Multi-objective mixed-integer linear optimization model for sustainable closed-loop supply chain network: a case study on remanufacturing steering column

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Abstract

Industrialization has caused dire consumption of resources and has already caused acute damage to the environment. Due to stringent environmental regulations, organizations are enforced to adopt sustainability strategies such as reuse, repair, reduce, and remanufacturing. To remanufacture products, manufacturing organizations have to transform their supply chains to be closed or circular. In this study, a mathematical model is formulated to transform a traditional linear supply chain into a closed-loop supply chain (CLSC) for an organization located in India. It is accomplished by incorporating remanufacturing with reverse logistics into the supply chain to achieve sustainability thereby satisfying the sustainable development goals (SDGs). A multi-objective mixed-integer linear programming approach was used to formulate the model to optimize the supply chain to improve the operations of manufacturing, recycling, repair, and disposal to minimize the environmental effects and to maximize the net profit of the product. The GAMS optimization software was used to solve the model, and sensitivity analysis was carried out to validate the robustness of the proposed network. The result states that the organization can make profits by adopting the SDGs. Industry can optimize the number of parts to be repaired, dismantled, recycled, and determine the supplier's optimum quantity of parts purchase. Lack of awareness on the potential of sustainable CLSCs is hindering its acceptance in the economy. The proper use of the proposed model not only helps the organization to maximize profit but also minimizes the environmental impact by attaining sustainability. This study is helpful for organizations that are eco-conscious and are willing to balance economic profit and environmental well-being by adopting sustainability in CLSCs.

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Author keywords

Automobile; Closed-loop supply chain (CLSC); Environment modeling; Multi-objective mixed-integer linear programming (MOMILP); Optimization; Remanufacturing