Rail Intermodal Transportation of Hazardous Materials: Balancing Sustainability with Risk and Cost

Manish Verma
Professor of Operations Management, DeGroote School of Business, McMaster University, Canada

Shirin Shahabinejad
McMaster University, Canada

Abstract

In North America, rail-truck intermodal transportation (IM) infrastructure has been used to move hazardous materials (hazmat) over the past two decades. The increasing demand, high-capacity utilization of existing pipelines, and the land-locked regions containing rich fossil fuels have translated into an increasing load on the railroad network, which forms an integral part of a rail-truck supply chain. Understandably, the focus over the last decades have been on establishing a trade-off between transport cost and hazmat risk to facilitate safe and efficient shipment planning. However, in light of the initiatives around reducing carbon emissions, this research makes the first effort to explore the interaction between sustainability and the traditional performances measures (cost, and risk). We propose a novel sustainability index, which together with the extant performance measures for transport cost and hazmat risk inform the development of a multi-objective optimization program for managing hazmat shipments over across an IM system. The proposed framework is applied to a realistic case study in North America, and the resulting analyses validates the effectiveness of the proposed framework thereby demonstrating its capability to balance economic, safety, and environmental considerations in rail intermodal hazmat transportation. Through subsequent analysis, we also uncover the effect of carbon emissions restrictions on both a localized part and across the entire network. The findings provide actionable insights for transportation planners and logistics operators seeking to optimize rail-intermodal hazmat shipments while adhering to sustainability goals.