caused on Japan's industry sectors by flood disasters because it can cause business production halted or reduced due to the direct physical damages and multiscale infrastructure and services disruptions. Facing these threatens, enhancing resilience to flood disasters are essential to build a robust and competitive resilient industry and reduce the losses. However, little evidence regarding the dynamic resilience (recovery ability) of firms to flood disasters has been provided. Besides, increasing arguments indicate that integrating influencing factors into the recovery function is critical because the production activities are highly dependent on production factors (labor and production facility) and infrastructure supply. Therefore, the framework for estimating the business recovery curve after a flood disaster is proposed. In addition, how various factors, including the initial damages, inundation depth, disruption of lifeline services, and financial condition, quantitively impact production capacity rates are investigated.

2. Methodology

This section begins by describing and modeling the recovery process under the semi-Markov process framework, including the sojourn time distribution and transition probabilities. Followed by establishing the recovery function conditional on different initial damages. Then, the parameter maximum likelihood estimation is conducted to estimate the parameters in the proposed recovery function. Moreover, the effects of influencing factors on the recovery function can be evaluated by incorporating the covariates into sojourn time distribution parameters. Recovery rate from initial state i to n at time t can be estimated by:

$$R(t_{i,n}) = \int \dots \int_{\sum_{l=i}^{n-1} ST_l \le t} \prod_{l=i}^{n-1} f(ST_l) d(ST_l)$$

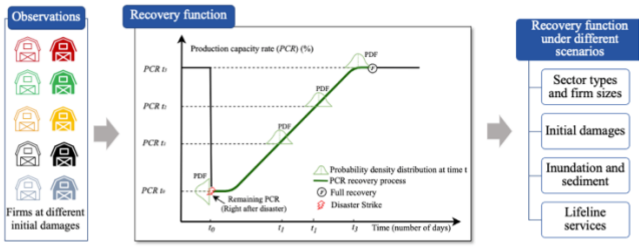

Figure.1. Illustration of the research framework

3. Case study

From June 28 to July 8 2018, an extremely heavy rainfall occurred over wide areas of Japan and caused national wide heavily damage from western Japan to the Tokai region; it is officially named the “Heavy Rain Event of July 2018” by Japan Meteorological Agency (hereafter, the flood event). As of January 9, 2019, at least 237 people died, and 8 people were missing in various flood-related incidents, primarily due to mudslides and vehicles being swept by the floodwater. Besides, the number of houses suffered from completely destroyed, half-destroyed, and partially destroyed were 6767, 11243, and 3991 houses; 28469 houses were flooded. Regarding the losses in the industrial sector due to the flood disasters, losses reached an estimated 9.86 billion dollars.

4. Results

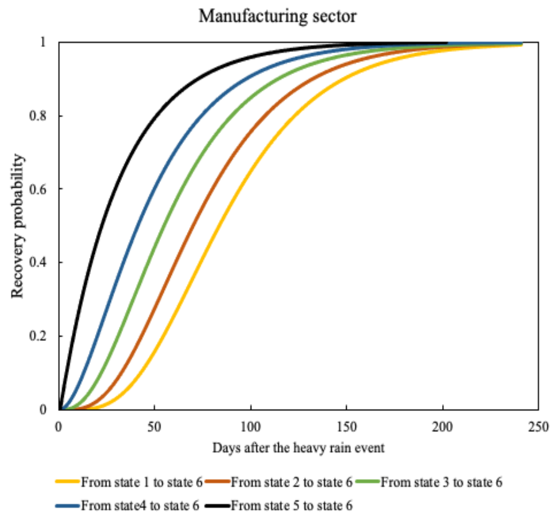

Figure.2. Estimated recovery curves from different initial damages in industrial sectors

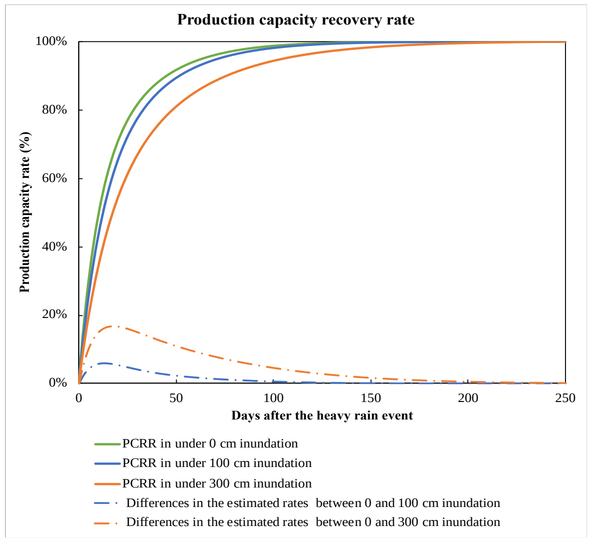

Figure.3. Estimated production capacity recovery rate under different inundation depths

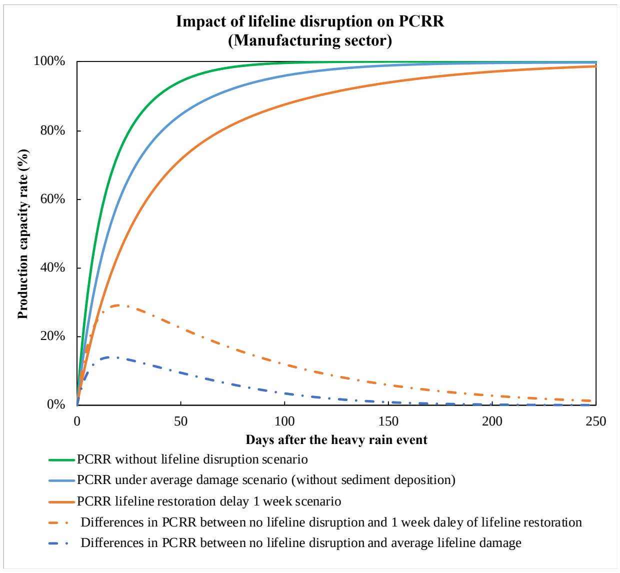

Figure.4. Estimated production capacity recovery rate under different lifeline supply scenarios

5. Discussion and conclusion

Minimizing the disruption of lifeline services, such as water, electrical power, and transportation, is critical for industries to maintain productivity and access resources needed for quick response and recovery efforts immediately after the disaster. Enhancing access to diverse and comprehensive disaster risk financing mechanisms before, during, and after a disaster event is essential for the continuity, competitiveness, and survival of industries.