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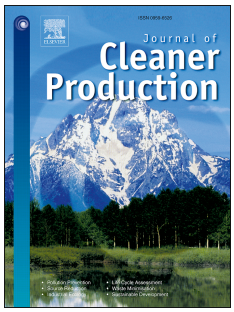

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ACCEPTED MANUSCRIPT

Bi-objective Vehicle Routing Problem for Hazardous Materials Transportation

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Abstract

In hazardous materials distribution and recollection, economic, social and environmental aspects need to be considered simultaneously when. The stakeholders involved in these activities have different and sometimes conflicting objectives, shippers and carriers are interested in a cost efficient distribution while government and population are interested in a safe transportation. A method for providing trade-off solutions is proposed through the determination of a set of routes that simultaneously minimizes two conflicting objectives, the total routing risk and the total transportation cost. This hazardous materials transportation problem is modeled by vehicle routing problem using a heterogeneous fleet of trucks. The multi-objective version of vehicle routing problem has not been as studied as its mono-objective version. Two solutions methods are proposed, a multi-objective neighborhood dominance-based algorithm and an ϵ-constraint meta-heuristic algorithm, both of them based on neighborhood search. A comprehensive comparison among the proposed solution methods is carried out using multi-objective metrics. The algorithms are tested on 20 modified benchmark instances (including the risk assessment associated parameters) with up to 100 customers. The results show that the use of the dominance-based algorithm presents a better performance, in terms of the quality of the Pareto front approximation, than the utilization of the ϵ-constraint method.

Keywords: Transportation Risk Analysis, Heterogeneous Vehicle Routing Problem, Multi-objective Neighborhood Search

1. Introduction

Environmental and safety concerns have become significant drivers towards a more efficient and responsible transportation. Examples of the former are the transportation of hazardous materials (HazMat) and green logistics. As remarked by Androutsopoulos and Zografos (2012), most of research in HazMat transportation focuses on selecting the routes of minimum risk. However, for more than 25 years authors as List et al. (1991) have pointed out the need of multi-objective models in HazMat routing. HazMat transportation decisions are multi-objective in nature, and they comprise different and sometimes conflicting objectives among different stakeholders as shippers, freight carriers, administrators, customers and residents (Taniguchi et al., 2010). In addition to the minimization of the risks, other objective functions need to be considered, including economic, social, and environmental aspects associated with the transportation of this type of goods.

Solving real-life optimization problems in science, engineering, economics and other in the presence of trade-offs between two or more conflicting objective functions, leads to multi-objective optimization. This work deals with the HazMat transportation problem where a fleet of different type of vehicles (trucks) is used for distributing a single HazMat utilizing a road network traversing population centers. It aims at determining a set of routes that minimizes simultaneously two conflicting objectives, the total routing risk and the total transportation cost. The route segment risk is considered to vary with the type and load of the trucks, and the size of the neighboring population. An adaption of a mono-objective algorithm based on local search (Bula et al., 2017) is carried out. Two different no-preference or generating multi-objective optimization approaches are implemented: scalarization, through the development of an ϵ-constraint method; and vector optimization, a Pareto-dominance based method. Multi-objective vehicle routing problems are multi-objective combinatorial optimization problems and solution methods based on local search applied to solve these problems

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