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Capacitated vehicle routing problem model for carriers

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Background: The Capacitated Vehicle Routing Problem (CVRP) is one of the most important transportation problems in logistics and supply chain management. The standard CVRP considers a fleet of vehicles with homogeneous capacity that depart from a warehouse, collect products from (or deliver products to) a set of customer locations (points) and return to the same warehouse. However, the operation of carrier companies and third-party transportation providers may follow a different network flow for collection and delivery. This may lead to non-optimal route planning through the use of the standard CVRP.

Objective: To propose a model for carrier companies to obtain optimal route planning.

Method: A Capacitated Vehicle Routing Problem for Carriers (CVRPfC) model is used to consider the distribution scenario where a fleet of vehicles depart from a vehicle storage depot, collect products from a set of customer points and deliver them to a specific warehouse before returning to the vehicle storage depot. Validation of the model's functionality was performed with adapted CVRP test problems from the Vehicle Routing Problem LIBrary. Following this, an assessment of the model's economic impact was performed and validated with data from a real carrier (real instance) with the previously described distribution scenario.

Results: The route planning obtained through the CVRPfC model accurately described the network flow of the real instance and significantly reduced its distribution costs.

Conclusion: The CVRPfC model can thus improve the competitiveness of the carriers by providing better fares to their customers, reducing their distribution costs in the process.

Introduction

Transportation is an important part of logistic operations, which is aimed to deliver the goods required by a customer to the right place at the right time. According to Johnson & Schneider (1995:46), the licensed transportation industry started to grow continuously since 1975; transport deregulation was identified by Bienstock and Mentzer (1999:42) as a reason for this growth in the United States. On the other hand, the licensed transportation industry in Africa began to grow since the middle of the 1990s as a result of the increased competition caused by trade liberalisation and operational costs of trucking (Pedersen 2001:94).

Within this context, costs associated with transportation may represent a significant part of a product's value. Hence, for many companies, physical distribution costs may represent more than 25% of a product's sales value (Bienstock & Mentzer 1999:42). In 2014 it was reported by Havenga et al. (2016:9) that transportation cost in South Africa was approximately 57% (where the fuel cost represented 40% of the total road transportation cost) of total logistics costs. Hence, in some cases, outsourcing transportation services is an alternative for reducing a company's distribution costs. This can be done by contracting an external transport provider or carrier (Sventekova 2007:II-18–II-20). According to Antoniolli et al. (2015:1), a company can save up to 60% of its transportation costs by contracting a carrier. In the Netherlands approximately 43% of transportation activities were outsourced to third-party companies in 2016 (Dutch Logistics Hotspots 2017:1). However, these savings depend on the costs of the carrier, which are closely associated with the efficiency of its route planning. Although the importance of carriers has been recognised, only a few distribution models can be applied to obtain optimal solutions for real problems.

In this regard, a distribution model for route planning, formulated as a Capacitated Vehicle Routing Problem for Carriers (CVRPfC), is proposed to address the distribution scenario of a real situation which has a sequence restriction associated with its delivery and vehicle-storing locations. The proposed model is outlined below through, (1) a literature review within the