

A Sustainable Approach to Urban Last-Mile Logistics: Modeling and Analysis of a Green Two-Echelon Location-Routing Problem with Eco-Conscious Customer Behavior

The rapid expansion of e-commerce has placed unprecedented pressure on urban logistics: Last-Mile Delivery (LMD) now poses a significant environmental impact contributing to over 30% of total CO₂ emissions in the delivery sector and worsening congestion. We propose a Green Two-Echelon Location-Routing Problem (G2E-LRP), explicitly integrating (i) a heterogeneous fleet with both conventional and zero-emission vehicles of varying capacity, and (ii) eco-conscious customer decisions: clients may either receive home delivery or travel to a nearby hub, based on their individual emission rate, package size and a maximum walking/traveling green distance. The problem is formulated as a MILP and multiple cases are analyzed under varying zero-emission vehicles capacities to assess their impact on system-wide emissions and delivery distances. Exact methods were used to solve small instances, while a decomposition-based heuristic approach enabled the resolution of medium-sized cases. The model was applied to a Portuguese company offering last-mile delivery services. Results gives insights on the ability of the proposed model in balancing distances and reducing emissions.

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