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Evaluating the Economic Damages caused by Single and Combined Floods Targeting Multiple River Basins in the Tokai Region of Japan

Hiroyuki SHIBUSAWA, hiro-shibu@tut.jp

Takeshi ICHINOSE, ichinose.takeshi.pt@tut.jp

Mingji CUI, ichinose.takeshi.pt@tut.jp

Toyohashi University of Technology, 1-1 Tempaku Toyohashi Aichi, Japan

Extended Abstract

In recent years, heavy rain has been occurring frequently in many areas in Japan due to abnormal weather. Heavy rains in July 2020 caused the Kuma River and Chikugo River in the Kyushu region to overflow, causing human and property damage due to collapsed houses, landslides, and flooding of low-lying areas. Economic damage also occurred due to damage to transportation infrastructure and lifelines such as expressways, railways, electricity, gas, and water. Even in areas where direct damage did not occur, such as flooding or the suspension of transportation infrastructure, indirect damage occurred, such as the suspension of business operations and business operations due to damage to materials suppliers. In this way, economic damage is widespread throughout the supply chain. In recent years, there has been a tendency for floods to occur in multiple basins at the same time due to linear precipitation belts, causing more damage. In this way, when assessing flood risk, it is important to understand not only direct damage but also indirect damage after a disaster. Additionally, if multiple flood disasters are expected to occur over a wide area, it is necessary to consider the flooding of multiple rivers.

In this study, we will examine methods for assessing the economic damage that spreads to other regions in situations where production activities and logistics functions in the basin are halted and restored due to flooding expected from heavy rains or typhoons. We will focus on the three rivers known as the Kiso Three Rivers and their basin areas, and assume that each river will be affected by a single disaster, and that all three rivers will be affected by a combined disaster at the same time. Using a dynamic inter-regional input-output model, we perform simulation analysis for cases in which a single basin is affected by a disaster and cases in which multiple basins are affected simultaneously. We clarify the damage and recovery process in production activities in the basin and other regions.

In this paper, we use inter-regional input-output tables at municipality level to

construct a dynamic Input-Output model that takes into account production technology and traffic disruption bottlenecks. We estimate an inter-regional input-output table for non-competitive import type for 1,896 regions across Japan with four production sectors based on the national input-output table in 2015. Industry is classified into four sectors: agriculture, forestry and fisheries, mining/manufacturing, construction, and service. We use a dynamic regional input-output model that takes into account forward and backward linkages. The direct damage to each production sector in each region immediately after a disaster is given by the damage rate of added value (labor and capital). The disaster damage rate in this study is the ratio of the number of employees in areas expected to be flooded to the number of employees in normal times, and also takes into account the depth of flooding.

The disaster damage rate was derived using polygon data from the Ministry of Land, Infrastructure, Transport and Tourism's National Land Numerical Information: ``Flood inundation area data (estimated maximum scale)'' and ``2014 Economic Census data (number of employees by small zone).'' I will do it. First, we use Arc-GIS to overlay these polygon data in layers and calculate the area of the expected flood area of each small zone, taking into account the depth of inundation. The inundation rate is determined by the ratio of the area of the flooded area to the normal area of each small zone. Furthermore, the number of employees by sector in the expected flood area is calculated by multiplying the number of employees by sector in the small zone by the inundation rate. Next, the number of employees during normal times and the number of employees during floods, calculated for each sector at the small zone level, are aggregated at the regional level. Using the ratio of these values, the disaster damage rate for each region and sector can be calculated.

The dynamic regional input-output model incorporates a bottleneck structure in production activities caused by a shortage of inputs. This is specified by the Leontief production function. In other words, inputs from different sectors are not substitutable, and inputs from the same sector in multiple regions are completely substitutable. After a disaster, production activity in each region stagnates due to a shortage of goods, so external support for the supply of goods is needed for early recovery. In this model, we calculate the amount of produced goods that are in short supply during a disaster compared to normal times, and assume that a certain proportion of these goods will be supplied (imported) from outside the region.

In the simulation analysis, we assume a situation in which production activities in the flooded areas of the three basins are affected by flood damage. That is, we will consider four cases involving only the Kiso River, only the Nagara River, only the Ibi River, and all three rivers. In the simulation, one week is assumed to be one period, normal times are assumed to be

period 0, and the flood is assumed to occur in the first period. We will analyze the recovery process of production activities up to the 96th period. Simulation analysis shows that the economic damage is greater in case of multiple flood disasters than in single flood disasters. This is because the linkages (supply chains) between industries that extend widely from the disaster-stricken areas will increase the indirect economic damage and prolong the recovery of production activities in each region. This tendency is shown to be more pronounced in the case of complex disasters. The results of this research will provide useful information for regional resilience policies.

Keywords: Flood Risk, Economic Damage, Spillover, Resilience, Input-Output Analysis

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