A multi-period collaborative model for analyzing the impact of a city hub on city logistics

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City logistics aims to optimally plan, manage, and control the vehicle movements within a logistical network in an urban area, considering integration and coordination among involved stakeholders. Since collaboration is a crucial element in city logistics, innovative solutions for city logistics related to this element have been introduced over the years. The widely-used solution is by considering the use of two or multi-echelon systems using one or more intermediate consolidation points, such as urban consolidation centers, city hubs, micro depots, etc. The additional cost due to the double handling process in the implementation of a city hub makes it important to discuss the broader implications and potential cost reductions in other parts of the stakeholders involved. In practice, the main focus of this intermediate consolidation point is on consolidating flows to make the transportation or distribution activities more efficient and more environmentally friendly. Another opportunity in such a system is to use these consolidation points as temporary storage facilities in a B2B setting, such that retailers can save costly storage space in the urban area. However, the study of the inventory aspect in city logistics is relatively unexplored. Therefore, this project aims to study the effect of using a UCC or city hub in a city logistics system in terms of inventory and routing aspects.

Two scenarios are considered to observe the impact of a city hub in a city logistics setting. Both scenarios use a network with multiple retailers in which each supplier is responsible for delivering a different type of product to the retailers over a finite and discrete-time horizon. Each retailer has a deterministic demand for each product type, a daily time window for deliveries, and a maximum inventory level. The objective function is to minimize the total cost, which is the sum of the inventory and transportation cost. The first scenario is the base scenario in which there is no city hub. In this scenario, each retailer uses a replenishment policy to define the order size. Then, each supplier determines its optimal delivery plan and delivers its product to the retailers directly. In the second scenario, a city hub acts as an intermediate consolidation point. The city hub has a role in receiving the products from the suppliers and defining the optimal delivery routes for the retailers in the city. Therefore, a two-echelon network is formed in the second scenario. Since one of the critical elements in city logistics is considering the ecological impact on urban transport, several logistics providers have innovated to use environmentally-friendly vehicles, e.g. cargo bikes, electric vans, etc. Hence, in the second scenario, a heterogeneous vehicle model with cargo bikes and vans is used for the delivery part from the city hub to the retailers, where the cargo bikes can also perform multiple trips if necessary.

In our current approach, the inventory and routing decisions are defined sequentially. For the inventory part, we use five different replenishment methods to determine the order size from each retailer in each period. Then, a metaheuristic algorithm based on Large Neighbourhood Search (LNS) is used to solve the route optimization problem of scenario 1 and the second echelon part of scenario 2.

An experimental study is conducted to investigate the impact of the city hub's implementation in the city logistics context. Some test variables in this experimental study include the number of suppliers, number of retailers, holding cost, and replenishment method. Each test variable has several different values to be tested, and each unique combination of variables represents a scheme. Several data instances that correspond to each combination are generated. With this experimental study, we aim to see the effect of each variable involved and find in which combinations the city hub will be relevant to improve the city logistics performance. Some performance measures, such as total inventory and routing cost, number of travelled distances, loading degree, and number of trips, are used to evaluate each combination.