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Assessing the Indirect Economic Losses of Sea Ice Disasters: An Adaptive Regional Input-Output Modeling Approach

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Disaster losses estimates are helpful for arranging disaster relief and postdisaster reconstruction. However, most of the previous analysis of sea ice disasters focus on direct losses, whereas very few studies evaluate the indirect economic losses. To fill this research gap, this study provides an assessment of the indirect economic losses caused by the sea ice disaster in Liaoning Province in China using an adaptive regional input-output (ARIO) model. The results show that indirect economic losses were 885 million yuan, which account for 25.3% of the direct economic losses. In particular, the impacts were found to be severe in the following sectors: agriculture, food manufacturing, chemical industry, catering industry, machinery and equipment manufacturing, and transportation and post industry.

INTRODUCTION

Sea ice disasters, such as marine icing, ice pileup against the structures, ice ridging, and ice pressure buildup, are one of the most serious types of disasters in northern China. Sea ice can cause various types of damage to marine infrastructures, such as destroying various offshore facilities, squeezing ships, blocking ports and waterways, and destroying aquaculture facilities (GB/T 28921-2012; National Standardization Administration, 2012). The Bohai Sea and North Yellow Sea of China, located on the edge of the Northwest Pacific Ocean, are considered the lowest seasonal frozen sea areas in the world. Sea ice disasters mainly occur within 10 km of the coastline in northern China and often last three to four months (Gu et al., 2014). The coastal icing area in this region accounts for about 6.0% of the total land area in China and involves nearly 20% of China's total population and 30% of China's gross domestic product (GDP). This area is an important economic zone in northern China and is the center of the Northeast Asian economic circle. Because of the rapid development of marine economy, a large number of population and industries have gathered in the coastal regions. Oil-related industries, such as oil exploitation, aquaculture, port shipment, petrochemical refining and metallurgy, and steel metallurgy, are densely distributed in the ice-covered sea regions and corresponding coastal regions (Gu et al., 2014). According to statistics of sea ice disasters, a severe sea ice disaster roughly occurs every five to six years, and sea ice disasters even occur every year in some areas. Many serious sea ice disasters have caused major impacts on the economy (Yang, 1994; Liu et al., 2016). For example, in the winter of 2009–2010, the direct economic losses caused by sea ice disaster in China were 6.318 billion yuan (Sun et al., 2011). The loss statistics associated with sea ice disasters improved after the large-scale sea ice event that occurred that year.

Economic losses caused by natural disasters include direct economic losses and indirect economic losses. Direct losses usually refer to the damage or destruction of residential buildings, enterprise property, and infrastructures that are directly affected by disasters (Yuan, 2010). Direct economic losses do not contain any intermediate link. They are usually calculated based on the survey of the actual losses with a consideration of the cost of restoration and reconstruction. Conversely, indirect economic losses are defined as extensive losses beyond the physical damage of disasters, which is caused by business interruptions of disasters and the reduction of economic outputs (Boisvert, 1992). To meet one of the seven goals outlined in the Sendai Framework for Disaster Risk Reduction proposed in 2015 at the Third United Nations (UN) World Conference on Disaster Risk Reduction (United Nations Office for Disaster Risk Reduction, 2015), it is necessary to develop a comprehensive disaster prevention and disaster mitigation plan, with an annual global investment of 6 billion dollars, to curb the global annual average direct loss of GDP caused by disasters to less than 1.5% by 2030. The UN Climate Change Conference in Paris and the Intergovernmental Panel on

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KEY WORDS: ARIO model, indirect economic losses, sea ice disaster, China.