Closed-loop Supply Chain Network Design under Demand and Return Uncertainty

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Abstract

In this study, we consider an integrated closed-loop supply chain (CLSC) network design problem under uncertainty in regards to product demand and return quantities. To incorporate uncertainty in decision-making, we formulate a two-stage stochastic mixed integer linear programming model to determine the optimal locations of (re)manufacturing and processing facilities along with their capacity levels and forward and reverse product flows in the CLSC network to minimize total of design and expected operation costs.
For the solution of the model and its analysis, we develop a Benders decomposition approach that is enhanced for computational efficiency via induced constraints, strengthened Benders cuts, and the use of multiple Benders cuts as well as mean-value scenario based lower-bounding inequalities obtained via dual subproblem disaggregation. Computational results illustrate that the enhancements provide substantial improvements in terms of solution times and quality.
Using our model and the solution approach within a sample average approximation (SAA) framework, we provide further analysis of network designs based on inspection location and recovery rates. Although product inspection at the retailer or the collection center locations generally reduce costs by avoiding use of resources unnecessarily, our analysis also indicates that parameters such as product type and reason-for-return, expected recovery rates, inspection costs, and transportation costs can be instrumental in deciding where the return product inspection should take place and, in turn, dictating the overall cost as well as the structure of the CLSC network.

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