

## A simulation modelling approach for vehicle routing problem in cluster-based pharmaceutical supply chains

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Pharmaceuticals directly affect the health conditions of millions of people. It is important to find the most effective and optimized methods for pharmaceutical supply chains to provide a better quality product from manufacturers to the end-consumer. The supply chain process of the pharmaceutical products, when compared with the other commercial goods and services, is given higher priority since it costs high amount of money and time to produce and deliver pharmaceutical products, since the process is not well-managed. Furthermore, all the contributors in the pharmaceutical domain go through specific rules and regulations, uncertainty in demand, constraints such as biological factors in the process. In recent years, with the continuous improvement of the medical service level and technical level, people's demand for drugs significantly improved year by year. Therefore, it is vital that the delivery of pharmaceutical products is conducted effectively and efficiently. In addition to quality, the routing and scheduling of vehicles represent an important component of many distribution and transportation systems' costs. With the computational constraints of solving Vehicle Routing Problem (VRP) which is *NP-hard*, a few optimization and approximation approaches have been introduced to successfully solve VRPs in the recent past. Thus, this study depicts a vehicle routing optimization with the objective of minimizing the cost based on the *pharmaceutical product clusters* using a simulation-based solution approach using *SupplyChainGuru*<sup>®</sup> modelling and simulation tool. Vehicle routing models are developed to simulate the pre-identified clusters (product families) using test cases from the literature and the benchmark instances listed on the repository of CVRPLib. Then the behavior and the nature of vehicle routing in pre-defined product clusters are identified and modelled via varying wide variety of variables. The baseline model is compared with the scenarios of each product cluster and the most optimized vehicle routing model will be identified and validated through simulation. The study concluded that the overall cost is minimized, when the pharmaceuticals are routed to better suit their product characteristics, rather than distributing the products without considering the inherent product characteristics, which are dynamically modelled and evaluated to provide better quality products to the patients. This product clustering-based simulation of VRP will indeed optimize the VRP in Pharmaceutical Supply Chains and will provide the platform to extend the cluster based optimization to related industries as well.

**Keywords:** Optimization, Pharmaceutical Supply Chains, Vehicle Routing

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