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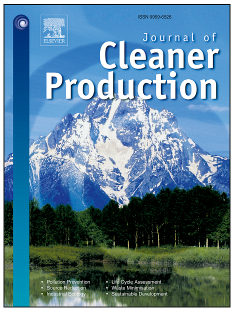

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Data-Driven Approaches to Integrated Closed-Loop Sustainable Supply Chain Design under Multi-Uncertainties

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Abstract

In this paper, the problem of sustainable closed-loop supply chain (CLSC) design under multi-uncertainties is studied. To identify an efficient way to enhance environmental and operational benefits of CLSC, we use "Big Data" and propose data-driven approaches to generating robust CLSC designs that mitigate uncertainty and greenhouse gas (GHG) emissions burdens. More specifically, in addressing multi-uncertainties (i.e., buyers' expectations, demands, and recovery uncertainties), a distributed robust optimization model (DRO) and an adaptive robust model (ARO) are developed for designing carryings and waste disposal facility locations of CLSC. Both models use historical data based on uncertain parameters for previous periods to make decisions on future stages in a robust way. Moreover, we incorporate K-L divergence into an ambiguous set of uncertain parameters to measure the value of data. The results of numerical analysis show the need to account for K-L divergence in an ambiguous set of DRO models, as GHG emission costs increase even when little K-L divergence disturbance is in place. Furthermore, from the data-driven framework, we find that government subsidies and an accurate estimation method (i.e., less K-L divergence) enhance environmental and operational benefits. Regarding model robustness levels, solutions generated from our ARO models outperform deterministic solutions not only in terms of their average objective value but also in terms of differences from ideal solutions.

Keywords: Sustainable Supply Chain, Robust Optimization, Closed-loop Supply Chain, Data-driven Approaches

1. Introduction

Recently, with increasing environmental concerns, social responsibilities, and operational benefits, businesses have become more aware of sustainable supply