World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:11, No:08, 2017

A Stochastic Vehicle Routing Problem with Ordered Customers and Collection of Two Similar Products

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Abstract : The vehicle routing problem (VRP) is a well-known problem in Operations Research and has been widely studied during the last fifty-five years. The context of the VRP is that of delivering or collecting products to or from customers who are scattered in a geographical area and have placed orders for these products. A vehicle or a fleet of vehicles start their routes from a depot and visit the customers in order to satisfy their demands. Special attention has been given to the capacitated VRP in which the vehicles have limited carrying capacity for the goods that are delivered or collected. In the present work, we present a specific capacitated stochastic vehicle routing problem which has many realistic applications. We develop and analyze a mathematical model for a specific vehicle routing problem in which a vehicle starts its route from a depot and visits N customers according to a particular sequence in order to collect from them two similar but not identical products. We name these products, product 1 and product 2. Each customer possesses items either of product 1 or product 2 with known probabilities. The number of the items of product 1 or product 2 that each customer possesses is a discrete random variable with known distribution. The actual quantity and the actual type of product that each customer possesses are revealed only when the vehicle arrives at the customer's site. It is assumed that the vehicle has two compartments. We name these compartments, compartment 1 and compartment 2. It is assumed that compartment 1 is suitable for loading product 1 and compartment 2 is suitable for loading product 2. However, it is permitted to load items of product 1 into compartment 2 and items of product 2 into compartment 1. These actions cause costs that are due to extra labor. The vehicle is allowed during its route to return to the depot to unload the items of both products. The travel costs between consecutive customers and the travel costs between the customers and the depot are known. The objective is to find the optimal routing strategy, i.e. the routing strategy that minimizes the total expected cost among all possible strategies for servicing all customers. It is possible to develop a suitable dynamic programming algorithm for the determination of the optimal routing strategy. It is also possible to prove that the optimal routing strategy has a specific threshold-type strategy. Specifically, it is shown that for each customer the optimal actions are characterized by some critical integers. This structural result enables us to design a special-purpose dynamic programming algorithm that operates only over these strategies having this structural property. Extensive numerical results provide strong evidence that the special-purpose dynamic programming algorithm is considerably more efficient than the initial dynamic programming algorithm. Furthermore, if we consider the same problem without the assumption that the customers are ordered, numerical experiments indicate that the optimal routing strategy can be computed if N is smaller or equal to eight.

Keywords : dynamic programming, similar products, stochastic demands, stochastic preferences, vehicle routing problem
Conference Title : ICORDA 2017 : International Conference on Operations Research, Decision and Applications
Conference Location : Barcelona, Spain
Conference Dates : August 17-18, 2017