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An Integer Programming Model for Intermodal Transportation Resilient to Disaster Impact

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Abstract

Intermodal freight transportation is used heavily in commercial logistics, whereas it is not considered as the primary solution in humanitarian logistics. Transportation resilience during the response phase of a disaster relief operation is an important performance criterion and it mostly depends on the availability of the transportation modes. This study aims to present a resilient transportation framework without handling of relief items individually by highlighting the differences between intermodal transportation and multi-modal transportation. We developed an integer programming model based on a time-space network by considering route and vehicle availabilities changing dynamically over a specified time horizon. We consider five different types of vehicles (truck, freight train, vessel, plane and helicopter) on three associated modes (ground, maritime and air) with different capacities. We propose using a unit loading device for humanitarian logistics that is compatible with different transportation modes. We develop a mathematical model that includes integer variable representation for vehicle fleets of different transportation modes and compare its performance with the single mode transportation by using real life scenarios. Our main results are as follows. In terms of cost, intermodal transportation is very effective when demand is dense and response time is short, and the cost reduction is 43% in the extreme. Vehicle usage is in line with cost behaviour. Fill rate of vehicles is high on average and is not affected much with problem parameters. Inventory is held more in intermodal transportation when it is cost-effective to use transportation modes with large capacities.

Keywords
Integer programming, time-space network, unit loading device, intermodal transportation unit, humanitarian logistics

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