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Low-carbon multimodal vehicle logistics route optimization with timetable limit using Particle Swarm Optimization

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A B S T R A C T

Optimizing the multimodal transport route for vehicles is crucial for reducing costs, enhancing efficiency, and minimizing emissions in the vehicle logistics industry. This study addresses several operational challenges, including seasonal fluctuations in vehicle sales, the scheduling of transportation modes, and client-specific order timing requirements. This paper presents a 0-1 integer programming model under carbon trading policy considering the timetable limit, with the objective of minimizing the aggregate costs of transportation, transshipment, short-term storage, time-window penalties, and carbon emissions. A linear weight reduction technique is employed to formulate the Improved Particle Swarm Optimization (IPSO) algorithm with dynamic inertia weights for model resolution. The model and algorithm's efficacy are validated by a real-world case study of multimodal transport in China. The results reveal that the IPSO algorithm reduced convergence times by 30.38 % and 17.78 % in off-season and peak season data, respectively, compared to the traditional PSO algorithm. Additionally, the optimized multimodal transport solution reduced unit costs by 19.3 % and 14.8 %, respectively. The findings indicate that transport timeliness significantly influences optimal route selection. Factors such as extended short-term storage duration, missed shipping schedules, and expedited orders compel multimodal transport to shift toward road transport. An increase in carbon trading prices effectively encourages a shift from road transport to multimodal transport; however, excessively high carbon trading prices fail to regulate this transition. Furthermore, as transport distance increases, the transport costs and carbon emission advantages associated with multimodal transport also increase correspondingly. This research advances multimodal logistics by integrating seasonal variations and carbon trading into a novel optimization framework.

A R T I C L E   I N F O

Keywords:
Low-carbon multimodal transport;
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