Python Implementation of Multi Level, Multi Objective Linear Programming Models for Transport Industry Decision Making: A Case Study

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Abstract

Complex decision-making problems with multiple conflicting objectives and hierarchical interactions between stakeholders characterize the transportation industry. In traditional optimization, the interdependency between strategic and operational decisions is generally not considered. The work demonstrates a Python implementation of Multi-Level Multi-Objective Linear Programming (ML-MOLP) models for transportation decision-making, using a case study on Indian freight transportation networks. The proposed framework considers the multiple objectives such as minimizing transportation cost, minimizing delivery time, controlling carbon emissions, and efficient utilization of resources while taking into account the hierarchical decision structure involving the central planner and regional operators.

The model is developed with the use of Python libraries PuLP and SciPy for optimization and Matplotlib for visualization of the results. Multi-objective solution techniques such as weighted aggregation and the e-constraint method are used to generate Pareto-optimal solutions that capture trade-offs among conflicting goals. A case study on the Pune-Mumbai freight corridor is used to evaluate the efficacy of the proposed approach under realistic constraints like fluctuating fuel prices, traffic variability and capacity constraints. Computational results show that the proposed multi-level framework offers better quality of decisions and more flexibility than standard single-level optimization models. Sensitivity analysis also shows the robustness of the solutions to different demand scenarios. This study highlights the practical use of Python-based optimization tools in transportation planning and provides a scalable framework to support sustainable and efficient logistics decision-making.

Keywords

Multi-objective multilevel linear programming, transportation optimization, decision-making, ε-constraint method, Python programming.