Risk Propagation and Resilience Analysis in the Global Production Network: A Case Study of the Agricultural Sector under Shock

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This paper takes a global production network perspective and constructs a multilayer network based on the multi-regional input-output data published by the Asian Development Bank (ADB). We use the SIR model to simulate the dynamic propagation process of an initial shock to the agricultural sector within the global economy, and explores the impact of this shock on the resilience of the global and national economies.
We chose the SIR model as the analytical tool and made innovative improvements to significantly enhance its ability to trace propagation paths. Traditional SIR models, when applied to complex networks, typically report only the number of infected nodes at each time point, without clearly identifying which nodes are infected or revealing the specific infection paths and sources. By incorporating key factors such as node size and edge weight into the propagation process, we further optimized the model's infection rules and propagation mechanisms, enabling precise identification of infection paths and sources and providing a clear depiction of how risks propagate layer by layer in the network. This improvement not only enhances the accuracy of the SIR model in complex network analysis, but also provides a more valuable analytical tool for dynamic risk propagation simulations and network resilience assessments.
First, based on the 2023 multi-regional input-output data, we simulated the initial shock to the agricultural sectors of the United States and Brazil. The results show that fluctuations in the agricultural sector directly transmit to downstream industries that rely on agricultural raw materials. China is significantly affected early on, even before the shock occurs in other countries, due to its heavy dependence on agricultural product imports. The initial shock to the U.S. agricultural sector has a greater impact on the global production network than the shock to the Brazilian agricultural sector. Compared to an initial shock in the computer manufacturing industry, agricultural shocks exhibit faster propagation and stronger diffusion effects. Next, based on input-output data from 2007 to 2023, we conducted a time-series analysis of global economic resilience under the initial shock of U.S. agriculture. We found that the impact of fluctuations in the agricultural sector on global economic resilience is relatively stable. This stability is primarily due to the inherent stability of the agricultural sector itself and the diversified development of the global production network. Furthermore, by decomposing the global production structure and using a counterfactual analysis method, we explored the impact of changes in Chinaâ€™s domestic production structure and international trade structure on its economic resilience. The results show that since 2018, the optimization of China's domestic production structure has significantly enhanced economic resilience and shock resistance, while the adjustment of its international trade structure remains insufficient.
The innovations of the research are as follows: (1) We innovatively improved the SIR model by incorporating key factors such as node size and edge weight into the propagation process, optimizing the infection rules and propagation mechanisms. This enhancement allows for the precise identification of infection paths and sources. (2) Based on the simulation results from the SIR model, we developed a comprehensive resilience assessment index, which can be used to measure the overall resilience of the global economy, as well as focus on the resilience of specific countries or industries, providing a new analytical tool for resilience studies. (3) Through counterfactual analysis, we systematically analyzed the impact of the optimization of domestic production structure and the adjustment of international trade structure on the economic resilience of individual countries, revealing key sources of risk and offering a more comprehensive perspective and valuable empirical evidence for designing response mechanisms to external shocks.