Ripple effect assessment of intertwined supply networks: A system dynamics approach

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Abstract

Supply Chain (SC) disruptions are one of the important issues which interrupt the flow of materials, and information at different stages of any product. The trend of information growth, availability of enormous data from various sources, dynamic environments, and globalization drives the modern SC networks more complex and disrupted by unexpected events such as manmade/natural disasters, labor strikes, and material shortages. The global pandemic COVID-19 unveils the transformation of the SC to be more resilient, visible, and responsive against unprecedented events due to the complex environments. These requirements have driven supply chain risk management (SCRM) as an important avenue for academic researchers and SC practitioners. Risk identification and assessment provide the decisions regarding the development of mitigation strategies. The SC network is vulnerable not only due to the impact of sudden disruptions and also because of the risk propagation. The subsequent risks derive from risk propagation (i.e., ripple effect) that impacts SC performance, and resilience is considered as a significant stressor of SCs. This disruption propagation to other nodes may prevent or delay the function of an organization and affect its profit, efficiency, and most importantly customers' goodwill. In this view, the pandemic COVID-19 is a distinctsort of natural disruption that has a severe impact on today's business environment. It causes various risks including supply disruption, material shortages, market uncertainty, production shutdowns, and increased lead times.

Therefore, it is essential to understand the dynamic nature of risks cascading across the SC nodes. Presently, the sudden interruption of semiconductor supply disrupts different global SCs, and it could extend until at least 2023. This disruption highlights the salience of combining SC networks to provide the service to society. Towards this direction, we attempt to analyze the ripple effectof an intertwined supply network that comprises automobile, consumer electronics, and medical devices SCs using the system dynamics concept.The model aims to demonstrate the varying impacts of semiconductor shortages on different SCs by quantifying and visualizing the ripple effect.

The simulation findings can help the researchers to understand the dynamic nature of SC activities, the impact of the risk propagation, and the significance of stress testing for faster decision-making. Developing proactive mitigation strategies using mathematical optimization techniques can be an extension for the future.Hence, ripple effect visualization, modeling, quantification, and control have become promising avenues in risk assessment. The recent growth in digital technologies, artificial intelligence (AI), and data analytics have the potential to manage and mitigate risk propagation. In addition to the risk assessment, a conceptual framework is proposed for disruption and ripple effect management in *Intertwined supply networks* (ISN). The framework combines a data-driven approach, simulation, and optimization which represents a digital twin for identifying potential risks through social media analytics, assessing risk propagation, and obtaining mitigation strategies respectively.