Opportunities and threats of mixing delivery options in the e-commerce era

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Online shopping is increasing the flows which transit into the urban areas. While the business to consumer (B2C) segment of e-commerce represents around 30% of the e-commerce turnover, they generate 56% of the all e-commerce shipments [1,2,3]. Moreover, e-commerce involves individual fragmented and time sensitive orders of generally small-sized items, leading to more traffic in urban areas and negative externalities on the environment [6]. These are challenging factors for City Logistics applications, which are more and more focused on the integration of different delivery options (e.g., cargo bikes, drones, lockers, etc). But how mix the different delivery options. Are there delivery options that can conjugate the sustainability of the system from the economic, social and environmental point of view? This paper deals with these fundamental questions.

While the scientific community has been recently devoting significant efforts to propose efficient and innovative approaches to address many types of City Logistics problems, a standard framework for simulating and studying the impact of optimization in City Logistics is currently missing, limiting the technology transfer to industry. Furthermore, most of the research advances in city logistics have not yet been assessed on realistic benchmark, representative of the many complex real world urban settings. In our opinion, the later issue is due to the following current limitations:

- *unavailability of full data:* given a urban area, gathering the real data associated to all four stakeholders usually requires to much time and/or expertise to be actually implemented;
- *difficulty of combining/reusing existing data:* whereas existing studies may provide realistic data involving one or more stakeholders, there is still no trivial way to combine such data from different sources.

The contribution of this paper is twofold. First, we propose to mitigate the two above-mentioned limitations by introducing a simulation-optimization framework for validating policies in City Logistics applications. Second, we apply our framework to a case study focused on the online urban freight distribution in the city of Turin (Italy) and the effect of the usage of different policies for the mix of the delivery fleet. We focus on the online shopping and its effect, considering fossil fuelled vans, carg bikes and lockers as delivery options, combined in the following four benchmarks scenarios:

- Scenario 1. Only traditional vehicles (i.e., fossil fuelled vans) are used to manage the parcel delivery in urban areas.
- Scenario 2. According to [4], nowadays the outsourcing of classes of parcels to green carrier subcontractors (i.e., they use bikes and cargo bikes) it is a common practice to obtain operational and economic efficiency and customer proximity, while reducing the environmental impact of

logistics activities. Thus, in the B2 we consider that a green subcontractor delivers the parcels up to 5 kg in the central and semi-central areas of Turin. On the contrary, the traditional carrier manages all remaining parcels.

- Scenario 3. We consider the adoption of delivery lockers. They represent self-service delivery location, in which the customer can pick up or return its parcel, according to the best and convenient time for him. In practice, these can be seen as special "super-customers" that aggregate the daily demands of a subsets of actual customers.
- Scenario 4. In this benchmark, we consider the integration of the vans with both bikes and lockers.

For each scenario, a group of instances is generated, while each delivery problem is modeled as a the Dynamic Stochastic VRP with Time Windows and is then solved by the algorithm presented in [5].

According to our results, some insights can be derived. First, Urban logistics are complex problems where applying a structured analysis methodology able to mix qualitative and quantitative methods leads to better solutions compared to the ones in literature. Second, mixing the different options can lead to a significate reduction of externalities, but this process must be governed by policies able to avoid the conflicts between the actors in the system. The results highlight how the switch to vehicles with a low environmental impact and to lockers could lead an improvement in the economic efficiency of the business model of the traditional carrier and in the working conditions of the drivers. Moreover, the bikes represent the most suitable vehicles to face the online requests of deliveries, due to their high flexibility. Furthermore, the adoption of environmental-friendly vehicles could result in benefits in terms of CO2 emissions reduction. At the same time, this integration of different deliveries options could cause a loss of efficiency for traditional carriers. Thus, the integration should be carefully evaluated in advance by simulations in silica of the system. Moreover, a multimodal last-mile delivery integrating all the delivery options considered in this paper allows to reach the lowest levels of emissions when the number of customer is low/medium. On the contrary, vans and bikes represent the most appropriate option to deal with a high demand, while still pursuing environmental benefits.

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KEYWORDS

Last Mile delivery; parcel delivery; City logistics