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Collaborative Strategies for Efficient Environmental Cost Distribution in Sustainable Supply Chains

Growing environmental concerns and increasingly stringent regulations have compelled supply chains (SC) to rethink how they distribute the costs of environmental impacts. However, this is a complex challenge, especially when trying to balance sustainability with financial performance and fair cost-sharing among stakeholders. This paper addresses this challenge by developing a decision support tool that combines a Mixed Integer Linear Programming (MILP) model with cooperative game theory to achieve efficient cost allocations among key SC participants. The MILP model optimises network design and planning decisions to maximise the overall Net Present Value, while also monetising logistic environmental impacts, ensuring that these costs are assessed alongside conventional financial metrics. To fairly allocate these costs among suppliers, manufacturers, retailers, and logistics providers, we apply two cooperative game theory methods: the Core solution and the Shapley value. These ensure both stable and equitable cost-sharing based on collaboration and contribution. Using a real-world base case study, we show how our approach significantly reduces total environmental costs compared to non-cooperative strategies. Moreover, the Shapley value helps distribute costs more fairly, especially benefiting financially constrained stakeholders. This research offers a structured and collaborative way of building more sustainable systems through fair cost allocation.

Author: DE SOUSA MARTINHO RAPOSO, Maria da Graça (tecnico.ulisboa.pt)

Co-authors: BARBOSA-PÓVOA, Ana (Instituto Superior Técnico, University of Lisbon); DA SILVA, Catia (CEGIST, Instituto Superior Técnico)

Presenter: DE SOUSA MARTINHO RAPOSO, Maria da Graça (tecnico.ulisboa.pt)

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