E04

Business Interruption Loss Assessment of Flood Disaster for Industrial Sectors

○Lijiao Yang, Tomota,Hirokazu Tatano, Yoshio Kajitani

1. Introduction

The quantification of business interruption (BI) loss induced by natural disasters is significant to gauge the vulnerability of firms and local economies, determine appropriate disaster assistance, and undertake continuity and recovery planning. This study proposes a methodology to estimate BI loss caused by floods based on business surveys after the Tokai Heavy Rain. BI loss is estimated as lost production or sales from the perspective of producers. Three outcome variables that directly affect the scale of BI loss are emphasized: production capacity loss rate right after the disaster, length of stagnation time (the period of no production capacity recovery), and length of recovery time. Functional fragility curves are adopted to estimate the conditional probability of production capacity loss rate given inundation depth, and accelerated failure models are adopted to estimate the conditional probability of stagnation time and recovery time, respectively, given appropriate explanatory variables. Combining these three statistical models enables us to conduct probabilistic analysis of BI loss of different sectors. To validate this methodology, the estimated total affected time and BI loss are compared with official suggested values. The results show that affected times are far larger than the official values for all sectors. However, the difference of BI loss is not large because of different treatments for production capacity loss rate right after the disaster. That is, the proposed methodology elaborates business resilience that reflects in the remaining amount of production capacity for the stagnation period and this cancels out the loss caused by longer affected time.

2.Methodology

The questionnaires sent to businesses in the inundated area were conducted by the MLIT of Japan. The main concept of the surveys is illustrated in Fig. 1. When a disaster occurs, production capacity (PC) and sales of firms may decrease to a certain proportion of the normal state. The decrease of PC may persist without recovery due to disruptions of utilities and transportation, labor shortages, and other adverse conditions. We define this period as “stagnation time.” After the stagnation period, PC gradually or rapidly bounces back to the normal state. This period is defined as “recovery time,” which is normally a nonlinear process but is simplified as a linear process to reduce the complexity of survey forms. The definition of affected time refers to these two periods.

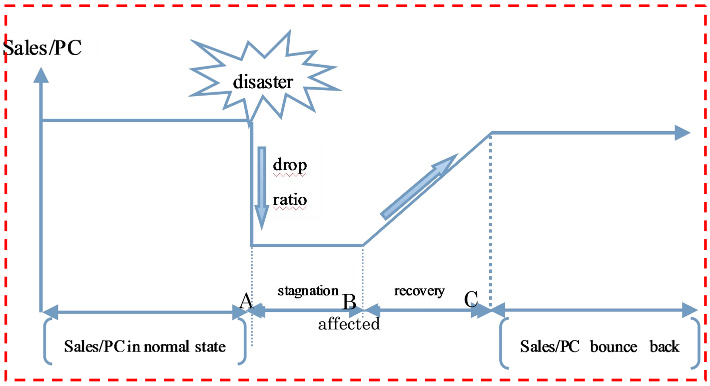

Fig. 1 Description of business recovery process adopted in the survey

Note: PC refers to production capacity, the period from points A to B is stagnation time, and the period from points B to C is recovery time. The decreased percentage of sales or PC is known as production capacity loss rate (PCLR).

The methodology to quantify the BI loss is proposed based on the surveyed data on the PCLR, stagnation time, and recovery time. It includes mainly two kinds of probability models. One is the functional fragility curves model to estimate the probability of PCLR conditioned on inundation depth. The other is the parametric accelerated failure time (AFT) model to calculate the conditional probability of stagnation time and recovery time given the PCLR and/or inundation, respectively. First, the observed inundation depth and PCLR are used to obtain the parameters of the functional fragility curve, where lognormal distribution is employed. Second, observed

PCLR/inundation depth are used to fit a parametric AFT model for the stagnation period. Similarly, the recovery time is fit by a parametric AFT model taking inundation, drop ratio, or stagnation time as explanatory variables. Finally, these three statistical models are integrated into the BI loss. The flow chart of this methodology is shown in Fig. 2.

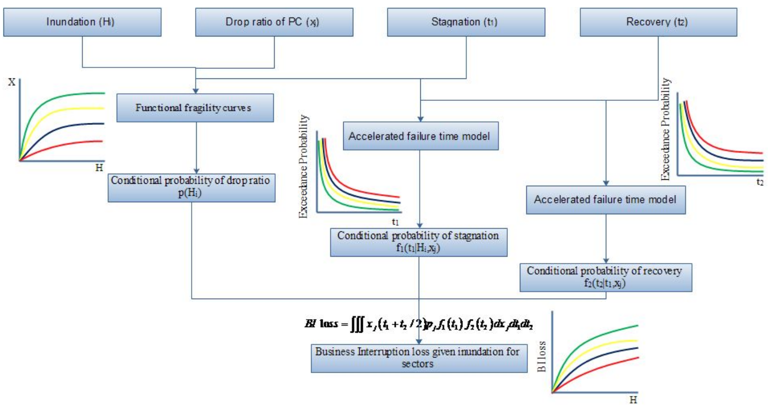

Fig. 2 Flow chart of proposed methodology to estimate BI loss

3. Case study

This study area Aichi prefecture is located in the Tokai region of Japan. The capital of Aichi prefecture is Nagoya, the third largest city after Tokyo and Osaka. It is the center city of the Chūkyō Metropolitan Area. The population of Achi prefecture is about 7.4 million and GDP is about 361.5 business interruptionllion U.S. dollars (2010). This area focus on automobusiness interruptionles with an outstanding concentration of industries, including aircraft, space and machine tools. Many world famous companies are located in this area such as Toyota car factory, Fuji Heavy Industries, Mitsubusiness interruptionshi Motors Corporation, Brother Industries Ltd.,Aisin Seiki Co.Ltd.and so on.
The significant damage to Nagoya city was huge, amounted to 4 deaths, about 380,000 people were advised or instructed to evacuate, 9,983houses flooded above their floors, and 22,689 houses flooded under their floors. This damage to Nagoya city is the second one after typhoone Vera since records.

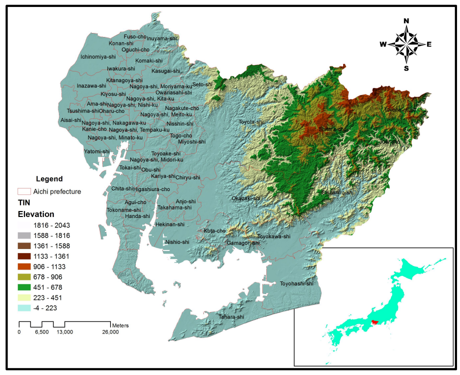

Fig. 3 Location of case study area

4. Conclusions

In this study, we proposed a probabilistic methodology for estimating BI loss caused by flood disasters based on business surveys after the Tokai Heavy Rain in Japan. Three factors were considered to determine the BI loss: PCLR, stagnation time, and recovery time. Functional fragility curves were adopted to estimate the conditional probability of PCLR given inundation depth, and AFT were adopted to estimate the conditional probability of stagnation time and recovery time given appropriate explanatory variables. A case study of the Tokai heavy rain disaster demonstrated the feasibility of this methodology.

The proposed methodology is able to provide information of functional fragility curves, probability distribution of stagnation time and recovery time, and information confidence intervals, which enable probabilistic analysis of BI loss. In summary, this methodology not only provides resilience characteristics of sectors given the hazard size, but also provides a method to conduct rapid BI loss estimation. These results could be widely applied to business continuity plans, flood insurance, as well as BI loss estimation in different sectors, among other areas.

5. References

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