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Innovations in last mile logistics: Towards inclusivity, resilience and sustainability

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The prominence of last mile logistics in urban areas is becoming more and more evident, due to increasing urbanization and rapid changes in consumer behaviour (Dablanc et al., 2017). E-commerce is one emblematic example of a transformative and ever-increasing phenomenon (Gatta et al., 2023). Recent projections show that, in 2024, retail e-commerce sales are estimated to exceed 6.3 trillion U.S. dollars worldwide,[1] and online marketplaces account for the largest share of online purchases (35%).[2] Apart from being one of the most cost-intensive activities of the supply chain, last mile logistics has become a big concern of policymakers (Bjørgen & Ryghaug, 2022). Deliveries in urban areas contribute significantly to urban air pollution emissions which are linked to climate change; logistic vehicles occupy road space in urban areas, and they are disproportionally involved in fatal collisions, all with a negative impact on social sustainability and liveability of cities (Bosona, 2020).

Technological innovations like digitalization and automation, along with intensive consumer involvement in supply chains, are changing last-mile operations from both the demand and the supply side (Tavasszy, 2020). Here, a promising innovation relates to integrating passenger and freight transport, with a potential to reduce negative externalities of transport, while serving the on-demand economy (Marcucci et al., 2017). This integration has been a subject of research of growing importance. Le Pira et al. (2021) proposed different service models for this integration using the framework of Mobility as a Service (MaaS). Recruiting travelling citizens to serve as occasional carriers and using public transport to carry freight will increase load consolidation and asset-sharing, which are important strategies in the roadmap towards zero emission logistics (ALICE, 2019).

Recent European Research projects funded by the H2020 and subsequent Horizon Europe frameworks are specifically dealing with innovations in last mile logistics towards sustainability and integrated services.

In particular, LEAD (https://www.leadproject.eu/) on "Low Emission Adaptive last mile logistics supporting on demand economy through Digital Twins" focuses on Digital Twins for urban logistics by developing logistic innovations through living labs and then replicating them in a digital environment to analyse their impacts in six European cities (Madrid, The Hague, Lyon, Oslo, Budapest and Porto). Study cases ranged from the use of a parking lot as a transhipment hub for zero emission vehicles to crowdshipping and electric vehicles charging facilities. The resulting Digital Twin allows cities to test different policy settings and simulate their effects before their implementation, thus allowing to make policy decisions based on evidence and avoid the implementation of measures that would not have the intended effects.

Similarly, the SENATOR project (https://www.senatorproject.eu/) on "Smart Network Operator Platform enabling Shared, Integrated and more Sustainable Urban Freight Logistics" aims to establish a novel urban logistics model to enhance the sustainability of cities. To achieve this goal, the project is building a smart network operator, functioning as a control tower, bolstered Platform. The platform will serve as a decision support tool, facilitating the integration and planning of all logistics operations; this aims to mitigate the adverse effects of urban distribution and serve as an efficient mechanism for collaboration among stakeholders, including citizens, operators, transporters, and administration.

Inspired by all the innovations occurring in last mile logistics, the aim of this Special Issue is to contribute to the literature by highlighting the societal contributions of innovations beyond economic efficiency, in

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[1] https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/(Last access on 30th April 2024).
[2] https://www.statista.com/statistics/861336/share-online-shopping-customers-vs-sales-by-platform/(Last access on 30th April 2024).

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particular: inclusivity, resilience and environmental sustainability. In many cases these outcomes must be traded off against each other (Vural & Aktepe, 2022). This has implications for policy making and for the societal desirability and feasibility of innovations. In addition, the aim is to present innovations in last mile logistics that bridge the gap between theory and practice. In this respect, both methodological and practice-oriented contributions have been considered.

The Special Issue builds on special sessions of the third Edition of the International Conference TIS ROMA 2022 "New scenarios for transport infrastructure and systems. Transition to inclusivity, resilience and sustainability" (https://tisroma.aiit.it/). TIS ROMA 2022 was organized by the Italian Association for Traffic and Transport Engineering (AIIT) and gathered more than 100 participants from many countries and with different backgrounds. The special sessions on innovations in last mile logitics were coordinated by Michela Le Pira (University of Catania & AIIT) and Carla Nascimento (Molde University College) and organized with the support of Nadia Giuffrida and Francesco Pilla (University College Dublin & SENATOR project), Rodrigo Tapia and Lorant Tavasszy (TU Delft and LEAD project).[3] The sessions comprised eleven presentations on different topics, spanning from models and simulations of integrated logistics ecosystems to new approaches for omni-channel and hyperconnected services, stakeholder engagement in last mile logistics planning, and innovative solutions regarding the use of parcel lockers and micro-depots or night deliveries.

Nine papers populate this Special Issue. Innovations to improve e-commerce deliveries are investigated by five studies. Models and simulations are proposed to define and test innovative solutions (Alves et al., 2023; Moslem & Pilla, 2023; Prencipe et al., 2024; Teimoury & Rashid, 2023). The use of digital platforms integrating different actors to support on demand logistics is also explored (Beckers et al., 2023). Stakeholder engagement in last mile logistics planning emerges as another important topic and is considered as one of the pre-requisites for the success of any innovation policy, as investigated by Akgün et al. (2024) and Paddeu et al. (2024). This is also one of the main results of Bruzzone et al. (2023) and de Oliveira et al. (2024) who specifically deal with the potential integration of passenger and freight using public transport.

More in detail, **Alves et al. (2023)** make use of agent-based modelling and simulation to test the use of delivery lockers and to perform an operational cost analysis. By simulating multiple scenarios the Authors show that time, external and re-delivery costs are the most impacting system costs, and conclude that deliveries performed via lockers have an economic potential only if accompanied by incentive policies resulting from stakeholder engagement. **Moslem and Pilla (2023)** also propose the use of lockers for e-commerce deliveries and perform a multicriteria analysis with experts to define the best location for parcel lockers in Dublin, Ireland. By analysing different locations and using multiple criteria, the results show that post offices are the best places for parcel lockers, contrary to previous studies suggesting shopping centres as the most suitable locations (Iwan et al., 2016). **Prencipe et al. (2024)** focus on e-groceries, a niche segment of e-commerce which has been rapidly developing during the COVID-19 outbreak (Maltese et al., 2021). The authors develop a novel Decision Support System based on a mathematical model for evaluating the efficiency of e-grocery home delivery through eco-friendly vehicles (e-cargo bikes, e-mopeds, and e-vans). Results are evaluated via key performance indicators and support the adoption of zero-emission e-grocery strategies by accounting for environmental and economic aspects. Another mathematical modelling approach is proposed by **Teimoury and Rashid (2023)** who investigate drone delivery and its coordination with ground vehicles to take advantage of both large truck capacity and high drone speeds. The authors test the model in a case study and show that truck and drone coordination is beneficial in terms of costs and time, but also emissions, and social penalties. A different approach to innovate e-commerce last mile logistics is proposed by **Beckers et al. (2023)**, who propose the concept of Logistics as a Service (LaaS) to connect logistics service providers, shippers, and consumers. The idea is to integrate the consumer in the logistics process, by proposing customized solutions, while increasing his/her awareness of transport impacts, thus fostering sustainable choices. Besides, policy makers can have an important role by incentivising greener alternatives and regulating options that create negative externalities.

The second strand of studies propose stakeholder engagement in last mile planning to foster the acceptability of innovative policies. **Akgün et al. (2024)** perform semi-structured interviews with retailers in Edinburgh, Scotland, to test the acceptability towards the use of urban consolidation centres (UCCs). UCCs can represent a good solution towards consolidation, but they are often considered politically infeasible, and their acceptability should be tested *ex-ante* (Marcucci & Danielis, 2008). The authors show that, in general, retailers are not positive towards using UCCs, being already satisfied by the services provided by their existing LSPs. However, their decision would change with restrictive traffic management policies limiting deliveries in city centres. The main conclusion is that all parties should work together to make the UCC model successful. **Paddeu et al. (2024)** make use of co-creation techniques to involve stakeholders in the identification of freight decarbonisation pathways. The study is based on the UK and involves different steps, including literature reviews, stakeholder mapping exercises, and stakeholder engagement in coproduction workshops. Short, medium and long-term pathways are identified, with electrification considered as playing a key role in the long term. An interesting lesson from stakeholders is the need for strong multilevel governance with a clear regulatory framework and incentives for change.

The last two articles focus on scenarios of integration of passenger and freight transport. **Bruzzone et al. (2023)** propose a freight-on-transit (FOT) system by generalizing a multi-commodity network design problem model able to simultaneously address customer and policy maker preferences. The model is tested in a cross-border area between Italy and Slovenia and results show that FOT can be beneficial for the logistics sector and successful if supported by adequate policies and technologies and by stakeholder engagement. **De Oliveira et al. (2024)** determine key factors for developing integrated freight and public transport systems by performing a literature review and an evaluation with experts. The main benefits of integrating freight and public transport are environmental, since it fosters the optimisation of urban space and reduction of movements of freight vehicles. Integration is beneficial also in terms of transport operation, accessibility for people and goods and economic development. However, there are many barriers, especially related to the lack of a collaborative culture and the need to change consumer behaviour.

The papers published in this Special Issue provide multiple perspectives and propose different approaches to tackle last mile logistics via innovations. However, some general conclusions can be drawn. First, among multiple innovations, consolidation, asset and service sharing emerge as key elements of future, sustainable last mile logistics. The use of UCCs, lockers, and of passenger vehicles are all promising solutions to reduce the distance travelled by freight vehicles, thus also contributing to sustainability. In addition, finding alternative delivery solutions, like using the unused capacity of public transport to transport goods, also increases the resilience of the system. The need for transport resilience has been particularly evident during the COVID-19 pandemic, causing several disruptions to supply chains and freight transport, but also to passenger transport. Finally, the idea of involving stakeholders in last mile logistics planning and to integrate the consumer in the delivery process is fundamental to increase the acceptability of innovative solutions, but also to contribute to inclusivity and transparency of planning processes.

[3] https://tisroma.aiit.it/special-sessions-on-innovations-in-last-mile-logistics-towards-inclusivity-resilience-and-sustainability/(Last access on 30th April 2024).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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