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Mapping the water-economic cascading risks within a multilayer network of supply chains

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Trade linkages within the supply chain can be mapped onto a complex network. Disruptions in regional resource supplies (i.e., water scarcity) have the potential to generate industrial losses in remote areas due to the interconnected flow of goods and services. While numerous studies have assessed the economic and virtual water supply networks, they assumed rapid and linear transmission of industrial risks in the network, without modeling the transmission process and vulnerability between nodes. Such oversights can lead to the misestimation of risks, especially in the context of climate change. Therefore, it is urgent to construct a cascading model for the supply economic and water supply network that consider step-by-step avalanche in nodes, to help identify vulnerable sectors and mitigate economic risks.

In this research, we utilize the 2017 multi-region environmental multiregional input-output (E-MRIO) table in China to construct a comprehensive multilayer network. Each province is represented as a distinct layer within this network, incorporating 42 economic sectors(nodes). These layers and nodes are interconnected through trade linkages. To simulate the cascade process, we introduce the concept of net fragility for a node, calculated as the difference between the ratio of the sum of net inflows and net outflows of a node to its own total output and the threshold. Once a node fails (i.e., net fragility less than 1) the cascade process is triggered, then we quantify the total number of collapsed adjacent nodes, i.e., avalanche size. The bigger avalanche size refers to the province-sector higher vulnerability to economic shocks. Furthermore, we use the risk probability of province-sectors suffering from water scarcity as external shocks to describe the supply network response process under different water quantity and quality constraints. By comparing with the economic impact results, we can further identify vulnerable nodes affected by the dual restraints of water scarcity and economic shocks.