Integrated Stochastic Inventory and Input-Output Models for Enhancing Disaster Preparedness of Disrupted Interdependent Sectors

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Natural and man-induced disasters have been found to categorically disrupt the vital functions of several infrastructure and economic sectors that produce commodities and provide services indispensable for any given region to thrive. The intrinsic interdependencies linking these sectors exacerbate the disaster consequences as exemplified by a wider range of inoperability across input-output dependent sectors. The unavailability of the required total production input from non-operational sectors amplifies the resulting economic losses. However, inventory levels during a disruptive event influence sector capability to absorb these input requirements while in an inoperable state. Hence, disaster preparedness may be improved by a thorough implementation of inventory-enhanced policies to critically disrupted interdependent sectors. This research investigates the reliability of economic loss estimates and sector recovery analysis as influenced by the inherent stochastic behavior of inventory. Inventory modeling is incorporated into a dynamic cross prioritization plot (DCPP) that merges the risk assessment metrics, namely, economic loss and inoperability into a decision support tool that prioritizes the critical sectors for inventory enhancement. Risk assessment models without factoring inventory at the time of disastrous events were found to have overestimated total economic loss by an average of 22% or $136M against simulated inventory values derived from empirical cumulative distribution functions of individual sectors. Hence, the sets of critical sectors found by implementing the DCPP varied according to assumed inventory models. This research also performs an assessment of economic loss and inoperability values under extreme event conditions. The inclusion of inventory modeling reflects a more realistic system representation and strengthens the basis of the decision support tool in prioritizing the critical sectors. While the study focuses on enhancing preparedness through stochastic modeling of inventory for manufacturing-based sectors, complementary analysis is recommended to manage the resilience of the service sectors.