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Research Article

Towards More Sustainable Cities: Tools and Policies for Urban Goods Movements

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Although urban freight transportation is crucial to address societal demands, it also has a major negative impact on the environment, the economy, and society. Then, the growing interest in promoting more sustainable and liveable cities is pushing to point out more in depth the role of urban goods movements within the planning process, as well as city administrators to implement new sustainable city logistics actions/policies/measures. Therefore, after a brief overview, the study presents more advanced techniques (models and methodologies) to help in the assessment of planning scenario. This paper concentrates on the importance of urban freight transport and logistics. Then, technical and logistics actions are outlined, and future last-mile delivery challenges are discussed. The main objective is to support urban planners, on a strategic and tactical scale, in obtaining an overview of urban freight transport systems that point out the challenges for implementing sustainable city logistics scenarios. It is also of interest to technicians because they can identify the most suitable methodologies, as well as the features that they need for selecting and assessing ex ante the effects of city logistics measures. This work is useful for researchers in various sectors because it allows them to formalise and then to solve the problems for simulating the complex system of urban goods movements where there are different actors with own interests that are conflicting.

1. Introduction

The sensibility for sustainable development was born in the eighties [1]. By 2030, the Sustainable Development Goals (SDGs) aim to ensure that everyone lives in peace and prosperity, protect the environment, and end poverty on a global scale. The United Nations launched Agenda 2030 in 2015 [2]. Within the 17 identified SDGs, *SDG 11* (*make cities and human settlements inclusive, safe, resilient, and sustainable*) focusses on cities as one of the goals of pillars to achieve the Agenda 2030. The European Commission (EC) developed guidelines for the creation and implementation of sustainable urban mobility plans to address the aforementioned problems with urban planning [3]. In addition, given that plans are prone to rapid obsolescence and lack adaptability to new events, it is appropriate to incorporate uncertainty into modelling scenarios. In this regard, an appealing concept that can help improve the resilience of SUMPs, addressing both the movements of people and goods, is one of the triple access planning for uncertain future [4]. It assumes that the triple access planning (TAP) pushed toward a triple access system (TAS), which considers that the land-use system (*spatial* proximity), the transport system (*physical* mobility), and the telecommunications system (*digital* connectivity) can all contribute to the future sustainable urban accessibility. Furthermore, when developing and implementing the plan, it is important to explicitly take into account accommodating uncertainty, which refers to unpredictable change dynamics such as demographic shifts, economic developments, activity location decisions, regulatory context, technological advancements, travel demand, and stakeholder behaviour.

In this regard, city logistics is an essential component of urban planning. In fact, urban freight transportation not only helps to meet the demands of the population, but also has a major negative impact on the environment, the economy, and the society. For example, freight vehicles are responsible for 56% of PM and 23% of CO_2 urban transport emissions. In Italy, about 6% of accidents involve trucks and vans, and in Europe, the average external costs of urban freight distribution are quite similar to passenger traffic. Furthermore, in recent years, the incidence of logistics costs on the selling price has decreased from 12.1% to just over 6%. Similarly, the cost associated with transport operations also decreased, from a 5.9% incidence on the sale price of 5.9% in 1987 to 2.6% in 2018 [5–8]. The goals of improving the sustainability and liveability of the city prompted city planners to deepen urban freight transport within urban mobility planning, thus promoting the sectoral logistics plan within the SUMP approach. Therefore, in light of the ever-increasing role that urban logistics plays for the sustainability of modern cities, specific guidelines for Sustainable Urban Logistics Plans (SULP) were developed within the EU project ENCLOSE (energy efficiency in city logistics services for small and mid-sized European historic towns) [9]. In addition, several measures have been implemented to limit the impacts of urban freight traffic such as congestion or pollutant emissions [7, 10–16] and different assessments (both ex post and ex ante) showed that significant outcomes were reached in the fields of city sustainability, for example:

(i) environment, i.e., with the reduction of pollutant and greenhouse gas (GHG) emissions using more environment-friendly vehicles, such as electric vehicles [17–24]

(ii) economic, i.e., with the reduction of delivery costs both in terms of direct costs supported by operators [25, 26] and the community [7, 27, 28];

(iii) social, i.e., with the reduction of road accidents involving freight vehicles in urban areas [29–32]

Furthermore, the opportunity offered by new technologies and telematics is opening up new research challenges for both city planners and researchers in defining new methods and models to optimise delivery operations, for example, delivery bay booking, real-time optimised delivery tours, smart tour advisor, as well as to assess future scenarios [33–38].

Therefore, the main objective of this paper is to provide an overview of the analytical tools and best practices to help sustainable urban freight transport planning, as well as practical guidelines to which planners could refer when faced with daily realities of cities and the need to link measures and goals of Agenda 2030. Therefore, to promote a more sustainable and liveable city, where urban freight transport plays the key role in satisfying the needs of city users with limited negative impact, the document aims to support urban planners on a strategic and tactical scale to obtain an overview of urban freight transport systems, highlighting the challenges for implementing sustainable city logistics scenarios. It integrates within the triple access planning (TAP) approach which is suited to analyse and fully characterise urban freight transport planning process [39], which maximises the integration of its characteristic elements, reduces the risks associated with uncertainty, and enables the proposal of more resilient and sustainable actions. In fact, city administrations need such tools given that they have to design and describe the system in a way that supports mechanisms for the sustainable distribution of goods that take into account social cohesion, the environment, and the economy. Hence, it is also of interest to technicians because they can identify the most suitable methodologies and the features that they need for selecting and evaluating ex ante the effects of city logistics measures. The work is useful for researchers in various sectors because it allows them to formalise and then solve the problems of simulating the complex system of urban goods movements where there are different actors with own interests that are something conflicting [40, 41].

In this context, this paper outlines the process that should be implemented for supporting the improvement of the sustainability and liveability of cities. According to the existing literature, the relevance to include freight logistics in the sustainable urban planning process is highlighted and the development of methods and models (tools) as well as measures that can support the planning process to build more sustainable and liveable cities are presented.

The triangulation research approach has been used in the development of the proposed overview. The analysis offered is the result of a qualitative review approach that combined many data sources to create an in-depth understanding of the phenomenon under this study. In order to develop an overall framework of the complex issue of sustainable urban planning that takes into account the various dimensions and perspectives of sustainability, this research has been developed on three fronts: by reviewing the relevant academic works; by analysing technical reports and official EU documents; and by analysing EU and other research projects. This approach draws on the authors' deep internal knowledge of the phenomenon.

The rest of this paper is organised as follows: Section 2 provides an overview of sustainable urban planning and urban goods movements, while Section 3 summarises the methods and models developed to analyse and forecast urban freight demand (both in terms of shopping and restocking), including decision support system (DSS), which could benefit from the opportunity offered by Digital Twin [33, 37], developed for scenario assessment. Section 4 discusses some relevant technical and logistics actions/policies that can be implemented to optimise freight transport within inner urban areas (i.e., historic areas), including the opportunity offered by the TAP approach. Finally, Section 5 draws the conclusions.

2. Sustainable Urban Planning and Urban Goods Movements

In the next few years, the worldwide population is expected to exceed 9 billion. It is estimated that in 2050 about 67% of the population will live in urban areas [42]. Therefore, the promotion of sustainable development cannot ignore the contribution of the cities. The role of cities is taken into account within Agenda 2030 through SDGs11 (*to make cities* *and human settlements inclusive, safe, resilient, and sustainable*) and 13 (*target urgent action to combat climate change and its impacts*). To promote an effective urban mobility strategy that meets the mobility needs of people and businesses while limiting the negative impact generated by traffic and increasing the liveability of cities, urban planners must analyse urban transport systems by developing methods and tools that combine passenger and goods movements [13, 14, 43, 44]. In fact, although passenger and freight transport share the same infrastructure, predominantly in urban areas, they are largely seen as different systems and remain separated. It is important to emphasise that cities are unique complex systems because of their high population density and the range of human activities that occur there, from living to working to playing to maintaining one's health. Population density and associated activities require an increasing quantity of commodities, making supply chain management necessary for both traditional in-store sales channels and the recently developed online sales channels. For example, e-commerce sales in the US rose by 14% in just one year, from 2009 to 2010. With constant sales in the USA, total e-commerce sales for 2022 were projected to reach $1,034.1 billion, upto 7.7% from 2021. This represents 14.6% of total sales [45]. In 2021, 74% of European Internet users placed orders or made purchases for personal use. With time, end customers have shifted from conventional distribution channels to new ones, changing their behaviour and making new purchases. Consequently, although urban freight transportation has historically received little attention, it is crucial to build sustainable and liveable cities. In reality, freight transportation plays a major role in the unsustainable city in terms of traffic accidents, pollution emissions, and congestion. For example, freight vehicles are involved in a significant portion of traffic accidents in Europe, while urban transportation accounts for about 25% of the CO_2 emissions [46].

Changes in social structure and economic innovations in the supply chain, combined with the need for more sustainable mobility and more liveable cities, exacerbate the problems related to the *purchase of goods* by end users (shoppers) and the *restocking of retail outlets*. In fact, as pointed out and shown by several empirical studies, this segment of mobility contributes significantly to unsustainable development through high levels of pollutant emissions, increased road accidents, and congestion [21, 22, 25, 47]. Furthermore, the structure and composition of the trips carried out by city users are evolving, and trips related to shopping can sometimes exceed systematic ones (i.e., work and study [45, 48]). Furthermore, trips undertaken for shopping are mainly made by private cars; on average 69% of the total travelled kilometers related to freight movements (shopping and shop restocking) are performed by private citizens, only 24% are due to trucks. The remaining share is attributable to service trips [49–52].

In addition to the diversity of the products being transported and the modes of transportation, urban logistics involves a variety of factors and several parties involved. Public agencies, transit companies, retailers, and end users are the most significant stakeholders. Their goals and interests may differ [53–56]. Transport companies and retailers are primarily focused on controlling costs while maintaining or improving service levels, but municipal authorities are looking for ways to reduce traffic, pollution, accidents, and noise.

In this context, as previously introduced, the European Commission promoted its sustainable and smart mobility strategy as well as the guidelines for the strategic sustainable urban mobility plan (SUMP) and the sectorial sustainable urban logistics plan (SULP). SUMPs, as strategic plans, focus on the mobility needs of people and businesses in urban areas, including urban logistics (*the plan should include measures to improve the efficiency of urban logistics, including urban freight delivery, while reducing GHG, pollutants, and noise*). The SUMP guidelines are also expected to become the main reference planning tool and help the public administration speed up the process to have a valuable plan for promoting the development of sustainable mobility.

In an effort to help local administrations reduce traffic impacts, countries are promoting different actions to address the development of plans and programmes in this direction. However, only few cities have implemented urban plans that explicitly point out the role of freight transport. In fact, cities are facing adversity from local operators (e.g., retailers, transport, and logistics operators) in changing their operations as well as the lack of robust and shared procedures for assessing the actions to be implemented. Furthermore, the low level of knowledge on this phenomenon (i.e., a few cities perform systemic surveys on urban freight transport; [57]) at the level of single municipalities restricted the start of a new era of planning for travel demand of both passengers and freight in cities. In this context, in Europe, the project named "Sulpiter–Sustainable Logistics Planning in Central Europe" was promoted [58]. It followed the approach previously defined by ENCLOSE (energy efficiency in city logistics services for small and mid-sized European historic towns [9]) for developing SULP, which, as said, is a sectoral strategy plan created to improve quality of life and address the mobility demands of enterprises and people in cities and their surroundings. It incorporates integration, participation, and assessment as guiding concepts and expands upon current planning practises.

As discussed in the European guidelines of the SUMP and SULP documents, sustainable urban planning for freight cannot ignore the setup and test of future planning scenarios. Specifically, the design of planning scenarios, including actions/policies aimed at guiding cities toward a climate-neutral economy, should be based on a participative process in which models/tools (with decision support systems) for assessing the expected impact of actions to be implemented play a key role [59]. This process is shown in Figure 1. It consists of the following stages:

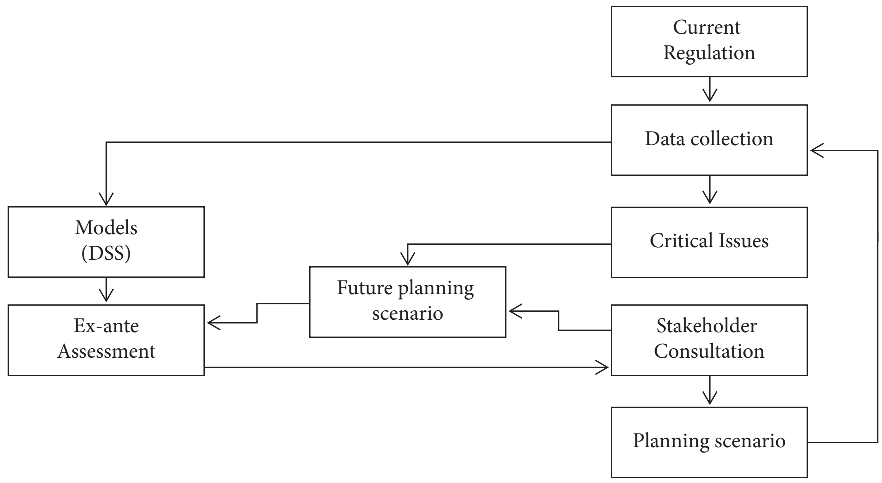

FIGURE 1: The process for defining planning scenarios.

(i) analysis of the *current regulation*;
(ii) survey for the identification of *current critical issues* through *data collection*. For example, traffic counts and interviews (with retailers, truck drivers, and so on) can help reveal the current status of the system and identify the relevant critical issues;
(iii) definition of methods and *models* (including decision support systems-DSS) to simulate the current status and *future planning scenarios*;
(iv) ex-ante assessment of the planning scenarios and comparison with expected sustainable goals/outcomes;
(v) sharing of the objectives and finding an optimal compromise among the different actors involved (*stakeholder consultation*).

Once the plan is implemented, it should be monitored to evaluate the effectiveness of the implemented solutions and eventually identify possible future actions due to uncertain and contingent trends.

Therefore, according to the process described above and in order to support cities in developing and implementing more sustainable planning scenarios, in the next two sections, the following are examined: (1) methods and models for analysing and forecasting travel demand; (2) technical solutions to be implemented in cities for addressing towards a more sustainable development. Actually, the definition of future scenarios should be founded on the simulation of the main effects generated (i.e., ex ante assessment—"what if" approach), with the goal of evaluating the attainable effects before implementation and their results verified afterwards. This is because the identification of the primary issues to solve should come before the deadline. Thus, the need for models and techniques for ex ante evaluation of city logistics scenarios motivates a review of the literature to find the models and techniques that can be applied to the ex ante evaluation of city logistics scenarios for assessing impacts and system performance, and consequently for contrasting future scenarios based on a predetermined set of target values. In addition, having a first set of workable solutions based on sustainability objectives and local characteristics can help planners define future scenarios by concentrating on the cities that were able to achieve the best outcomes and take advantage of the advantages of optimising loads, vehicle trips, and vehicle kilometres.

3. Methods and Models for Forecasting Urban Freight Demand

In the development and implementation of plans, in general, the assessment methodology of future scenarios plays a key role because it permits one to evaluate the performance of the future scenarios as well as to favour the acceptability of possible actions/measures to be implemented. In addition, it allows, at the initial stage, the identification of the critical stage of the system and the construction of future planning scenarios. Although there is a long literature on urban passenger mobility and that on urban freight mobility is growing, only few studies focus on urban freight logistics and passengers, jointly [43, 60–62]. Recently, guided by the statement that passengers and goods movements use the same city resources, and changes in one component affect the other and *vice versa*, e.g., changes in shops' opening hours can drive users to modify their trip choices with subsequent impact on urban traffic–more trips by cars [63, 64], the research interest towards such a mobility segment is growing. Furthermore, the limited literature on urban freight transport is mainly devoted to the study of the restocking process of stores, focussing on the optimisation of the single tours/trips performed by transport and logistics operators. The few current demand forecasting tools do not link user choices with restocking choices made by operators. For example, the development and spread of telematics is giving rise to new shopping patterns and conducting changes in retailing and in delivering [65–67]. As a result, it is becoming more important to focus on the behavioural aspects of shopping mobility and link them to restocking. To satisfy the needs of the needs of satisfying city planners to have tools to evaluate the urban freight transport system taking into account the behaviour of the involved actors, some modelling frameworks have been developed over the past years [49, 68–71].

As said above, end consumers, retailers, wholesalers, transport and logistics companies, and other actors make a variety of decisions that determine the movement of goods in cities [44, 72–74], which allow goods to reach urban activities and satisfy the demand of end consumers. Highlighting the movements of goods and the relative decision-making, three main mobility components can be identified (Figure 2) which are as follows:

(i) purchasing/shopping, i.e., it describes the movement of the final customer when they move to make purchases at a store or shop. The final customer makes decisions about where, when, and how to buy goods—including travel plans for in-store purchases—in a store or online;

(ii) shop restocking, i.e., it represents the movement of goods brought into a shop or store by transport and logistics operators, or by merchants. The need to restock their stores with merchandise is the primary driver of this transportation category;

(iii) e-delivering, i.e., it outlines the movement necessary to deliver Internet purchases to final customers. The people who make decisions about logistics and transportation are those who schedule delivery routes and times.

It should be noted that, in urban areas, commercial vehicles also move for activities not related to restocking. These are *service trips* (business journeys) made by employees of a company to their clients, and they are service excursions that are a cross between freight and passenger transit [51, 75]. 6.32 to 24.84% of all commercial traffic is made up of these [76]. The majority of service vehicles are vans and small trucks; therefore, their size makes them less impactful than giant trucks that block highways and intersections. Furthermore, supply chain limitations do not primarily influence their travel behaviour, and based on their travel characteristics, they can be evaluated using the conventional methods applied to work-related travels.

In this context, with the aim of introducing city planners, as well as urban transport technicians, and researchers with a novel modelling framework that can be used to support policy making and mobility planning, we recall a model for forecasting origin-destination flows within urban areas. Its main features are to combine the three mobility processes and integrate the three elements that characterise urban freight activity (that is, quantity, delivery, and vehicle), with the goal of highlighting the main decision-making process and the impact of each action scenario implemented in it.

3.1. The Integrated Urban Freight Modelling Framework. Modelling the demand for freight-transporting urban areas is a relatively new field of research. Different approaches have been proposed. Approaches can be classified on the basis of the reference unit: vehicle trip (*trip-based* models), the weight of the goods (*commodity-based* models), and the delivery of the goods (*delivery-based* models).

Trip-based models can represent the different segments of urban goods mobility. Commodity- and delivery-based models reproduce the distribution flows to stores and to food-and-drink outlets and the e-commerce flows. Commodity-based and delivery-based models can simulate, better than trip-based models, the interactions between the economic and spatial characteristics of demand and the supply of logistics infrastructure and services. The integrated framework that can simulate the purchasing, restocking, and delivery is the main topic here. In fact, the rise in e-commerce has also caused a shift in the models and procedures utilised for the transportation of products in metropolitan areas, toward an integrated approach to the restocking, e-delivering, and shopping/purchasing mobility of goods (Figure 3). Interested readers can refer to Comi and Site [77] for details on further modelling approaches.

Thus, the three primary modelling stages—purchasing, restocking, and delivery—that make up the reviewed modelling framework are based on the urban goods flows presented in Figure 2. The modelling system takes into account a disaggregated approach for every decisional level and is a multi-step model. Every suggested model is presented in the context of random utility discrete choice [78]. Every individual who makes decisions is regarded as a rational decision-maker who seeks to optimise utility in relation to the choices they make. Specifically, the individuals that made decisions are as follows:

(i) end consumer, i.e., who decides how much and where to buy;

(ii) retailer, i.e., who sells to end-consumers and decides where to buy goods to restock their stores and type of transport service to use (own account or third-party);

(iii) wholesaler/distributor, i.e., who decides the type of transport service to use;

(iv) carriers/courie, i.e., who provides transport services.

Through the simulation of purchase decision-making and, consequently, of travels made to reach stores and/or shops, the *purchasing* stage enables one to emulate the behaviour of end-customers while shopping (both in-store/shop and online). At this point, the amount that end-users are expected to purchase to meet their demands is estimated, and each traffic zone associated freight flows are defined.

Using the quantity attracted by each traffic zone (due to in-store and online transactions), we may predict the *restocking* quantity origin-destination (O-D) matrices for freight types.

The *delivering* stage next highlights the creation of tours carried out for the delivery of items to retail locations and final customers. Then, the simulated vehicle flows are generated from the e-purchase delivery and store restocking.

3.1.1. The Purchasing Stage. There are significant differences in purchasing ways (i.e., in-store or online) according to freight types; increasing the age, the number of in-store purchases raises; youngers perform the high number of

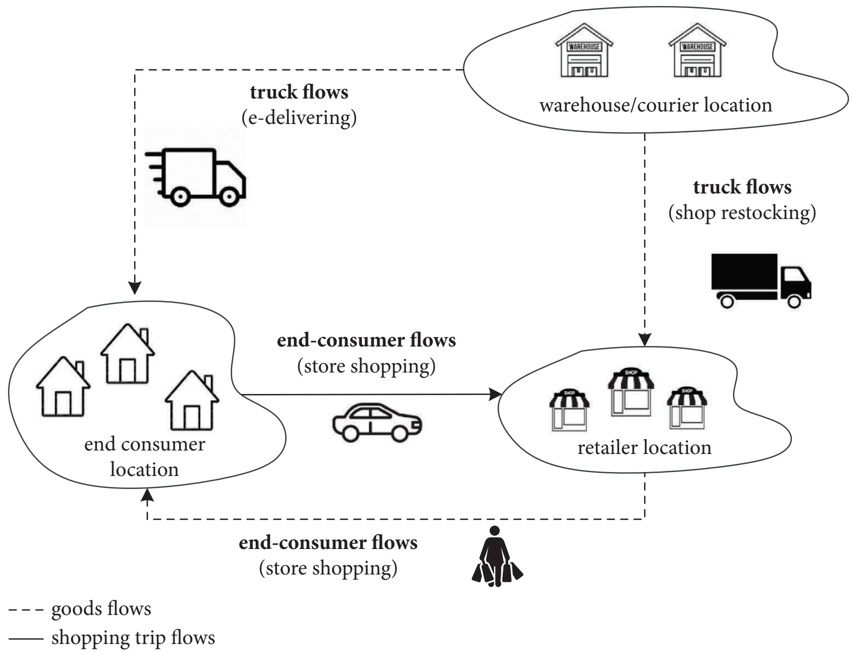

Figure 2: Components of the mobility of goods.

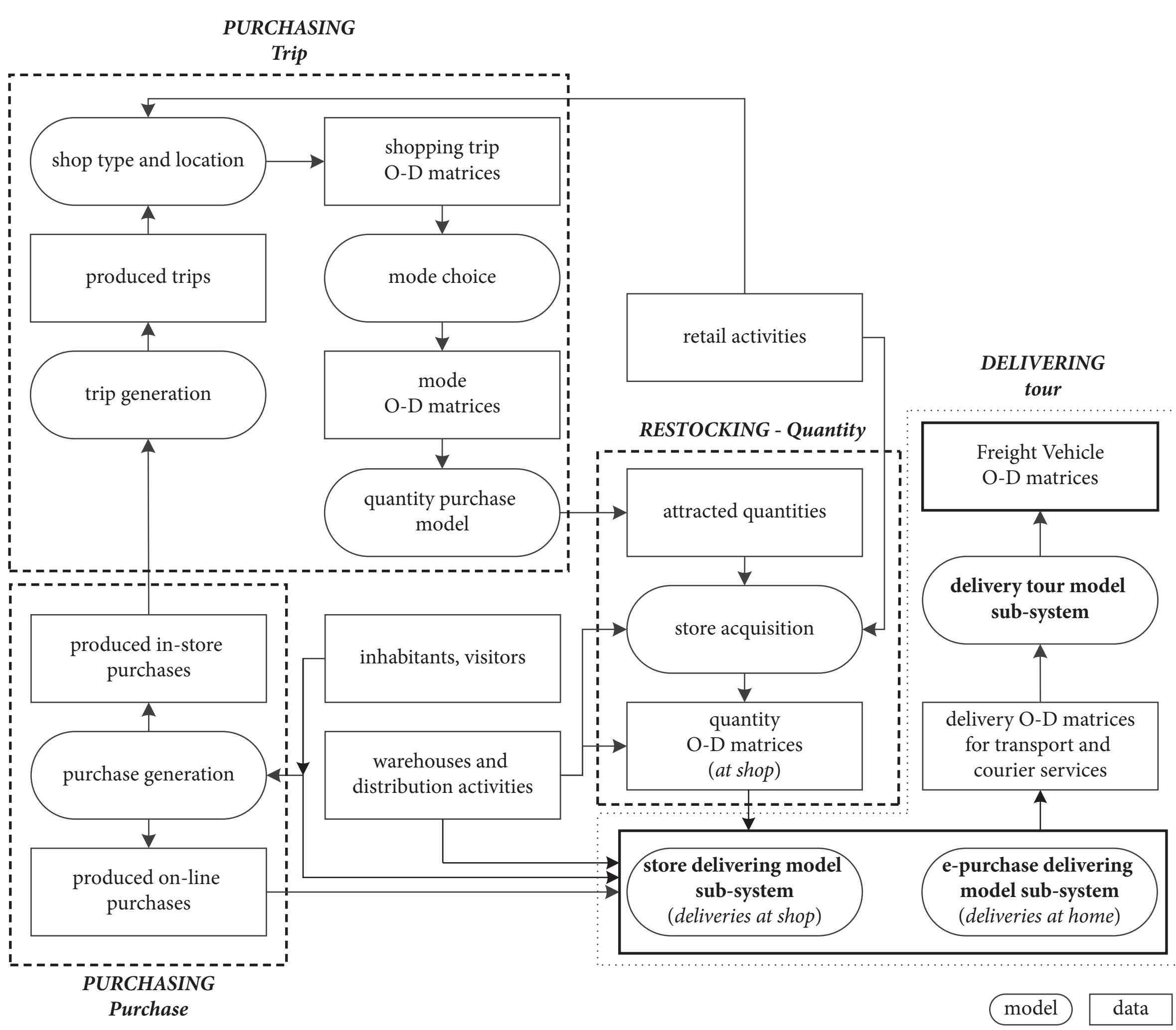

Figure 3: Mixed/integrated modelling framework [49].

e-purchases, while housewives make the highest number of weekly purchases [67, 79]. For example, more weekly trips are taken to purchase foods and clothing, while there are significant differences between freight and the choice of retail outlet. Young people (less than 29 years) prefer large retailer outlets and have the highest share of using a transit; the share of using car increases when the size of the shop and trip length increases [49]. Therefore, simulation tools should take all these features into account, given that they can significantly impact on the quantity bought at each store and subsequently on the restocking quantity to transport. As shown in Figure 3, the purchasing stages can be modelled through two submodels: the first (*purchase*) points out the end--consumer's decision to buy and the second (*trip*) simulates how such decisions drive users to travel for shopping. The output is the quantity of goods required to satisfy the demand at the store and online.

Then, given the study area, which was previously divided into a number of zones, and let d be its generic zone and i be the category of end-consumers (e.g., students and employees), the total quantity $\mathrm{QT}_{.d}[sk]$ required in zone d to satisfy the purchases (e.g., weekly) of goods of type s made by end-consumers belonging to category i living in zone o, can be calculated as follows:

$$\mathrm{QT}_{.d}[\mathrm{sk}] = \left(\mathrm{QI}_{.d}^{\mathrm{store}}[\mathrm{sk}] + \mathrm{QE}_{.d}^{\mathrm{store}}[\mathrm{sk}]\right) + \mathrm{QI}_{.d}^{\mathrm{online}}[s], \quad (1)$$

where

(i) $\mathrm{QI}_{.d}^{\mathrm{store}}[\mathrm{sk}]$ is the average quantity of goods type s destined to the internal zone d to be sold in retail outlet of type k for satisfying the demand by end-consumers living/working *within* the study area;

(ii) $\mathrm{QE}_{.d}^{\mathrm{store}}[\mathrm{sk}]$ is the average quantity of goods type s destined to the internal zone d to be sold in retail outlet of type k for satisfying the demand by end-consumers living/working *outside* the study area;

(iii) $\mathrm{QI}_{.d}^{\mathrm{online}}[s]$ is the average quantity of goods type s destined to zone d bought one line by end-consumers living/working *within* the study are.a

For more details on the calculation of the number of purchases made in the store or online, as well as for the conversion of at store purchases to trips and subsequently to quantity, refer to Comi [49].

3.1.2. The Restocking Stage. Such a stage allows the O-D flows for restocking shops to be pointed out, as well as to identify the O-D pairs of deliveries to end-consumers that bought online. Therefore, the output of this stage is the O-D flows at stores and at home (or better, to location of end-consumers). The stage consists of two main steps: spatialization of required freight flows by retailers (*acquisition*) and end-consumers. Generally speaking, the acquisition stage tells us the origin of the items needed to fulfil the end-user's request at home or in stores. For instance, the examination of the origin-destination flows of goods heading into Rome's inner area [49] revealed that the majority of Rome's warehouses are situated close to major roads in the suburbs surrounding the city centre (i.e., 73% of the freight originates from a warehouse that is less than 9 km away). Since 90% of the freight originates from a warehouse less than 16 minutes away, journey times can be restricted despite the high level of traffic on the road network. 91% of the goods arrive from medium-sized warehouses with an average of fewer than four employees, in terms of the warehouse size [80].

Let $\mathrm{QT}_{\mathrm{od}}[\mathrm{sk}]$ be the average total amount of products of type s moved in a specific amount of time (e.g., a week or day) between zones o and d for home delivery or retail shop replenishment. It can be determined as follows:

$$\mathrm{QT}_{\mathrm{od}}[\mathrm{sk}] = \mathrm{QT}_{.d}[\mathrm{sk}] \cdot p[o \mid \mathrm{d}s], \quad (2)$$

where $p[o \mid \mathrm{d}s]$ represents the acquisition share obtained, for instance, via a discrete choice *acquisition model*, and is the likelihood that the products attracted by zone d come from zone o (for example, warehouse or courier location zone).

3.1.3. The Delivering Stage. As mentioned in the previous section, the definition of delivery tours from a particular delivery O-D matrix in commodities has been the subject of multiple studies [81–84]. According to Comi [49], referring to the delivery flows for shopping restocking (assuming s and k as stated, without loss of generality), the delivery O-D matrices can be calculated as follows:

$$\mathrm{ND}_{\mathrm{od}}^{\mathrm{store}}[r] = \frac{\mathrm{QT}_{\mathrm{od}}^{\mathrm{store}}}{q[r]} \cdot p[r \mid d], \quad (3)$$

where

(i) $\mathrm{ND}_{\mathrm{od}}^{\mathrm{store}}[r]$ is the at-store delivery on *od* pair performed by the transport service type r;

(ii) $\mathrm{QT}_{\mathrm{od}}^{\mathrm{store}}$ is the average freight quantity flow moved on *od* pair for shop restocking;

(iii) $q[r]$ is the average size of delivery performed by transport service type r (*shipment size model*)

(iv) $p[r \mid d]$ is the probability that the deliveries destined to zone d are performed by transport service type r (*transport service model*), which in general also include the different mode of transport such as railways (e.g., metro, tram, and train [85–87]).

Similarly, it can be done for the deliveries destined to end-consumers from online purchases. However, the extension needs for the transport service model which has to include the choice of the different ways of receiving e-purchases (e.g., attended deliveries and pick-up points).

Finally, following Nuzzolo and Comi [88, 89], which readers can refer to, moving from O-D flows in deliveries, the tours, the delivery trips, and the subsequent *freight vehicle O-D matrices* can be obtained.

3.2. The Decision Support Systems for City Logistics. To simulate the outcomes of city logistics measures and analyse city logistics systems, researchers and practitioners have been forced to develop decision support system (DSS) due to the complexity of simulation methods and models, which require a careful investigation of the various choices made by stakeholders involved in goods transport [9, 90, 91]. With respect to urban freight transport and logistics, research in such a field has so far focused mainly on demand forecasting, action/policy assessment, and the management of delivery travels (tours).

Demand *forecasting* first focused on the simulation of vehicle trips using a truck-based approach and subsequently guided to capture more in depth the different stages of the decisional process of goods movements, delivery and quantity-based approach were developed. A similar development path was followed by the relative DSS. A truck-based DSS was developed in Germany by Sonntag [92] and allows origin-destination (O-D) for restocking activities in terms of vehicle trips to be obtained. Thus, the DSS was extended in Viseva-W, which considers the interaction between restocking and passenger flows by Lohse [93]. However, the interaction between freight and passenger trips is not simulated, and therefore the process underlining that freight flows are produced to satisfy the needs of end-consumers (passengers) is neglected.

Continuing to focus on restocking trips, French researchers developed the DSS named Freturb [94]. It does not focus on vehicle trips but on delivery movements. Through a statistical descriptive approach, it allows highlighting operators' choices in defining delivery movements and gives as output both delivery and vehicle flows in terms of transport service types, vehicle types, and journey types (i.e., round or tour/trip chain).

Gentile and Vigo [95] promoted a DSS called CityGoods as part of the City Port Project [96], which used the Freturb methodology. The models were calibrated using the findings of multiple surveys conducted throughout the study, using a statistical descriptive technique. The primary input variables used are the NACE (European Classification of Economic Activities) classification and the number of establishment employees.

Aiming to point out the supply chain and the interactions among the different stakeholders involved in urban delivering (named, wholesalers, retailers, end-consumers), Boerkamps et al. [97] offered a general modelling framework utilising a quantity-based method, and GoodTrip implemented it. While it is possible to simulate both present and future scenarios, the modelling framework's reliance on empirical relationships may pose certain constraints for further research. Comi and Rosati [98] introduced the CLASS (city logistics analysis and simulation support system) DSS, which links end-consumers' and restockers' choices through a multistage approach based on behavioural-probabilistic models. This system overcomes these limitations. In addition, it mimics the relationship between supply and demand and outputs performance indicators, such as land-use indicators, supply and demand, logistic profiles, and road network performances, that may be utilised in scenario assessments. By calculating several indices linked to land use, supply and demand, logistic profile, and road network performance and impacts, the tool was used to *assess* various urban environments. For instance, three distinct logistic profiles were found in Rome's inner area, indicating that the studied area is primarily distinguished by low homogeneity and high commercial density. The advantages of encouraging the replacement of the delivery fleet with newer, greener cars demonstrated that the pollutant emissions may be lowered by almost 40% [98].

Empirical DSSs were also developed to support planners in the definition of future scenarios (e.g., indicating the measures that are best suited for city uses–*action/policy assessment*). For example, a toolkit was promoted within the European project, Novelog [99]. The toolkit enables users to make an initial evaluation of the various activities and policies that can be put into practice in metropolitan areas. Specifically, users can empirically evaluate policies and activities and their effects according to a set of standards.

Lastly, a substantial body of research has been done on instruments that assist operators in determining the best delivery routes to satisfy clients (such as retailers or end-consumers in the case of residential deliveries–*management of delivery tours*). Using a fleet of trucks, the operators make the delivery trips to pick up and deliver freight. One of the most prevalent logistics optimisation issues is the vehicle routing problem (VRP). Despite being operational in nature, it has long been regarded as an academic field, and there are still numerous obstacles standing in the way of its advancement and use. Although there are many commercial software programmes available to tackle VRPs, each programme must be connected to the business' current software architecture and taught to the planning managers. Furthermore, every real-world VRP DSS is unique and needs a continuous communication channel with the developers. However, there are some open-access solutions that integrate usability, accessibility, flexibility, and ease of use [73, 100–104]. An example is developed by Erdoğan [101] which presents the VRP spreadsheet solver, an Excel-based open-source application for solving numerous VRP variations. While VRP (including scheduling) has garnered a lot of interest, research has only recently advanced to the point where the problem definition includes the prospect of allowing information on the real-time network status and highlights the process of learning about travel costs [34].

4. Technical and Logistics Actions

As discussed in earlier sections, different actions have been developed to reduce the impacts produced by urban goods movements. In particular [27, 105, 106], much attention has been paid to inner urban areas due to high concentrations of economic activities, as well as the presence of both large areas reserved to pedestrians and narrow streets with few spaces available for delivering. All such factors have a non-negligible impact on the traffic in terms of congestion (e.g., reduction of road capacity due to double-lane parking for delivering), road safety (e.g., increasing of the interference with pedestrians), and pollutant emissions (e.g., truck vehicles are usually aged and diesel). Table 1 summarises some assessment studies showing the sustainable issues addressed.

Table 1: Main studies assessing city logistics measures.

	Addressed issue	Application context	Proposed solution	Review/modelling
CIVITAS [66]	Social, economic, and environmental issues	Urban context	Stakeholders' engagement, city planning, and telematics apps	Review
Browne et al. [107]	Social and environmental issues	Urban context	Specific policy initiative according to local context	Multistage modelling
Gonzalez-Feliu et al. [50]	Social and environmental issues	Urban context	Specific policy initiative according to local context	Simulation based
Erdoğan and Miller-Hooks [108]	Environmental issues	Urban context	Routing plan	Optimisation based
Nuzzolo and Comi [109]	Social and environmental issues	Urban context	Railway freight distribution	Multistage modelling
Pulawska and Starowicz [110]	Environmental issues	City centre	Credit mobility Delivery bay Urban consolidation centre	Review
ENCLOSE [54]	Social, economic, and environmental issues	Urban context	City planning	Review
Russo and Comi [111]	Environmental issues	Urban context	City logistics measures ex post assessment overview	Review
Marcucci and Gatta [26]	Economic issues	City centre	Demand management initiatives (off-hour strategies)	Simulation based
Russo and Comi [32]	Social issues	Urban context	City logistics measures ex post assessment overview	Review
Comi et al. [112]	Economic and environmental issues	City centre	Delivery bay booking and route planner	Simulation based
De Marco et al. [113]	Social, economic, and environmental issues	Urban context	City logistics measures overview	Review
Gonzalez-Feliu et al. [114]	Social, economic, and environmental issues	Urban context	Stakeholder collaboration	Simulation based
Musolino et al. [73]	Environmental issues	Urban context	Routing plan	Optimisation based
Serafini et al. [115]	Economic and environmental issues	Urban context	Crowdshipping	Simulation based
Musolino et al. [116]	Economic and environmental issues	Urban context	City planning	Optimisation based
Russo and Comi [7]	Economic issues	Urban context	City planners' survey	Review
Comi and Savchenko [11]	Social, economic, and environmental issues	Urban context	Parcel delivering	Simulation based
Mohapatra et al. [117]	Environmental issues	Urban context	Fleet ownership pattern (size and composition)	Review
Pani et al. [118]	Environmental issues	City centre	Carbon policy instruments and incentive schemes	Simulation based
Ramirez-Rios et al. [76]	Social, economic, and environmental issues	City centre	Demand management initiatives (off-hour strategies and vehicle parking)	Simulation based

4.1. Towards Historic Area Preservation. By creating visions and policies for urban goods mobility, several cities have begun to recognise and tackle problems related to goods transportation at the regional or local level. In addition, thorough systems for the last-mile delivery of commodities are frequently absent. Last mile delivery is a challenging problem that will likely need to address concerns about anticipated changes in the industry, which are heavily influenced by uncertainty, in the near future [49, 119]:

(i) small scale frequent shop deliveries (caused by just-in-time policies and high rent costs that limit the amount of retail store surfaces available in the inner districts);
(ii) e-commerce and omnichannel retailing;
(iii) New means of product delivery to consumers, such as same-day, expedited, and immediate delivery;
(iv) Reverse logistics, which handles recycling and products that are no longer needed or desired [120].

Unfortunately, customers are not only increasingly demanding (e.g., reliability and speed of deliveries), but are also extremely cost sensitive and have a very low willingness to pay for new services. Then, the main future issues related to urban goods movements within the inner areas of the cities should refer to the following:

(i) external costs, i.e., air pollutants, noise, contribution to O-D flow demand, and bottlenecks for illegal parking;
(ii) internal costs, i.e., high delivery costs, traffic congestion, unavailable delivery areas, and failed deliveries.

As emerged from some surveys carried out in Europe [53], according to rankings, the two biggest issues facing freight transport and logistics in cities are pollution and traffic congestion. The lack of parking spaces for loading and unloading, the space constraints for logistics' facilities that result in their relocation and concentration in suburban areas (logistics sprawl), regulatory procedures, noise, poor liveability in urban areas, costs associated with logistics suppliers, suppliers' poor enforcement of regulations, energy costs, and wear and tear are additional issues related to urban logistics.

4.2. Future Last-Mile Delivery Challenges. Urban transport and logistics operators face new obstacles in the sector of urban freight delivery, which require them to create new business models that can adapt to local restrictions and requests. But these models have to consider a certain amount of criteria, such as local demand and customer preferences, existing legislation, or the operational characteristics of the area in which they operate. In addition, there are a number of uncertainty components that result from both endogenous and external factors that are common in urban settings and that become more significant when considering the distribution of goods associated with shopping.

Referring to the first (exogenous elements), the current pandemic has brought to light how, at least temporarily, shopping online has shown to be the most effective means of reaching end-users in times of extreme crisis and lockdown [121, 122]. Aside from that, the current global energy crisis is pushing companies to perform consolidation that maximises load capacity for the same number of kilometres travelled, encouraging the use of low-consumption sustainable vehicles in urban distribution (opportunity for telematics to suggest alternative delivery models and support/foster load sharing [123]).

Furthermore, with regard to endogenous factors, the question of uncertainty seems to be crucial. In contrast to passenger transportation, there are more decision-makers in urban freight transportation, increasing uncertainty because of user decisions and behaviour. In addition, retailers have a significant influence on how urban logistics operations are shaped, in addition to government transportation firms, and end-users/citizens who make decisions regarding passenger transportation. As a result, decision-making processes become more ambiguous. In addition, there are other levels of uncertainty associated with shopping, such as the impact of marketing (particularly in the introduction of novel products to the market), the globalisation of production (we operate in a single, enormous global market), the trend of stock exchanges that affects the pricing of specific primary goods, and so on. Fashions and customer habits are also influenced by these levels of uncertainty.

Due to the fact that purchased goods must be delivered to clients at home via delivery tours that are not always optimal, this new trend may have an influence on freight traffic in urban areas. This could lead to an increase in traffic impacts [124]. Therefore, the rise of door-to-door services and e-commerce, which is causing major changes in the delivery process, poses a serious threat to the sustainability of urban freight distribution [125]. The more effective tactics in this situation that can lessen the effects of urban freight should be focused on to [12, 54, 59, 106, 126] minimising the amount of commercial vehicles driven and the number of kilometres they travel; maximising the use of lightweight, environment friendly vehicles; maximising loading and unloading operations to minimise traffic congestion; increasing the cooperation and coordination among logistics and transportation providers; and minimising interferences with other elements of urban mobility (e.g., pedestrians). As a result, three primary research streams have emerged: *pick-up systems* [127–129], *crowdshipping* [125, 130, 131], and *two (multi-) echelon* delivery systems [70, 132].

Pick-up (locker) *systems* allow optimisation of deliveries to end-consumers [129, 133–137]. In actuality, a sizeable portion of consumers currently make transactions online, and e-commerce is expanding significantly. The e-delivering process, consisting of different stages, can be the object of significant improvements in terms of efficiency, cost, and so on. For example, delivery to the customer's door is not efficient for additional costs for repeated deliveries (e.g., not-at-home issues), as well as for the spawled destinations and not consolidated packages. According to the findings of an evaluation done in San Paolo, Brazil, lockers can be a viable substitute to lessen environmental externalities because they can cut fleet and vehicle mileage by more than 50% [138]. Similarly, the best position for the lockers can direct a notable decrease in house delivery. According to a study conducted in the Netherlands by Molin et al. [139], the percentage of respondents who chose home delivery may drop from 71% to 7% if the distance to the parcel lockers decreased.

On the other hand, *crowdshipping*—involving city users, such as citizens, in the transportation of freight—could be a promising course of action, motivated by the chance to minimise the number of trucks in urban areas and to take advantage of the transport capacity of nonprofessional users. Crowd shipping is a cutting-edge delivery method that has the potential to, at least, encourage greater utilisation of the untapped transport capacity, lowering transportation expenses and emissions [125, 140, 141]. Crowd shipping allows people who are heading to a specific location to make deliveries while on their way, and businesses may depend on them to finish some of their deliveries. The process of matching supply (of transport) and demand (for delivery) through online platforms is the basis of this integration of freight and personal mobility. Crowd shipping, as opposed to truck delivery alone, can save approximately 14% of the total cost and 26% of the miles driven, according to the findings of various pilot experiments [142]. In addition, the evolution of crowd shipping to move away from the conventional model centred on private vehicle trips and towards the usage of nondedicated public transportation journeys in conjunction with automated parcel lockers (APLs) represents a problem for the future. This solution might present a chance to lessen the effects of last-mile delivery, at least theoretically [143, 144]. According to the initial findings of a survey carried out in the Greater Copenhagen Area, younger people, students, and (to a lesser extent) those who are employed or self-employed are more likely to participate in the crowd shipping concept, whereas older people (60+) are less inclined to do so. In addition, compared to people with short-term education, older users and those with higher(er) incomes are more likely to spend time fetching and dropping off packages [143]. Besides, the decision of whether or not to use crowd shipping is known to be subject to various service, time, and price conditions, including trust in a correct delivery. The effect of trust has been investigated explicitly by Cebeci et al. [145] through a stated preference survey. The findings show a significant influence on the service choice of attributes related to service adoption, except for the delivery company's reputation and the possibility of damage. In addition, all attributes except delivery time have a significant influence on trust, which has a partially mediating effect on the adoption of the service except delivery time, and a fully mediating effect on adoption via reputation and damage.

E-retailers, particularly those operating on a big scale, typically implement a *two- or multiechelon* delivery system [132, 142, 146]. This system consists of a warehouse located on the edge of service areas, such as municipal boundaries, delivery centres, and customer locations. Orders are packaged in warehouses and shipped to the associated delivery (city) hub; shipments from various warehouses and distribution centres are received by the delivery hub (city), which subsequently distributes them to clients in its zone. Furthermore, mobile depot-based two-tier distribution systems were recommended as a solution to these problems due to tighter restrictions on urban freight transit, including parking places, and the high installation costs of logistical infrastructures in inner city regions [70]. Ultimately, research has shown that multiactor coordination and collaboration based on shared UCC can reduce the adverse effects of supply and demand stochasticity while preserving a high service level at a manageable level of operating costs [147, 148].

These measures could encourage changes to scheduling and night deliveries. Several studies [19, 149] have demonstrated that moving urban deliveries to off-peak hours can ease traffic and improve the effectiveness of freight operations. Daytime traffic congestion is usually very bad in densely populated urban regions. Even yet, there are highways and unloading areas that are not in use in the evening, at night, or early in the morning. Compared to peak times, off-peak deliveries can result in travel time savings of more than 50%, according to pilot initiatives in New York, London, Paris, and Stockholm [150].

Ultimately, telematics presents new opportunities to maximise delivery efficiency. Specifically, the development of new integrated and dynamic city logistics solutions and the consequent identification of new horizons for intelligent transport systems (ITSs) have been made possible by the emergence of emerging information and communication technologies (e-ICTs). Transport and logistics companies can and should have technological solutions to improve the efficiency and sustainability of their urban freight transport operations, according to the requirements of local and international authorities. New ICT-based solutions have the potential to reduce the number of kilometres driven in urban areas, improve safety, and mitigate the impact on the environment and traffic [34]. In this sense, the future challenges of urban freight transport should be the development of novel smart routing devices and services that can determine the best delivery path and resolve vehicle scheduling/routing issues. These new tools have the potential to significantly reduce travel time, which is estimated in the case study presented by Russo and Comi [151, 152] to exceed 20% compared to average travel times. This reduction would pertain to driving and working time, one of the main headings of costs supported by transport and logistics operators.

Finally, in order to capture the above indications, the urban planning approach should be revised embracing the concept of the "*well functioning*" [153] and to move towards the triple access planning approach [154], which allows us to integrate the three fundamental and essential elements that define the entire shopping experience—transport, telematics, and land use—in planning with the various urban freight distribution components.

5. Conclusions

To assist policymakers, practitioners, and researchers in assessing urban goods movements in order to improve the quality of life of city dwellers, the article reviewed current efforts in the subject of urban freight logistics. In particular, the study:

(i) reviewed urban transport planning focussing on urban freight transport;
(ii) reviewed the main class of methods and models capable of assessing ex ante the future urban mobility scenarios and linking end-consumer and freight-related restocking choices;
(iii) reviewed the decision support system that can help city planners;
(iv) categorised the primary classes of urban freight transport management and control measures and noted the issues that last-mile delivery will face in the future.

Given that urban and metropolitan goods movements make up a sizeable portion of traffic in these locations, interest in them is growing on a global scale. To improve the sustainability of the city, numerous city officials have put policies in place to lessen the negative consequences of goods transport. Moving from the review of the current needs of urban areas and taking into account that all these measures and services should be integrated and designed efficiently through a proper action plan (i.e., SUMP), the road ahead for sustainable urban mobility planning is pointed out, showing the need to include uncertainty and adopt the TAP approach. As well as considering the interests of urban transport stakeholders and actors, indications allow for the identification of extremely diverse bands of actions and potential linkages between goods and passengers, or consumers. However, different decision-makers may have to decide how the commodities must move in order for commodities to be obtained from producers to final customers.

Implementing goods transport initiatives must take these disparate objectives into account and identify the best way to balance the interests of each actor. Research revealed that while several methods have been proposed to highlight flows connected to freight, many of them assess passenger and freight traffic independently. The interplay between the movements of goods and passengers and their impact on the transport system is rarely clearly considered in municipal actions. Therefore, future research and work should focus more on offering instruments and guidelines that support policy makers, practitioners, and researchers. These guidelines should include the combination of urban passenger travel demand and commodity flows, as well as their interaction, cooperation, and coordination of freight transport activities, when planning sustainable urban freight logistics. Then, the new planning challenges, as those given by TAP, should be pointed out and the route for including them in the current planning tools should be investigated.

Data Availability

No underlying data were used to support the findings of this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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