



# City Logistics landscape in the era of on-demand economy

## Main challenges, trends and factors influencing city logistics

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## List of acronyms

**B2B:** business to business

**B2C:** business to consumer

**B2P:** business to person

**BEVs:** battery electric vehicles

**BSS:** Binnenstadservice

**CNGs:** compressed natural gas

**EDVs:** electric delivery vehicles

**EFFVs:** environmentally friendly freight vehicles

**EFVs:** electric freight vehicles

**EU:** European Union

**FC-EREVs:** fuel cell range extender electric vehicles

**FCVs:** fuel cell vehicles

**ICT:** Information and Communication Technology

**ICEVs:** internal combustion engine vehicles

**IoT:** Internet of Things

**LNGs:** liquefied natural gas

**LEZ:** Low emission zone

**LL:** Living Labs

**P2B:** person to business

**P2P:** peer to peer

**PI:** Physical Internet

**PPPs:** public-private partnerships

**SDGs:** Sustainable Development Goals

**UCC:** urban consolidation centre

**UFT:** urban freight transport

**TCO:** total cost of ownership

**ZEZ:** Zero emission zone

## Executive summary

One of the most dynamic and evolving sectors of urban transport is logistics. Last mile delivery systems are facing many challenges associated with the dawn of on-demand logistics, struggling to accommodate citizen's expectations for responsive logistics systems, that deliver products at low or even zero cost. The recent COVID-19 crisis has demonstrated the importance of the resilience of the logistics chain, which sees the most complex stretch in the last urban mile. It is also changing the way citizens buy, increasingly turning to online, on-demand platforms. This pressure on the system must therefore be efficiently mitigated.

To minimize the negative impacts of this phenomenon, LEAD is creating Digital Twins<sup>1</sup> of urban logistics networks in six cities (Living Labs), to test different innovative solutions for shared-connected and low-emission logistics operations and to address the requirements of the on-demand economy while aligning competing interests and creating value for all different stakeholders.

The first step, therefore, requires a clear identification of the challenges and trends that influence urban logistics, in particular on-demand deliveries, as well as the different perspectives and needs of the relevant stakeholders. This facilitates the definition and success of value cases to be tested in the Living Labs. In order to provide this knowledge, this deliverable provides a literature review and a survey with 125 participants, identifying the factors that most influence urban logistics, also broken down and analysed by type of stakeholder. New technologies, consumer requirements and economic & demographic elements were selected as the factors that most influence on-demand logistics.

Furthermore, to favour the identification of the innovative solutions to be tested in the Living Lab and the different LEAD strategies (D1.5), the deliverable identifies and schematizes the typologies of agile storage and last-mile distribution schemes, based on four categories: i) Delivery locations, modes and times; ii) Loading and unloading area management; iii) Consolidation iv) New technologies. This will help partners to understand how the solutions will likely perform under various economic, environmental and social conditions, looking at concrete experiences and evaluations throughout Europe and the rest of the world.

The long-term vision of LEAD is to design an Open Physical Internet (PI)-inspired framework for Smart City Logistics that incorporates the created Digital Twins, laying the foundations for the development of large-scale city Digital Twins. For this reason, the deliverable provides an overview on the state-of-the-art and new trends on PI developments. The specific case of the SONAE partner is presented, as the company is already applying the Physical Internet approach to its operations in the ICONET project.

Finally, LEAD wants to identify the most appropriate green vehicles for its value cases, at the same time reducing air pollution and increasing the efficiency of the entire system. In the last section, green vehicles are classified and evaluated in terms of requirements for their effective integration with logistics operations. An enablers / barriers map identifies the necessary actions, while for each vehicle the following are discussed: policy and legislation; technology and innovation; infrastructure;

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<sup>1</sup> A Digital Twin is a digital replica of a complex real-world urban environment that represents different processes, actors and their interaction.



consumer acceptance. A common element is the need for a charging infrastructure network suitable for the upscaling of these vehicles.

# 1 Introduction

## 1.1 The LEAD project

LEAD will create Digital Twins of urban logistics networks in six cities, to support experimentation and decision making with on-demand logistics operations in a public-private urban setting. Innovative solutions for city logistics will be represented by a set of value case scenarios that address the requirements of the on-demand economy while aligning competing interests and creating value for all different stakeholders. Each value case will combine several measures (LEAD strategies): a) innovative business models, b) agile urban freight storage and last-mile distribution schemes, c) low-emissions, automated, electric, or hybrid delivery vehicles, and d) smart logistics solutions.

Cost, environmental, and operational efficiencies for value cases will be measured in 6 Living Labs (LL). Evidence-proven value cases and associated logistics solutions will be delivered in the form of exploitable Digital Twins, incorporating the models that support adaptation to different contexts and that provide incentives for public-private partnerships (PPPs).

The LEAD consortium comprises 22 partners, all of whom are involved in the Living Labs, supported by 5 international partners for knowledge transfer. This structure incentivizes the co-creation of solutions by city authorities, logistics industry leaders, start-ups, and research experts in freight modelling, complex simulation and logistics optimisation.

## 1.2 How this deliverable links with the LEAD project

LEAD's vision will be realised through four key implementation objectives that are designed to address the specific business, technical and regulatory challenges and fulfil the innovation, dissemination and commercial ambitions of the project. These are i) Value cases co-design, ii) Digital Twins Tools, iii) Validation in Living Labs, iv) Scale-up.

This deliverable is framed within the first objective, which aims to develop a contextual framework to support the design and implementation of cost-effective sustainable integrated city logistics systems, by involving stakeholders in the co-creation of innovative last mile solutions and services that address the needs of the on-demand economy. The deliverable provides an analysis of the strategic, regulatory, business, technology, environmental factors influencing complex city logistics systems in the on-demand economy era. The analysis is backed by a consolidated survey on the current needs, trends and challenges of last mile logistics. This preliminary work is essential to generate up-to-date knowledge about the on-demand logistics ecosystem, functional to the articulation of the following activities both for the design of the solutions and strategies, for the definition of models and tools, and for the real-life applications (Living Labs experimentation, upscaling of the solutions).

### 1.3 Purpose of this deliverable and document structure

This deliverable collates, refines and frames existing knowledge and understanding of the city logistics landscape in the era of on-demand economy. The document starts highlighting the main challenges and trends that are influencing city logistics due to the on-demand economy. Based on these findings, it covers (i) typologies of agile urban freight storage and last mile distribution schemes; (ii) an overview of the Physical Internet (PI) optimisation criteria; (iii) green vehicles classification, considering their potential integration in urban logistics.

**Key challenges and trends influencing Urban Freight Transport (UFT).** Cities and industries need new knowledge-driven logistics solutions to cope with the contemporary challenges. The main factors influencing increasingly complex city logistics systems have been analysed, including strategic, regulatory, business, technology elements. The key challenges and trends that are influencing urban freight transport were captured through a desk research and reinforced via an in-depth survey, involving the project partners and a wider network of relevant stakeholders, including the Advisory Board and international cooperation partners.

**Typologies of agile storage & last-mile distribution schemes.** Retailers and logistics operators are testing alternative urban delivery schemes, such as home delivery, click and collect, kerbside pickup, parcel lockers and more. Different agile storage can be used as proximity stations or proximity points to improve the last mile delivery efficiency, particularly to distribute small- and medium-sized goods, utilising integrated network approaches. Market segment, customer profile, economic and operational resources are some of the main drivers for this complex choice. Thanks to the support of LEAD industrial partners, who apply these schemes or plan to do so, the deliverable categorized and analysed the configuration of these models, highlighting their trends and impacts.

**The Physical Internet: state-of-the art and new trends.** The development of the Physical Internet (PI) concept aims to a transition from single optimization problems to a holistic operational research approach based on an integrative transportation network. Since the resources of logistics companies should be used collaboratively, new developments are needed for the optimization of this transportation network where movers, nodes and containers are the three physical elements of the PI. The deliverable reviews different PI-related approaches to optimise the supply chain. Liaison with the ICONET project and the ALICE network generate additional elements to provide inputs on the state-of-the art and new trends on PI developments.

**Green vehicles classification and their integration in urban logistics.** The innovations introduced in the vehicles market have been disruptive, especially new engine technologies and driverless vehicles. Green vehicles are needed for decarbonising transport, reducing air pollution and increasing the efficiency of the system. In the last section, green vehicles are classified and evaluated in terms of requirements for their effective integration in city logistics. An enablers/barriers map for their integration in urban logistics defines what are the necessary technological, organisational and regulatory conditions for their uptake. The investigated elements include: policy and legislation; technology and innovation; infrastructure; consumer acceptance.

## 2 Key challenges and trends influencing urban freight transport

### 2.1 The context

#### 2.1.1 Cities: an unsustainable future today

Cities and metropolitan areas have increasingly become the main centres of the economic and social life. A globalised international system tends to increase opportunities in cities at the expense of more peripheral areas, accentuating their relative attractiveness.

Today, there are 4.3 billion people living in cities (55% of the world's population) and by 2050 it is expected to be 6.5 billion (66% of the world's population). In 2018, around 70% of the EU population resided in urban areas — comprising cities, towns and suburbs<sup>2</sup>. Further, it is estimated that urban areas are responsible for generating over 85% of EU GDP<sup>3</sup>. The increasing amount of people located in cities therefore implies new challenges, including mobility and logistics aspects (**UN-Report, 2014**).

Cities consume 75% of the available resources, 60%-80% of the energy produced and generate 70% of the CO<sub>2</sub> emissions produced, while occupying only 2% of the land (**Swilling et al. 2013**). These numbers highlight the weight that cities play in the current model of economic development.

The impact of climate change and the consequences that will ensue are the most visible damage the excessive and irrational consumption of resources implies. Drought, environmental disasters and soil depletion will be phenomena that we will probably have to cope with (**M. Allen et al. 2018**). Rapid and urgent action is needed to avert this change. The actions to be taken must reduce emissions by 45% compared to the 2010 level by 2030 and then reach global net anthropogenic CO<sub>2</sub> emissions in 2050 (**M. Allen et al. 2018**).

Mitigation measures are not sufficient. The whole economic paradigm and its compatibility with sustainable development needs to be rethought.

The Brundtland Commission defines the concept of sustainable development as “a model that meets the needs of current generations without compromising the ability of future generations to meet their own” (**World commission on environment and development, 1987**).

In 2015, the United Nations, with an extensive collaboration of numerous stakeholders, drafted the Sustainable Development Goals (SDGs) for 2030. The idea behind these objectives is a concept of multidimensional development where the economic, environmental and social dimension is simultaneously considered. These dimensions are held together by the principle of intra and

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<sup>2</sup> <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20200207-1>

<sup>3</sup> [https://ec.europa.eu/transport/themes/urban/urban-mobility/urban-mobility-package\\_en](https://ec.europa.eu/transport/themes/urban/urban-mobility/urban-mobility-package_en)

intergenerational fairness: there can be no development without equity within the state, between states and between different generations of individuals **(UN, 2015)**.

The key role of the city was recognised in the drafting of the SDGs. Cities are not only the indirect recipient of policies aimed at sustainable development, but they are also considered key development actors. As the city is the centre of social and economic life for much of the world's population, it was deemed necessary to draw a specific *Goal 11: Sustainable Cities & Communities* on how cities must change to accompany and drive change towards a more sustainable world.

Goal 11 aims to make cities resource efficient (water, energy, waste), resilient to the possible effects of climate change, with an efficient, green, unpolluted and inclusive transport system designed so as not to develop and eradicate existing slums **(UN, 2015)**.

Although not explicitly mentioned, cities are also the recipient of *Goal 12 : Responsible Consumption & Production*, which aims to create sustainable production models **(UN, 2015)**. While metropolitan areas are the largest consumer centre and therefore the largest producer of waste material, sustainable production should focus on cities key role in balancing the relationship between production, consumption and waste generation.

To date, however, these targets seem hard to reach: 828 million people live in slums on the outskirts of cities and the rapid growth of the population puts increasing pressure on drinking water sources, sewage systems, the living environment of cities and public health, effectively making many cities the emblem of an unsustainable development model **(UNDP, 2018)**. Transport, freight and sustainability are strictly intertwined.

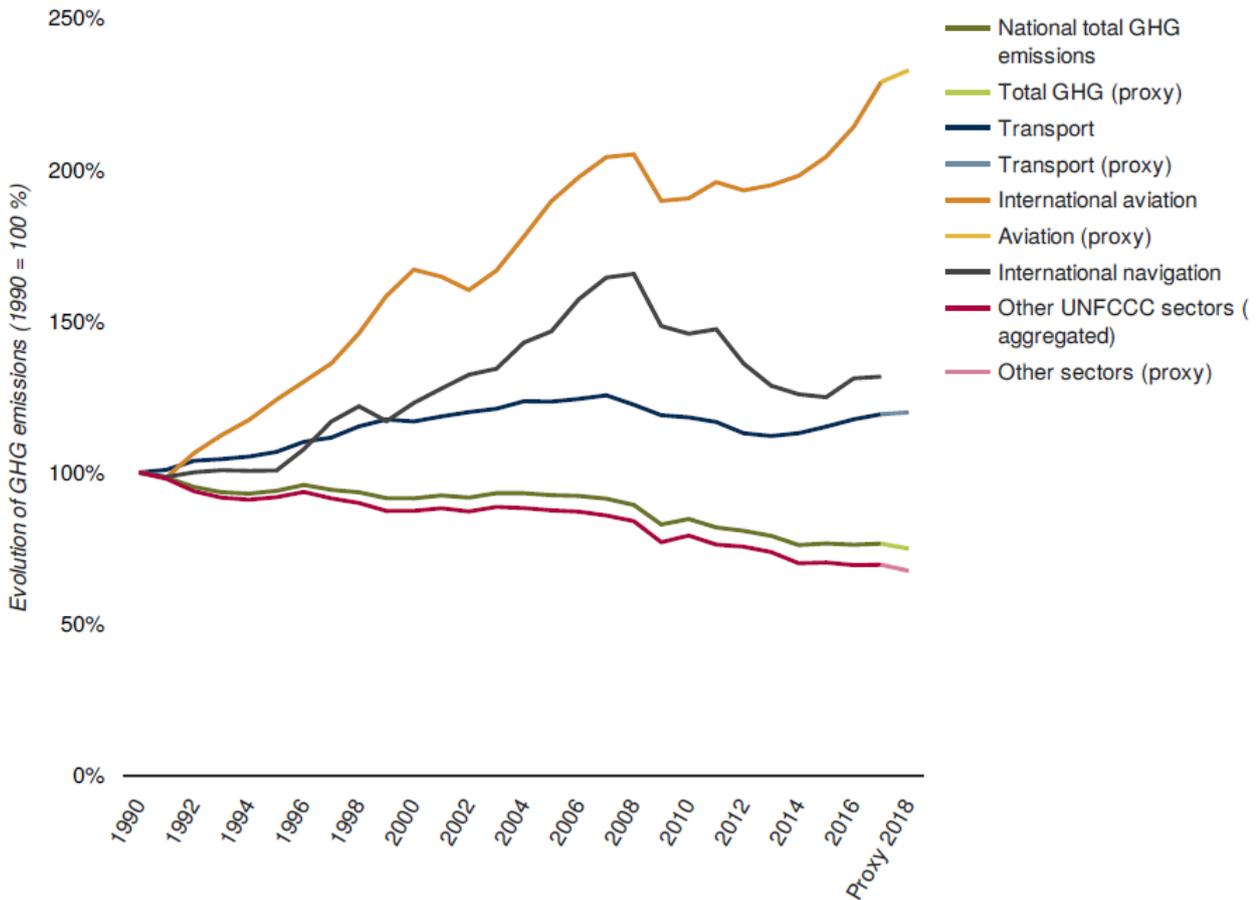
If the city is the centre of a globalized society, the transport sector is certainly its foundation. The flow of goods and services, people and information and the worldwide supply chain are only possible thanks to infrastructure, logistics capabilities and resilience of the transport system, as the epidemic crisis caused by the COVID-19 virus has clearly proven.

The link between transport and economic growth depends on the consideration that goods, before they can be consumed and generate wealth, must be transported from the place of production to the place of consumption.

The proper functioning of the entire transport sector supports economic growth and promotes further development by encouraging investment and opportunities for market expansion.

However, the economic boom of the last century and the first twenty years of the 21st century has also brought to light the weaknesses of this foundation. The entire transport sector contributes to the current non-sustainability of the economic system. Polluting fuels are used in the transport sector serving, very often, an inefficient supply chain characterized by inadequate logistical capabilities.

**Figure 1: EU greenhouse gas emissions in the transport sector**

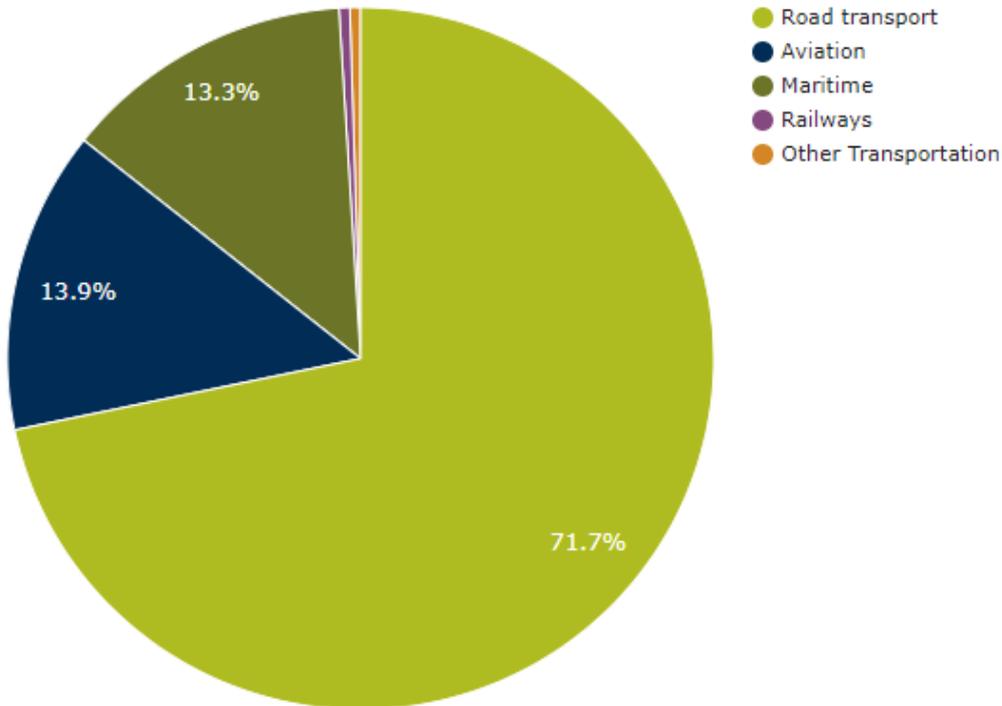


**Source: (European Environment Agency, 2020)**

Today, more than 20% of the world's CO2 emissions are related to the transport sector, 13% are related to passenger mobility demand, while around 7% is related to freight transport (OECD/IA, 2014; OECD/ITF, 2015).

Freight emissions are expected to increase four-fold from 2010 to 2050 due to increased trade, longer supply chains and a possible shift towards road transport. These figures therefore call for a sharp reorganisation of the entire transport sector, in particular the road transport sub-sector, where the share of greenhouse gas emissions is 80% (Figure 2) in the United States and 71% in the EU, respectively (OECD/ITF, 2015; Environmental Protection Agency, 2018; European Environment Agency, 2019).

**Figure 2: EU (Convention)- Share of transport greenhouse gas emissions 2019**



**Source: (European Environment Agency, 2019)**

### 2.1.2 Negative externalities due to urban transport

If the transport sector is generally a very inefficient sector, it is even more noticeable in cities because of the consequences it generates. The increasing density of housing and new commercial paradigms such as e-commerce and on-demand economy exacerbate already detrimental phenomena such as air pollution, noise, accidents and congestion. The combination of these phenomena entails economic costs known as externalities which not only undermine the productivity of the economic activities of cities, but directly affect the quality of life<sup>4</sup>. Consider, for example, the life expectancy losses due to road accidents or diseases ascribable to breathing harmful gases.

Road accidents (29%), congestion (27%), air pollution (14%) and climate change (14%) (Figure 4) are the four externalities that weigh the most in terms of economic costs in Europe. Road transport is responsible for most of the total external costs/externalities produced (about 83%) (CE Delft, 2019).

<sup>4</sup> "Externality arises when economic and/or social activities of one group have an impact on another group or person and when this impact is not considered or compensated by the first group." CE Delft. (2019). Handbook on External Costs of Transport. In European Commission. <https://www.cedelft.eu/en/publications/2311/handbook-on-the-external-costs-of-transport-version-2019>

The numbers in question are macroscopic and go beyond the aforementioned effect of greenhouse gases and air pollution. Overall, externalities represent a huge loss for society, equivalent to around 6.6% of EU GDP (CE Delft, 2019).

Most of the economic and social losses are concentrated in the city. For example, according to a McKinsey report, the cost of congestion in cities is between 2% and 4% of the cities' GDP (Bouton et al. 2017).

Freight transport has a significant impact on the externalities produced. In fact, light and heavy road vehicles and, to a lesser extent, rail and inland navigating vehicles produce, in the European Union (EU) alone, over 200 billion € total external costs (Figure 3). Half of these are produced by light vehicles, mostly operating within cities (CE Delft, 2019). A large portion of the total amount of externalities the transportation sector produces is due to freight transport thus implicitly linked to urban logistics, in general, and to the last-mile, in particular<sup>5</sup>, Table 1 shows that last mile logistics is burdened by the congestion problem, accounting for more than half (55.5 of 117.6 billion euros) of the external costs light commercial vehicles produce (CE Delft, 2019).

**Table 1 Total external costs 2016 for EU 28 freight transport by cost category and transport mode**

Cost category	Freight Transport						
	Road				Rail		IWT
	LCV-petrol bn €/a	LCV-diesel bn €/a	LCV-total bn €/a	HGV - total bn €/a	Electric freight bn €/a	Diesel freight bn €/a	Inland vessel bn €/a
Accidents		19.8		23.0	0.3		0.1
Air Pollution	0.3	15.2	15.5	13.9	0.01	0.7	1.9
Climate	0.7	12.5	13.2	9.6	0.00	0.2	0.4
Noise		5.4		9.1	2.1	0.4	
Congestion*		55.5		14.6			
Well-to-Tank	0.2	3.6	3.8	3.7	0.5	0.1	0.2
Habitat damage	0.2	4.2	4.4	3.6	0.8	0.2	0.3
<b>Total</b>			<b>117.6</b>	<b>77.5</b>	<b>5.4</b>		<b>2.9</b>
<b>Total per mode</b>		<b>195.1</b>			<b>5.4</b>		<b>2.9</b>
<b>Total as % of EU28 GDP</b>		<b>1.31%</b>			<b>0.04%</b>		<b>0.02%</b>
<b>Total freight transport</b>				<b>203.4</b>			

\* Congestion in terms of delay cost generated by the various vehicle categories.

Source: (CE Delft, 2019)

## 2.2 Current trends in urban freight transport

The increase in total external costs in the urban area is largely due to the continuous increase in light commercial vehicles used for last mile deliveries. The latter, although representing a minor proportion of the total number of vehicles circulating within the city, plays a fundamental role in explaining urban

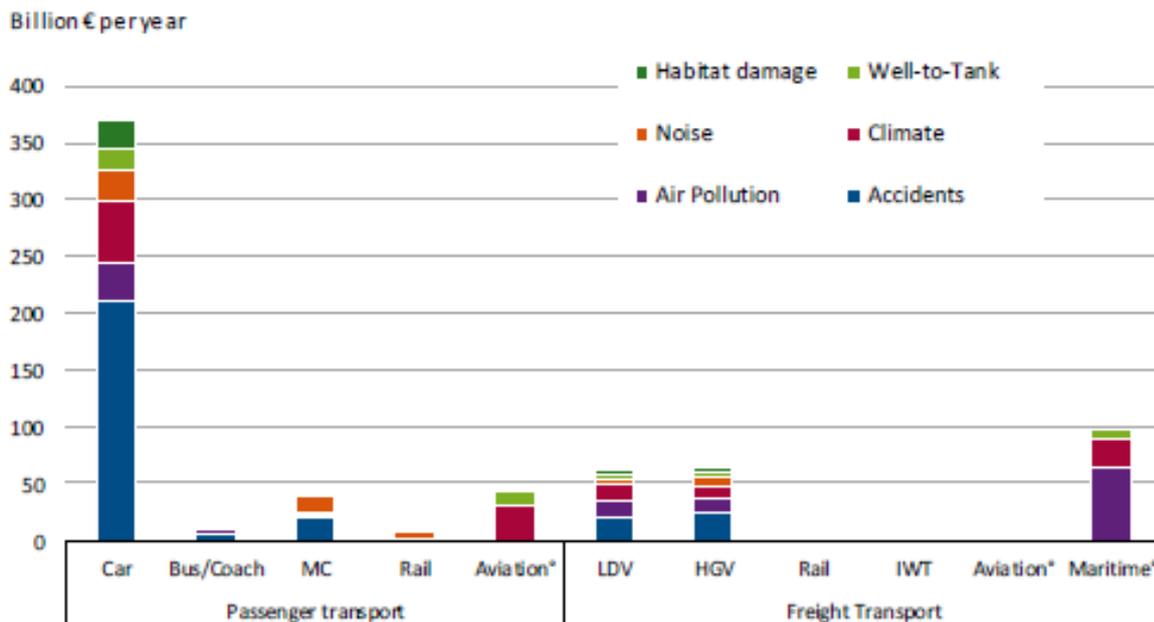
<sup>5</sup> An example of this can be the transition from the urban or peri-urban distribution center or warehouse to the end consumer.

road space occupation and externalities. Today, freight commercial vehicles, with respect to the overall situation, travel 15-25% of the kilometres in the city, occupy 20% to 40% of the urban road space, cause between 20% and 40% of CO2 emissions related to urban transport and are responsible for 30% to 50% of the main air pollutants (PM and NOx) (**Smart Freight Centre, 2017**).

Negative performance in urban logistics would have detrimental consequences for the liveability of cities and globally in the fight against climate change. Some scenarios today predict a 78% increase in last mile delivery by 2030 change (**World Economic Forum, 2020**). The subsequent increase in light commercial vehicles would provoke a 21% increase in congestion, equivalent to approximately additional eleven commuting minutes in 2030 compared to 2010. Globally, freight emissions would rise by 32% reducing the effects of measures put in place to mitigate climate change (**World Economic Forum, 2020**).

The increase in commercial vehicles used for freight transport not only depends on the rise in demand for goods and services, due to the growth of city dwellers and to the additional spreading of logistic sprawl, but also on e-commerce and on-demand economy.

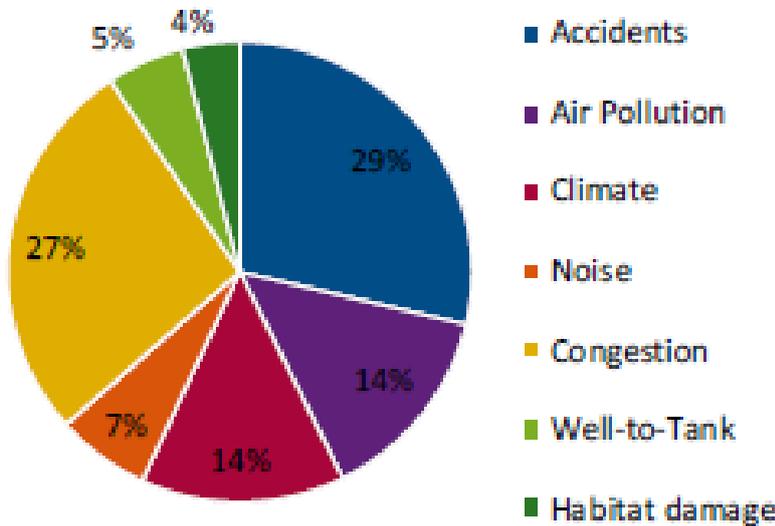
**Figure 3: Total external cost 2016 for EU 28 (excluding congestion)**



\* Data for aviation and maritime: rough estimations for EU28.

Source: (CE Delft, 2019)

Figure 4: Share of the different cost categories on total external costs 2016 for EU 28



Including data for aviation and maritime: rough estimations for EU28.

Source: (CE Delft, 2019)

### 2.2.1 E-commerce

E-commerce is the process of buying and selling products and services by electronic means. This can be classified based on who are the active parties in the sale. B2B (Business to Business) is when the transaction takes place between two companies, B2C (Business to Consumer) when there is a direct transaction between the company and the end consumer, and C2C (Consumer to Consumer), a less widespread category, when there is an exchange of goods or services between two consumers.

E-commerce is now experiencing growth of more than 10% per year worldwide and regionally. This is remarkable considering that, over five years, e-commerce sales ratios nearly tripled globally (**World Economic Forum, 2020**).

The first factor that explains this explosion is primarily the increase in people using the internet. In 2018, 4 billion people had access to the internet, an increase of 10% compared to 2016 (**Casaleggio Associati, 2018**). Today, the widespread use of the Internet is undergoing a further acceleration due to the epidemic crisis caused by COVID-19. In addition to this factor, online sellers are having a huge success because of the price and perceived convenience of the service. Amazon and Alibaba alone manage to bill more than a trillion dollars a year (**Casaleggio Associati, 2018**).

The widespread diffusion of smart devices considerably reduces transaction costs thus allowing a substantial increase in the total number of mobile-based transactions performed each year. Online channels are expected to grow significantly in the near future across all the retail industry where the most important actors are purposely pursuing a multi/omni-channel strategy so to either increase or retain their market power/competitiveness (**Verhoef et al. 2015**) .

Along with a strong and steady growth of this specific market segment a substantial strain has developed for brick-and-mortar retailers that are now compelled to improve e-commerce-equivalent capabilities so to make their stores competitive also online (**Fruhling & Digman, 2000; Kim & Park, 2005**) .

Given this context, both delivery logistics and service quality acquire a strategic value in determining retail competitiveness. Retailers competing online need to develop on-demand logistic capabilities to keep up with customer expectations which incorporate both high logistics service quality and low costs. Most of the customers' requirements with respect to logistics service quality are focused on short delivery times which often constitutes the main driver for the overall delivery experience. Last-mile delivery optimization plays a key role in promoting retailers' competitive advantage by increasing customer satisfaction (**Esper et al. 2003; Napolitano, 2013**) . This heavily depends upon how goods fulfilment is performed, especially since, while short, this segment accounts for approximately 50% of total logistic costs.

The increase in the number of e-commerce consumers translates into an increase in freight transport and an increase in light commercial vehicles. Although, in theory, online shopping can make people shop less in physical stores and therefore move less by reducing the kilometres travelled overall, this is not often the case because omnichannel activities<sup>6</sup> imply more kilometres travelled. The total number of kilometres travelled between freight and passenger transport does not seem to decrease (**Rai et al. 2019; Rotem-Mindali & Weltevreden, 2013**).

E-commerce therefore seems to be complementary or at least not a substitute for traditional retail-generated trips, and is therefore an additional cause of externality, also as a result of the development of the on-demand economy and the *just-in-time* logistics paradigm.

### 2.2.2 The on-demand economy

The *on-demand economy* refers to a new economic model that is based on the use of online platforms that allow immediate *matching* between a user who requires a good or a service and another who is able to provide it "sharing" the assets of goods, skills, time of which it is in possession (**Dagnino, 2015**). The term *on-demand* refers to the almost immediate use of a service.

The impact of the on-demand economy in society is enormous; in the United States, the 3.9 million workers employed in the sector in 2017 will increase, according to forecasts, to 9.2 million, with the creation of a new class of entrepreneurs and workers (**Intuit, 2017**). In the field of transport and

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<sup>6</sup> The "omnichannel environment" is a new retail paradigm enabling consumers shopping seamlessly and flexibly through a range of online and offline channels and touchpoints, using advanced technologies on smartphones and other devices. (Buldeo Rai et al., 2019)

logistics, this has led to the reorganization of the supply chain, which has been geared towards a new industrial philosophy, the so called *just-in-time*. It is a philosophy that has reversed the "old method" of producing finished products waiting to be sold (called *push logic*) by switching to *pull logic*, according to which it is necessary to produce only what has already been sold or that is expected to be sold in a short time. In the e-commerce sector, this translates into the sale of immediately deliverable products. *Amazon Prime* and *Amazon Now*, for example, allow online products to be received within a day or even two hours.

The perceived convenience of this new delivery service offered, also supported by the perception of zero delivery costs, is making other modes inadequate. In the US, 74% of consumers say that they will most likely choose again a company that offers a same-day delivery service<sup>7</sup>, while in the UK only 32% of consumers are willing to wait 2 or 3 business days for delivery<sup>8</sup>.

While this service improves the experience perceived by consumers, it creates strong downward competition among operators who are inclined to act with half-empty vehicles to deliver products as quickly as possible and gain customer trust.

Therefore, the consequence of this new paradigm is, among others the increase in traffic, due to the excessive presence of light commercial vehicles and the increased emission of CO<sub>2</sub> and polluting materials in the air.

### 2.2.3 On-demand logistics and Digital Twins

On-demand delivery conceptually includes a service that, taking advantage of professional crowdsourced delivery capabilities, aims at providing a tailored, yet low-cost, delivery service capable of satisfying customers' desired time/place on a very short notice. UberRUSH for instance allows, by using crowdsourced drivers, to serve online businesses by performing a reliable, flexible, low-cost and with reduced lead-time deliveries to local customers. Other operators such as, for instance, Amazon and DHL have developed similar logistics service capabilities. Wal-Mart, a major retailer in the US, has developed a comparable service by using their employees back-to-home trips to deliver online purchases to customers' homes (**Bhattarai, 2017**). Another on-demand delivery service foresees that customers pick up their orders placed online in a given physical place, be it a supermarket, a shop, or a dedicated pick-up point. Retailers increase their perceived attractiveness by dropping off orders in physical places that are convenient from a final customer perspective, even if this is not their final place of consumption (i.e. home). Amazon, for instance, promotes self-service parcel delivery/return service where customers play an active role in either retrieving or returning orders from/to Amazon Lockers. This service type can be both attractive and financially convenient for both operators and customers since they: (1) cut the gordian knot due to the need for the contextual presence of delivery person/customer thus substantially reducing the number of missed deliveries; (2) increase time flexibility for both logistic operators and customers in performing their respective actions thus implicitly contributing to their optimisation; (3) reduce both financial and environmental costs due to an increase in number of drops per stop made, an increase in the average load factor, a reduction in kilometres

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<sup>7</sup> <https://www.dropoff.com/blog/retail-delivery-consumer-survey-shoptalk-2018>

<sup>8</sup> <https://www.whistl.co.uk/news/british-consumers-want-their-deliveries-faster-than-ever>

driven, a reduction of double line parking, a decrease in the number of cruising for parking kilometres, and a reduction in the number of stop/start for each vehicle. These service arrangements are particularly valuable when it comes to the e-grocery market (**Marcucci et al., 2021**).

Recently, many and relevant changes have taken place in this context that have had a substantial impact on city freight distribution. In fact, both large and small e-commerce platforms are contributing to those social changes that are impacting on society due to urbanisation, aging population, asymmetric income distribution, and last but not least epidemic risks that have strongly stimulated a significant increase in instant deliveries and on-demand logistics. However, one should not underestimate the daunting problems these strong and quick changes are producing with respect to safeguarding environmental sustainability and guaranteeing, at the same time, economic and social goals such as labour and social inclusion, income distribution equality and resilience.

Given this framework of reference, one has to be able to describe/predict future outcomes quickly and reliably thus paving the way to the definition and deployment of effective and ex-ante acceptable intervention policies with the aim of tackling these fast-rising problems that the different stakeholders partaking in the complex and heterogeneous urban freight distribution system are facing.

Digital Twins can be appropriately developed within a Living Lab approach to policy-making and planning. Digital Twins are useful to achieve jointly ex-ante acceptable solutions since they provide easy-to-understand descriptions of future scenarios and illustrate the future implications of current choices in a stakeholder-specific manner. One should recall that planning recursively interlinks with piloting and evaluation, suggesting how a Living Lab approach can be integrated with Digital Twin modelling.

The integration of these two instruments is very promising for policy-making and planning. As **Marcucci et al. (2020)** have convincingly argued, one should clearly consider the following three main points: (i) a Digital Twin system can hardly represent the full reality of a complex urban freight transport system due to its, often cited and widely recognised, deep complexity of one side and lack of the data needed for continuously feeding the model as well as the structural instability of the relationships describing agents' behaviour; (ii) Digital Twins can support experiments and pilots in on-demand urban logistics planning and policy-making, by informing stakeholders about future implications of any given policy thus allowing for a more informed decision-making process; (iii) behavioural and simulation models constitute the common base for characterising urban freight transport, where a sound theory and knowledge with respect to the relationships linking contextual reality and behaviour is fundamental to explain what happens in the real world.

## 2.3 Factors influencing urban freight transport: a survey

As a preliminary activity, LEAD aims to collate, refine and further develop existing knowledge and understanding of the city logistics landscape in the era of the on-demand economy. By doing so, it is creating new knowledge-driven logistics solutions to cope with contemporary challenges, considering new trends and impacts generated by the COVID-19 outbreak.

The LEAD project launched a survey to gather views on the key challenges, trends and influencing factors characterising urban freight transport, involving key experts and practitioners.

Building upon the legacy of the EU-funded NOVELOG project<sup>9</sup>, a set of factors influencing the UFT environment has been drawn up. Participants were asked to assess to what extent each factor influences the development of the urban logistics ecosystem and to add any further factors that they consider important that do not appear in the list.

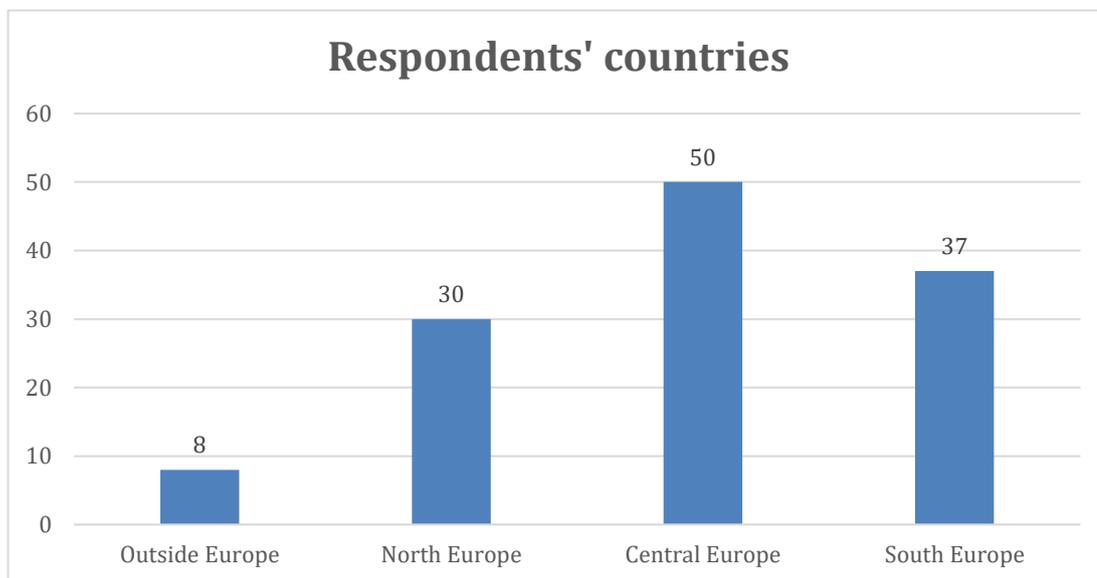
The survey took place online, and was disseminated through various channels interested in urban mobility and logistics, including POLIS, ALICE, CIVITAS, and the communication tools and channels of LEAD and its partners.

In order to facilitate the largest possible participation, a 2<sup>nd</sup> stage simplified questionnaire was prepared and translated it into six languages<sup>10</sup>, so that it could be shared also with local stakeholders.

### 2.3.1 General Information

A first overview provides information on the geographic origin of the respondents, as well as their nature (public, private, academia).

**Figure 5 - Respondents' countries**



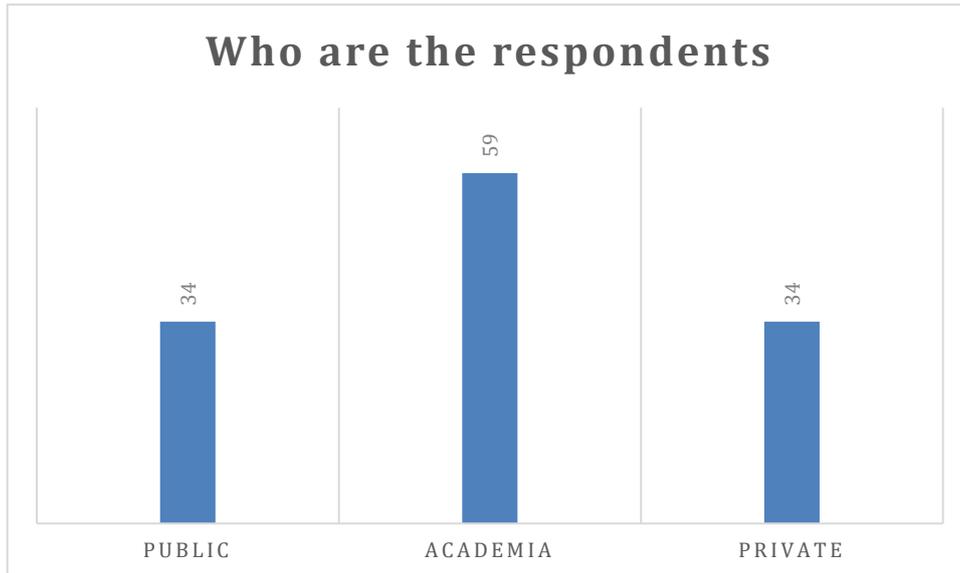
125 experts participated in the survey, coming mainly from Spain, Italy, Norway, the Netherlands, and Hungary (59.8%), which not by chance are the countries in which the project takes place. Germany,

<sup>9</sup> <http://www.novelog.eu/>

<sup>10</sup> <https://www.leadproject.eu/new-multi-language-survey-to-map-challenges-and-trends-in-urban-freight-transport>

France and Belgium cover the 14.1% of the respondents. It is noticeable to see that 3.9% of respondents come from outside Europe.

**Figure 6: Respondents' categories**



Most respondents are researchers (46.4%). Public authorities at every level represent 18.8% of the respondents whereas logistics operators correspond to 11%. Other respondents are citizens, members of companies, consultants, or manufacturers/producers.

While the sample size and its extraction from the population does not ensure its statistical representativeness, we support the idea that given the focused administration of the questionnaire among qualified respondents, this allows us to capture the most important factors.

### 2.3.2 Influencing factors

Influencing factors are elements, e.g. economic, demographic, social, operational, etc. that influence both the current and future state of UFT environments.

Building upon the legacy of the EU-funded NOVELOG project, a set of factors influencing the UFT environment has been drawn, including six main categories:

1. **Economy & demographics** includes factors relating to the demographic and socio-economic fabric of the urban population, as well as the type of shops in the city.
2. **Ecology & social responsibility** considers the weight of factors such as the demand for goods and services that favour environmental-friendly production, waste reduction, local and ethical sourcing.

3. **Consumer requirements** considers the level of attention of consumers to different aspects of delivery, such as their social impact, environmental sustainability, use of the data provided.
4. **New technologies** consider to what extent and how the development of new technologies makes on-demand logistics more efficient and sustainable.
5. **Corridors, nodes and space:** urban planning, space management and the performance of the infrastructural network influence the operational capacity of the operators and their impact on the urban fabric.
6. **COVID-19:** the lockdown and the consequent increase in online orders has accelerated the development of e-commerce and contactless delivery and payments, as well as stressed the entire supply chain.

Compared to NOVELOG, the set has been expanded considering the developments over the past 4 years, the scope of LEAD ('on demand economy' - shared, connected and low-emission logistics operations), and the COVID pandemic.

Participants were asked to both assess to what extent each factor influences the urban logistics ecosystem, based on a 5-scale (1 = Not at all; 2 = To a small extent; 3 = To some extent; 4 = To a great extent; 5 = To a very great extent) and add any further factor, not present in the list, they consider important. Notwithstanding the qualitative nature of the scale used, we believe using the average is helpful in facilitating an overall evaluation. By using the same scale, we ensure comparability of the results both within and across categories. What a Likert-scale cannot, by construction, ensure is the homogeneous interpretation of the various qualitative point scales across respondents. This however is an intrinsic limitation of the Likert-scale used and there is not much we can do about it. Nevertheless, since the overall aim is to acquire a qualitative evaluation of the relevance of the various elements considered, this is not, *per se*, a strong drawback with respect to the aims we pursue.

The following section describes results within each category, while sections [2.3.4](#) and [2.3.5](#) analyse the influence of a group of factors in comparison to other categories and provide for a qualitative assessment on need and challenges in urban freight transport based on open answers.

### 2.3.3 Results of the survey

This section presents the results of the survey, broken down per categories analysed. For each of them, the weight attributed by the respondents to each of the proposed influencing factors is reported and discussed. Furthermore, their position is also consolidated by type of respondents, that is, coming from the public, private or academia sectors. This provides interesting insights, to grasp the different sensitivities of practitioners, experts and operators with respect to the mechanisms that govern the sector, and how they perceive the variables of the on-demand economy. This knowledge will be essential to contextualize the upcoming analysis of Innovative Business Models, Governance and PPPs (D1.3) and the definition of the reference LEAD strategies to be explored through simulation in the Digital Twins and in real-life urban setting experiments (D1.5). Understanding stakeholder opinions is crucial to co-create efficient logistic solutions and can lead to an acceleration of successful participated policies.

### 2.3.3.1 Economy and demographics

The aim of this section is to evaluate the weight of economy and demographics factors in the urban logistics ecosystem through a quantitative analysis based on a 5-scale variable, highlighting not only the overall influence of every economic/demographic factor in comparison to the others, but also a breakdown of the different stakeholders' opinions (academia, public, private).

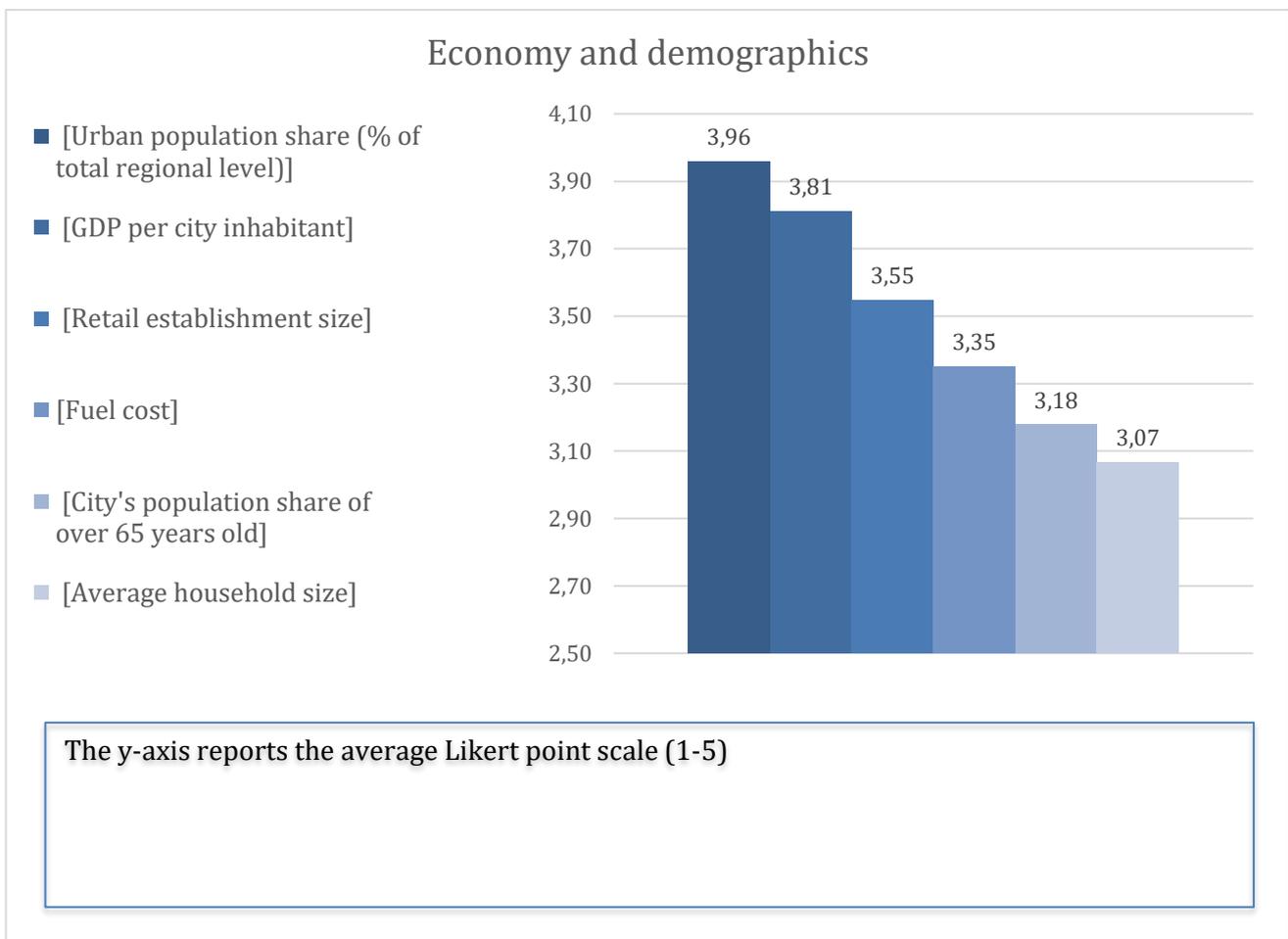
Respondents have rated six economic and demographic factors.

The importance of economic factors is crucial as there is a strong relationship between economic development and freight activity; noteworthy to mention for their impact to urban freight activity are also structural market factors such as fuel cost and retail establishment size. The first one is a significant part of transport costs while the latter can influence the level of freight trips.

Demographic factors are also pivotal: the physical distribution of the population and its structure affect the focus on regional distribution system, typology and frequency of delivery.

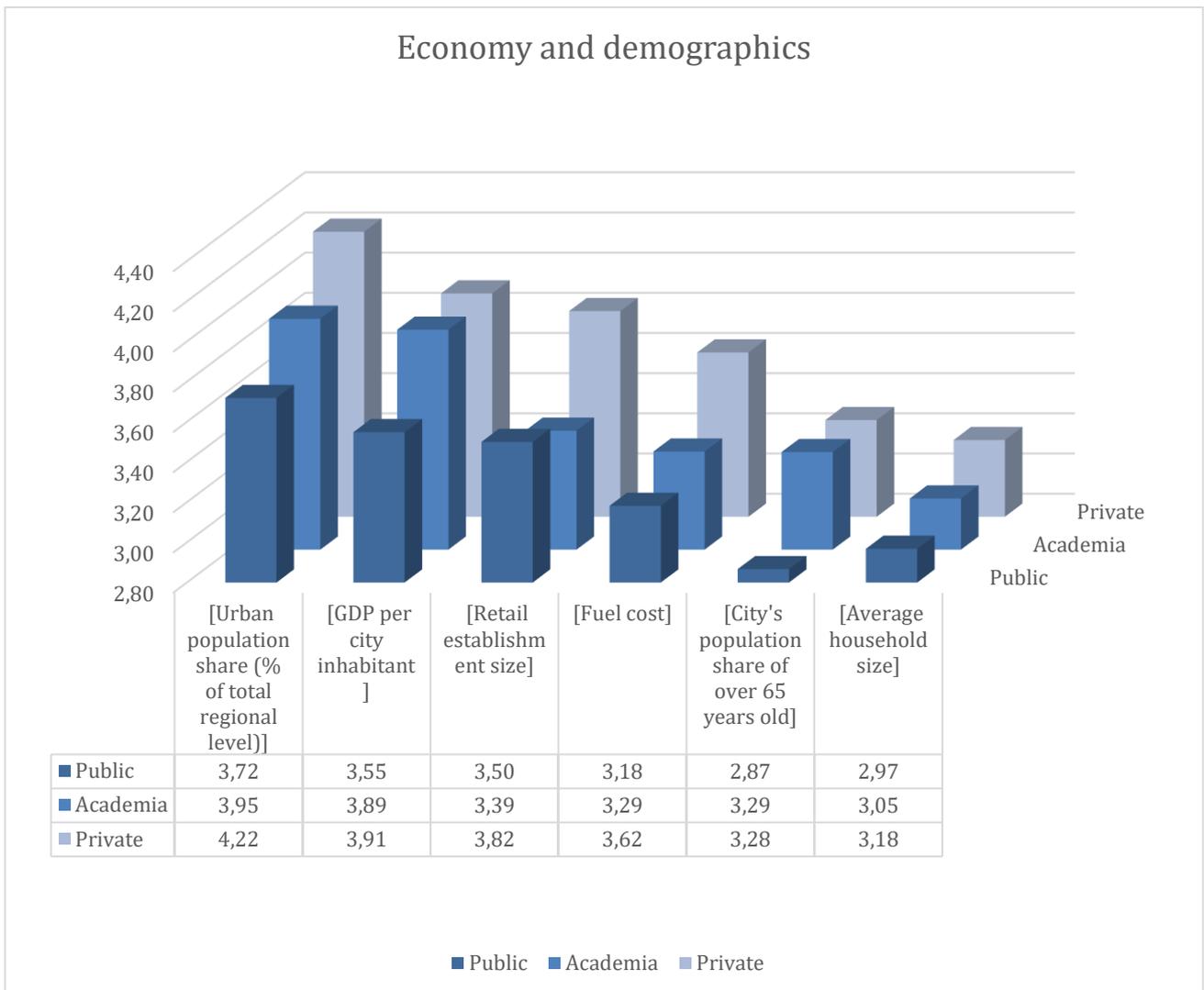
For every economic factor inserted in the survey, respondents have expressed the importance of such variable giving a score from 1 to 5. The average values have been grouped respectively in Figure 7 and Figure 8.

**Figure 7: Relevance of “Economy and demographics”**



The most important economic and demographic factors for the respondents are urban population share (% of regional level) and GDP (per city inhabitant). A high share of urban population is expected to lead to a regional logistics system that is more focused on its urban distribution part. Moreover, respondents acknowledge a strong relationship between economic development and freight activity. GDP increases are expected to lead to more freight movements. Retail establishment size is also considered a strong influential factor: evidence shows that small (e.g. independent) retail establishments are more likely to generate more freight activity, generating movements with smaller vehicles than larger establishments.

**Figure 8: Relevance of “Economy and demographics” by sector**



The second diagram depicts the same order of importance, this time broken down for the three sectors (public, private, academia). It is noteworthy to mention that overall private sector considers economic and demographic factors more important in comparison to academics and public sector, in particular

the latter gives less importance than the others to economic factors in the urban logistic ecosystem. A noticeable different point of view emerges for the variables retail establishment size and fuel cost: in fact, while for the public sector they are not important, is not the same for the private sector.

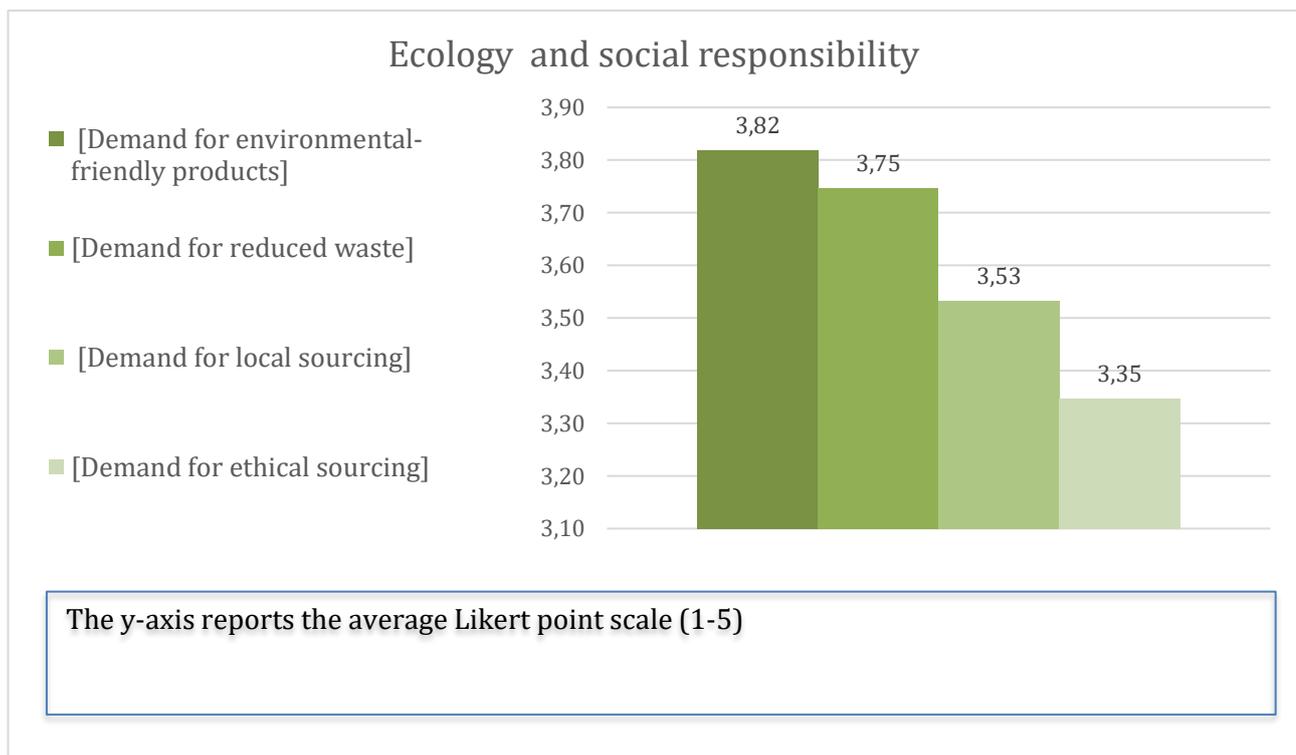
### 2.3.3.2 Ecology and social responsibility

The respondents were asked what are the most important factors related to ecology and social responsibility contributing to reshape urban logistic ecosystem; in particular, they have given a score from 1 to 5 to several variables such as demand for environmentally friendly products, demand for reduced waste, for local sourcing and for ethical sourcing.

The first one is important because the increased requirement of environmentally friendly products put pressure on urban freight transport at the levels of assets used and delivery processes. Demand for ethical sourcing and local sourcing stresses urban freight transport at the informational and at the physical delivery level and may lead to an increase of the frequency of urban freight trips and to an increased share of short supply chains. Lastly, demand for reduced waste generates pressure in terms of reverse logistics and circular economy.

It is crucial to understand if stakeholders deem disruptive such factors in urban freight environment. For instance, understanding if the private sector considers more important the future impact of zero-emission production in comparison to circular economy/local economy and ethical business models, could lead the public sector to different policies and subsequent measures. The ranking is presented in Figure 9.

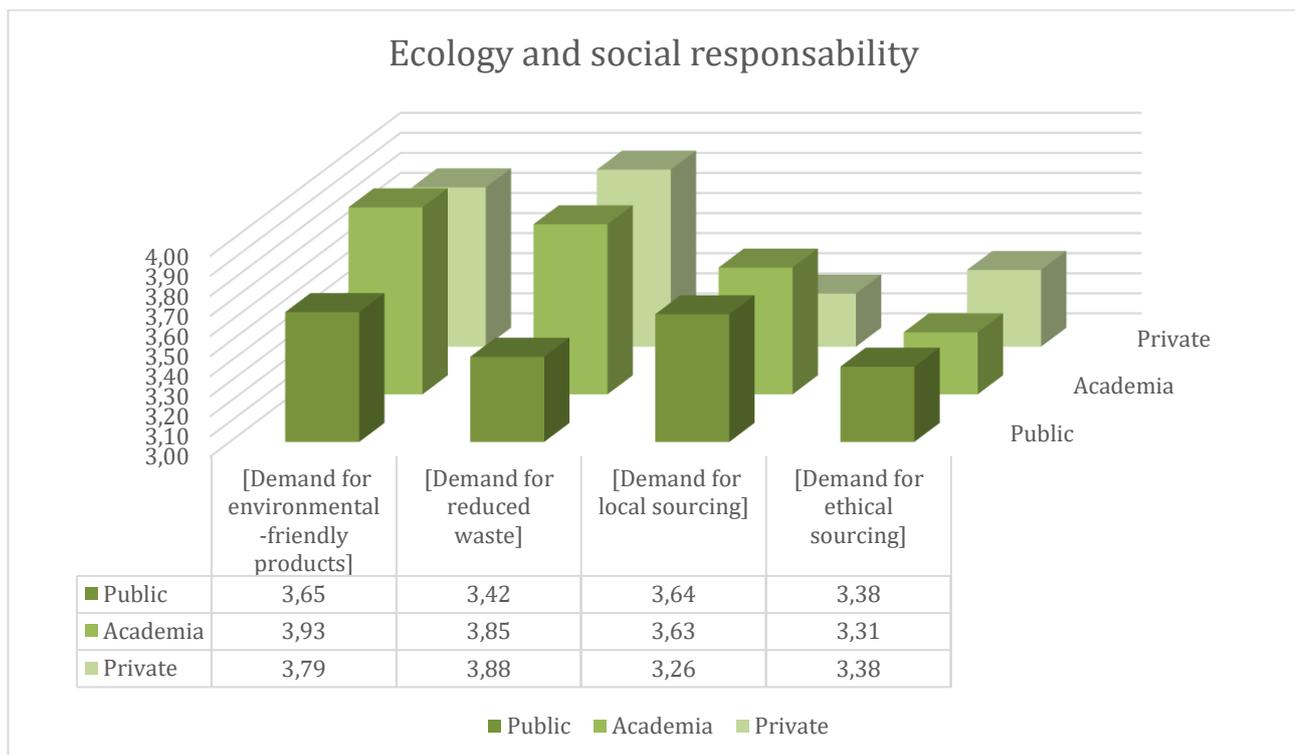
**Figure 9: Relevance of “Ecology and social responsibility “**



Demand for environmental-friendly products and demand for reduced waste are considered overall the most crucial influencing factors for ecology and social responsibility. Consumers increasingly require that both the products and the way these reach them are environmentally friendly, and they require products that are reusable and recyclable. Conversely, demand for ethical sourcing is not considered particularly significant, or perhaps there is not enough awareness about the issue of ethical treatment of employees and subcontractors involved in the procurement, production, and delivery of the products.

When the sample is broken down per groups (see Figure 10), the private sector considers the demand for reduced waste the central factor; by contrast, public sector deems demand for environmental friendly products and demand for local sourcing pivotal.

**Figure 10: Relevance of “Ecology and social responsibility” by sector**

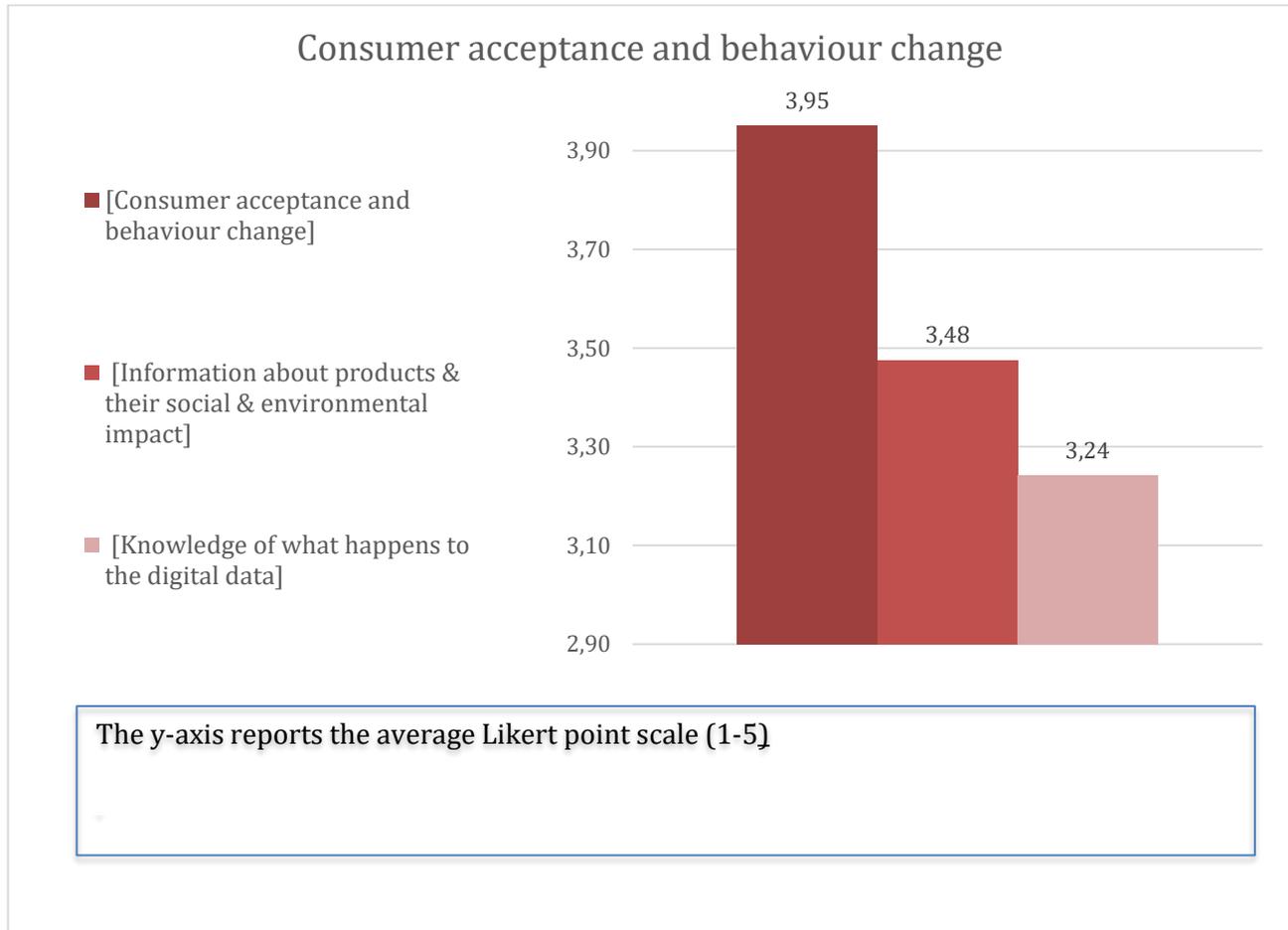


### 2.3.3.3 Consumer requirements

The market is increasingly becoming consumer and on-demand oriented. For this reason, a section of factors related to consumer requirements has been created: it is essential to assess if behaviour change can have an impact on the urban freight ecosystem. In particular, the behaviour of consumers can imply a modification of speed, price, quality and type of product. As a consequence, this can have an impact on the business models and create new information platforms and information-driven

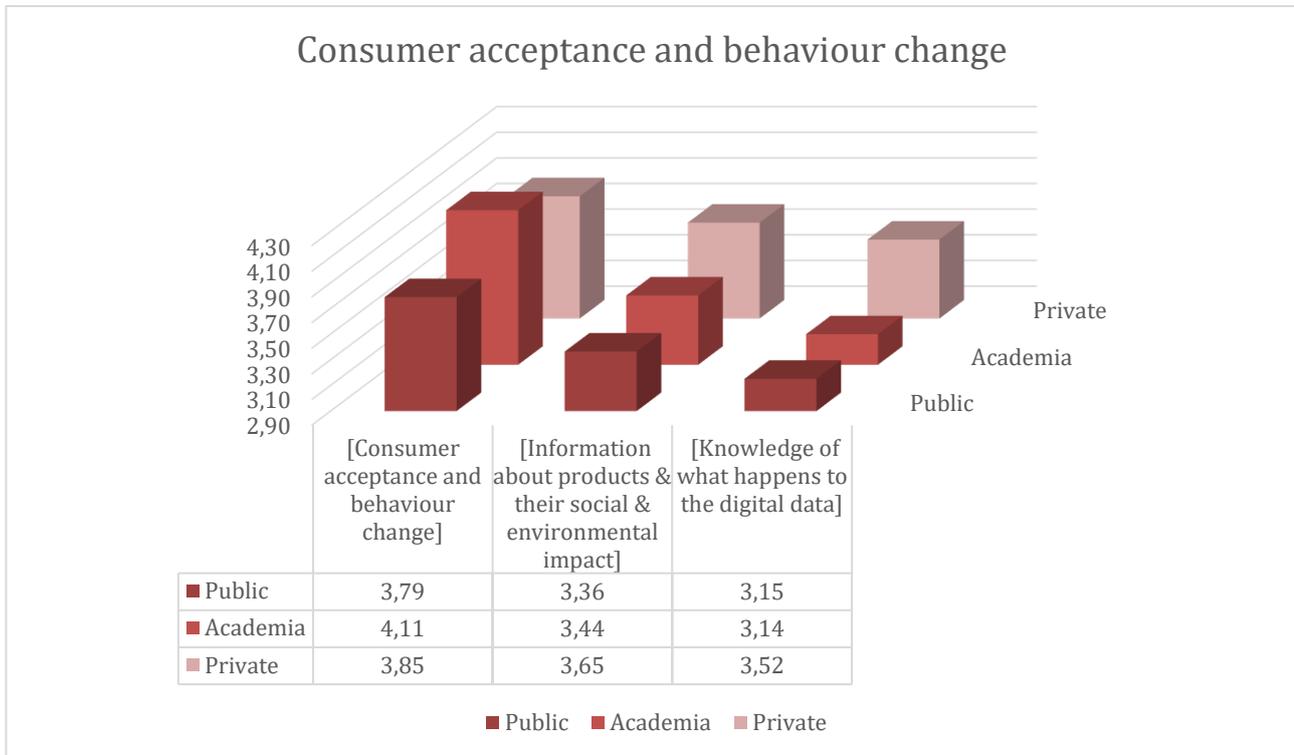
business. At the same time, the value of information (privacy, security and life cycle product) for the consumers is becoming a determining factor in product selection. This might raise additional requirements on the informational infrastructure of LSPs.

**Figure 11: Relevance of “Consumer acceptance and behaviour change”**



Overall, respondents consider consumer acceptance and behaviour change the most important factor by far, in particular by the academic sector. Willingness to pay or sacrifice service quality (e.g., speed) for more sustainable delivery options, perceived usefulness, security and privacy are key drivers influencing the impacts of on demand logistics on the urban system. The other two factors are considered more important from the private sector in comparison to the public and academic sectors. Consumers are increasingly concerned about the social and environmental impact of the products they purchase and receive. They more and more require that this information is easily accessible and covers the complete life-cycle of a product, and this is particularly perceived by the private sector, as a direct receiver of these requests. According to the industry, consumers also increasingly want to be reassured that privacy issues are respected.

**Figure 12: Relevance of “Consumer acceptance and behaviour change” by sector**



### 2.3.3.4 New Technologies

In this section, respondents have assessed the weight of several technologic innovations in the urban freight ecosystem. In this century, in fact, disrupting technologies have seen or will see applications in cities. Some of them (Intelligent Transport Systems, for instance) have been already applied with success while others could take off in the near future (driverless technology, Digital twins), have a limited use (Augmented reality) or will follow a long and challenging path before their implementation (Physical Internet). Here a non-exhaustive list of technologies applied in the logistics sectors and included in the survey:

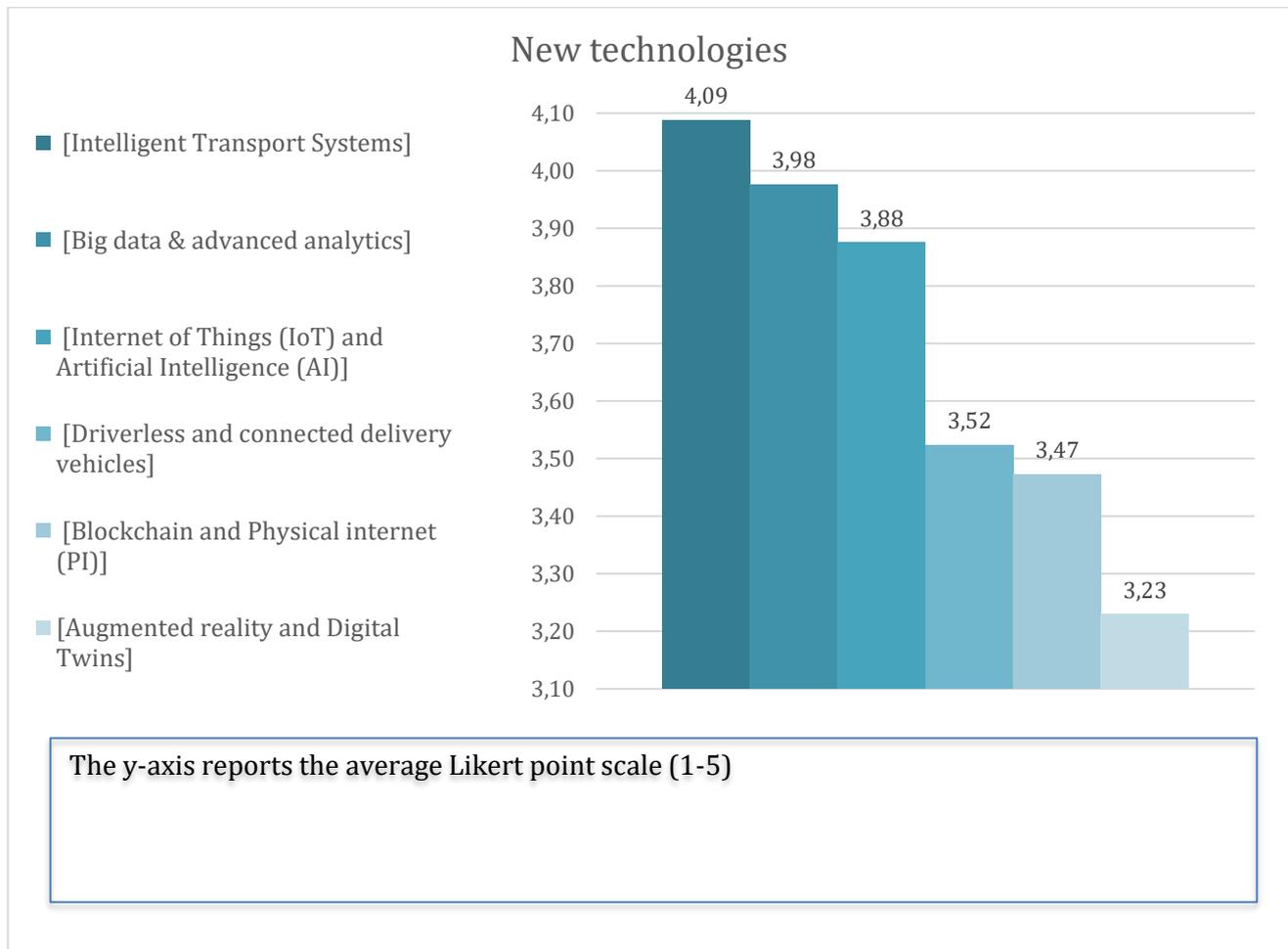
- **Internet of Things (IoT)** could be applied for enhanced inventory monitoring, improved consignment tracing & exception management, improved product status alerting, smarter energy management at distribution facilities, remote access to stores for night delivery;
- **Big Data & Advanced analytics** can enable extraction of previously unknown patterns to anticipate demand, improve efficiency and enhance level of service;
- **Intelligent Transport Systems** can be applied for road safety (road and accidents monitoring); congestion reduction (traffic flows monitoring, parking management); regulations compliance (limited traffic zones management, speed limit control); supply chain management (loading/unloading bays management);
- **Driverless and connected delivery vehicles** could fulfill every kind of delivery in a more efficient way;
- **Augmented reality and Digital Twins** could display information on the delivery vehicle's windshield (e.g. real-time traffic data, cargo status, delivery instructions); display information

on a specific parcel by looking at it and guiding the driver to find the delivery location (combined with wearable devices, e.g. smart glasses);

- Lastly, **Blockchain and Physical Internet (PI)** might foster a model of shared, interconnected and standardised logistics providing full interconnection of transport and logistics networks for their use in a single large global logistics network.

The figures below (Figure 13 and Figure 14) depict the ranking of key factors and a breakdown by sector. The most important technology-driven factors for the respondents are in order of importance ITS, Big Data and IoT+AI.

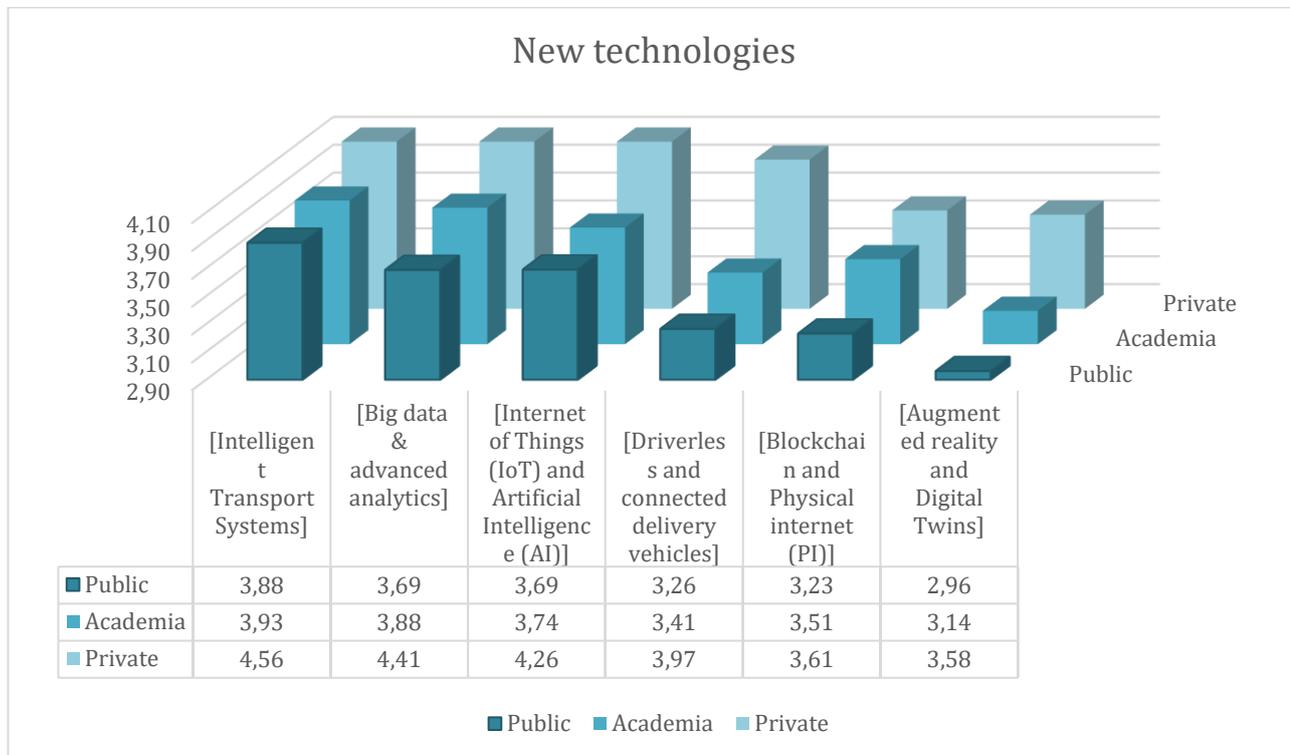
**Figure 13: Relevance of "New technologies"**



The second diagram depicts the same order of importance for the three sectors (public, private, academia). It is remarkable to notice that, overall, the private sector gives by far more importance to the new technologies than the other sectors.

Another important fact is the opposite vision between public and academic sector in relation to driverless and connected vehicles vs blockchain and Physical Internet, namely public sector neglects more PI and blockchain, whereas academic sector gives less importance to automated vehicles. This probably depends on the different degree of knowledge and familiarity, and on the type of application envisaged by the different sectors. For example, PI and blockchain are still abstract and not so tangible concepts. Public sector actors dealing with mobility and logistics are not yet so familiar with these concepts. Private players attribute much more importance to automation as well as to Augmented reality and Digital Twins given their efforts in testing them in their day-to-day applications, even if only at an experimental level.

**Figure 14: Relevance of “New technologies” by sector**



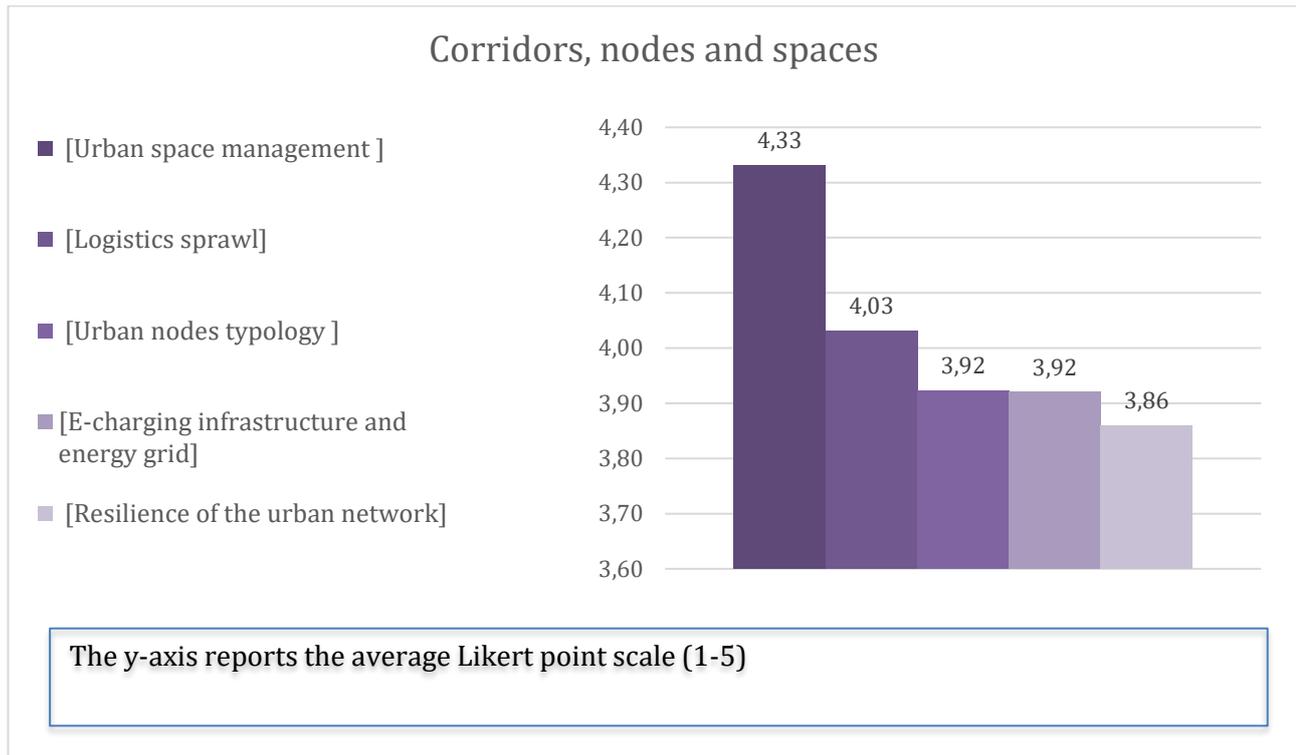
**2.3.3.5 Corridors, nodes and spaces**

This section considers the infrastructural elements of the urban freight ecosystem: management of space (curb side, street), localisation of logistics hub, presence of e-charging infrastructure, typology of urban nodes and resilience of the urban network define the quality of freight mobility inside a city. The survey assesses which factor are deemed more important according to the different perspective of stakeholders. The theme is crucial as the underestimation of the different perspectives on the infrastructural needs of a city can lead to the malfunctioning of the entire urban network.

It is essential to understand which factors will affect more urban freight ecosystem. Will freight activities be affected more by relocation of parcel transport’s hubs or by the way in which urban space

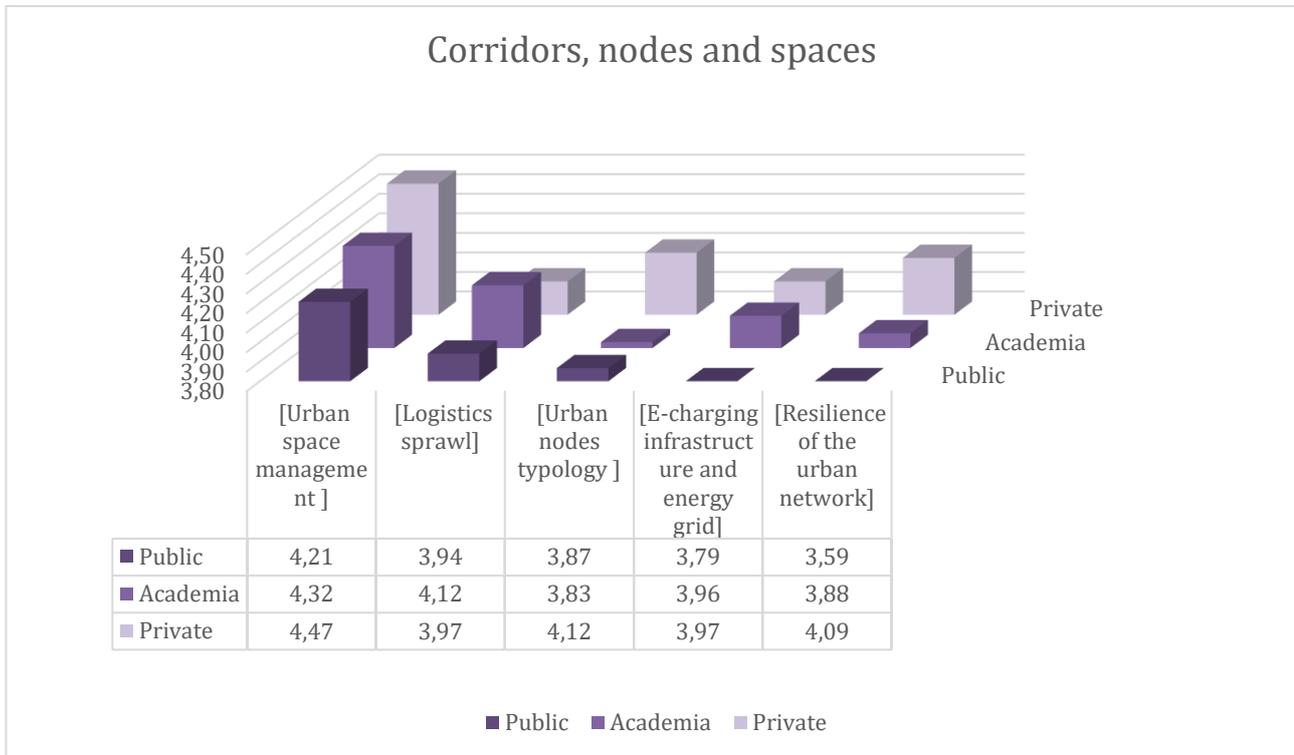
is distributed or designed (urban space management)? How important is to focus on each urban node (cross border function, inbound focused on local consumption/outbound focused on production and transit of goods, centric or poly-centric, etc.) and on the resilience of the whole urban network? Lastly, is e-charging infrastructure and energy grid a central or marginal issue in the urban freight ecosystem?

**Figure 15: Relevance of “Corridors, nodes and spaces”**



According to the respondents, urban space management and logistic sprawl are the most important factors influencing the development of the urban logistics ecosystem. The way urban space is distributed and designed has a major impact on the way people and goods move in the city. The rise of on-demand freight and mobility require to manage curb-side space more efficiently, in a shared and dynamic way. Logistics sprawl is the relocation of parcel transport's hubs from the urban cores to the outer suburban areas causes a trend towards spatial deconcentration of logistics terminals.

**Figure 16: Relevance of "Corridors, nodes and spaces" by sector**



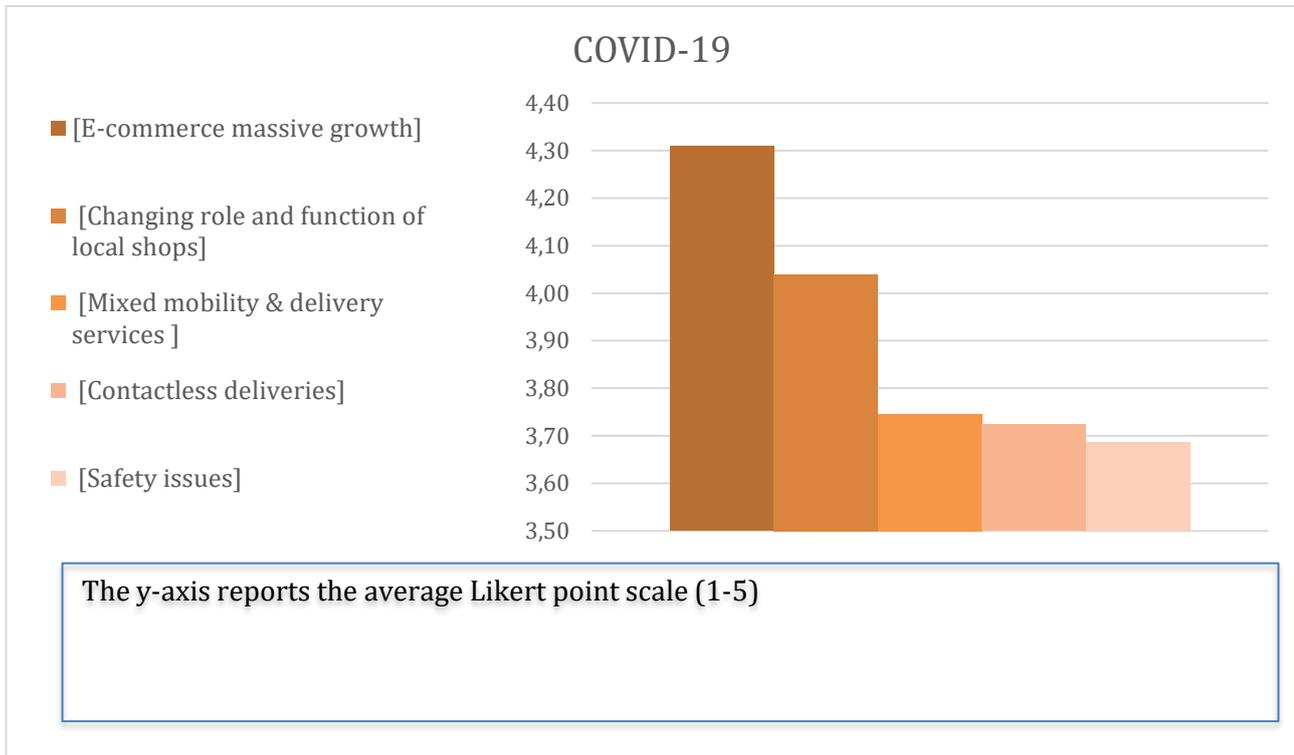
However, different sectors have different point of view: logistic sprawl is not so crucial for the private sector, that considers more important urban nodes and resilience of the urban network – therefore the broader network connectivity between the extra-urban (TEN-T) corridors and their functional urban area. In addition, public sector generally showed a lower interest in this category, in comparison to the others sector.

### 2.3.3.6 COVID-19

In this section, respondents have taken in account the effect of the outbreak of COVID-19. A crucial theme is the understanding of how the pandemic affects freight mobility and whether its effects will persist in the future. Is the e-commerce growth the only disruptive effect of COVID-19? Or are there significant changes in shops' functions or passengers' mobility? Are contactless deliveries and safety issues only temporary solutions, or will their advantages have an impact on the future of urban freight transport?

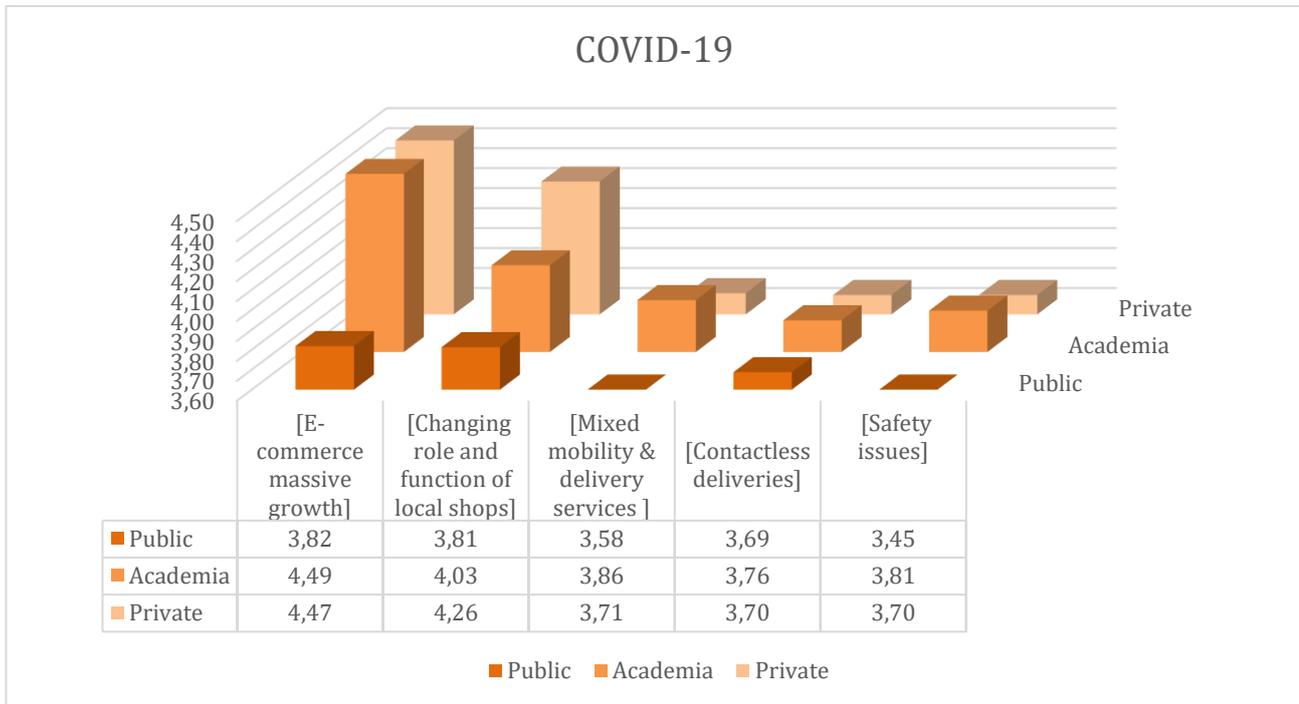
These questions are crucial because several cities and regions have modified their mobility policies because of COVID-19. Stakeholders have been asked to rate the following variables: e-commerce massive growth, changing role of local shops, mixed mobility & delivery services, contactless deliveries and safety issues.

**Figure 17: Relevance of “COVID-19”**



Overall, the most important influencing factors related to COVID-19 are the massive growth of e-commerce and the changing role and function of local shops. Due to the COVID pandemic, home delivery and instant delivery are growing with an excess of demand that the current offer is struggling to manage due to the lack of workforce in the specific segment. This also implies new spaces for more frequent stops of logistics operators and increasing digitalization. At the same time, the lockdown and movement restrictions are causing a reduction in the demand for traditional purchases in nearby stores. As a consequence, numbers of retailers offering omnichannel shopping (e-commerce platforms; phone) and new payment forms have increased. Many retailers are also refocusing more on local customers because there are fewer tourists.

Figure 18: Relevance of “COVID-19” by sector

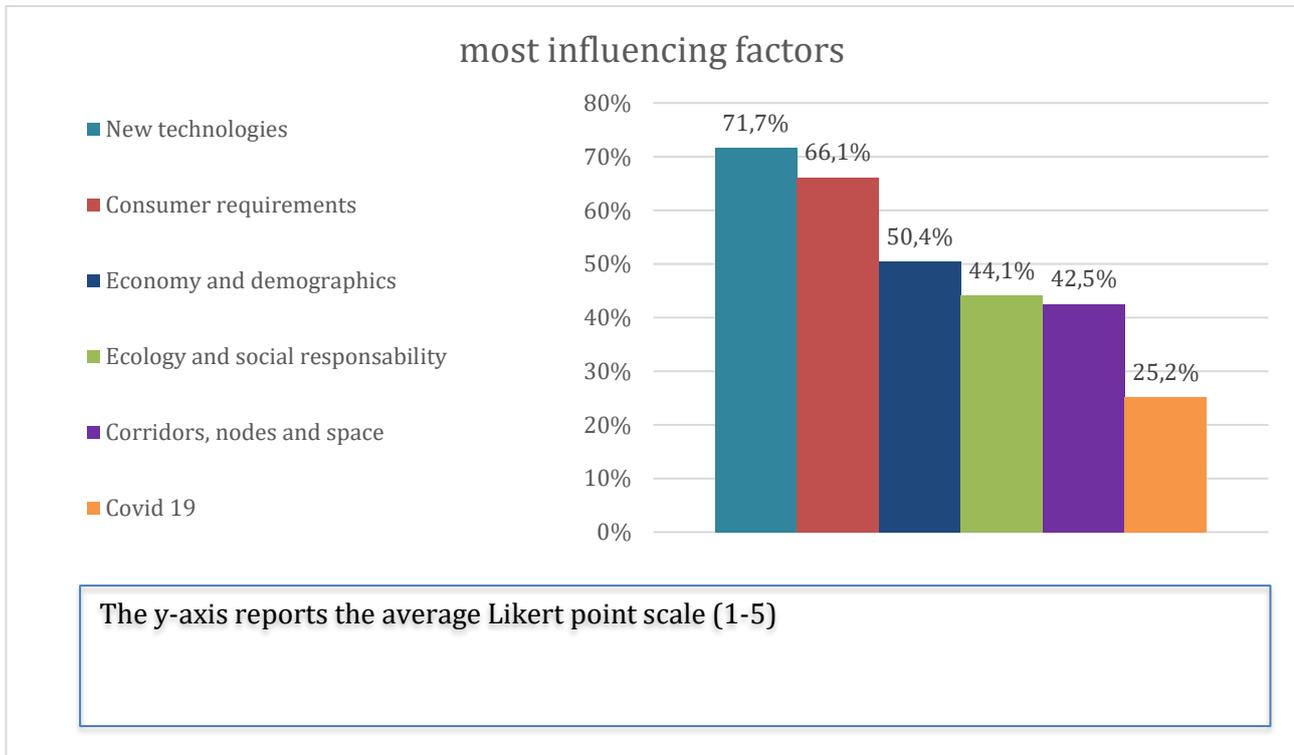


There are huge differences among the sectors: the public sector considers the impact of all the factors in a quite similar way and consider the impact of COVID-19 overall less essential in comparison to the others; the academic sector shows more interest to mixed mobility, delivery services and safety issues and contactless deliveries than private; when it comes to private sectors instead, is noteworthy to mention the pivotal importance is given to changing role and functioning of shops.

### 2.3.4 The most influencing factors

Participants were also asked to select the 3 most relevant macro categories out of the six previously mentioned in terms of their influence both to the current and future state of UFT environments. The two graphs below (Figure 19 and Figure 20) report how frequently all the elements were picked as pertaining to the most relevant categories.

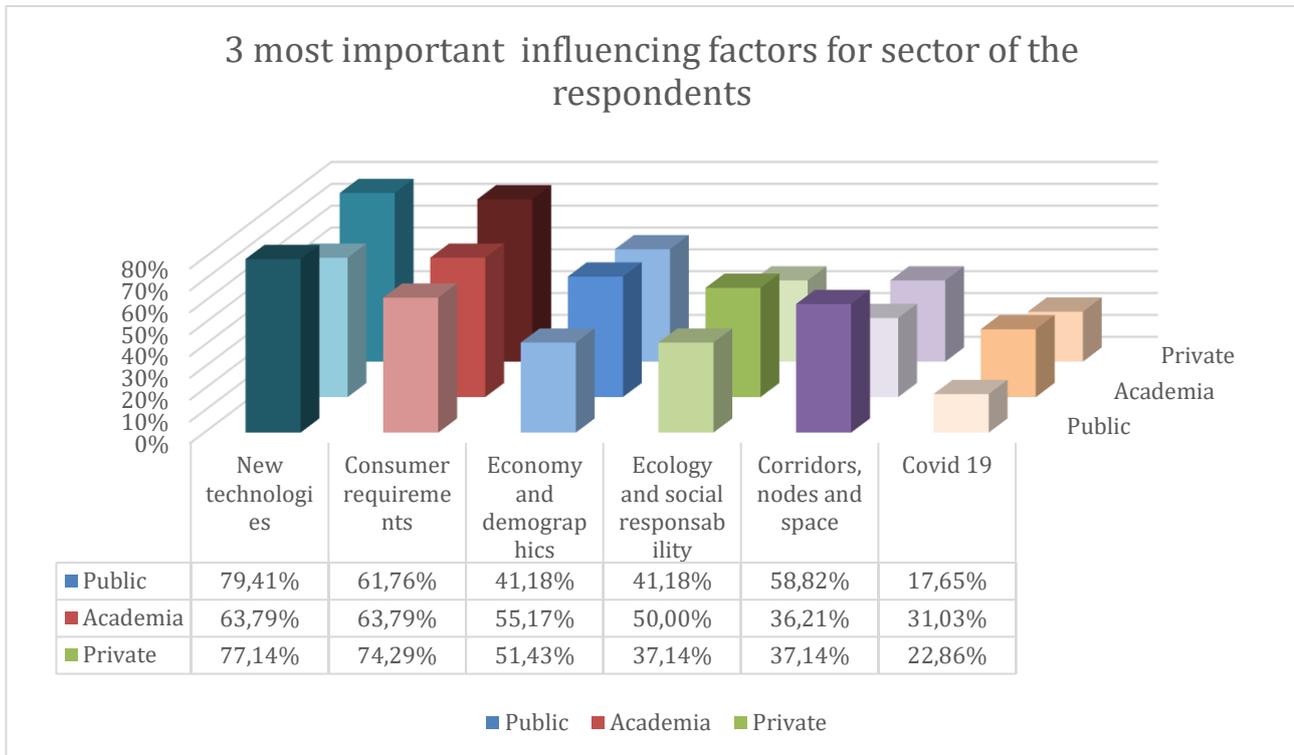
Figure 19: the most influencing factors: an overview



Overall, in order of importance, new technologies, consumer requirements and economy and demographics are the most important factors influencing the current and future state of UFT environments. By contrast, COVID-19 is the less considered by respondents, followed by corridors and ecology.

A breakdown for sector shows that the public sector deems more important than other corridors and nodes, whereas it considers less important economic and demographic factors; the academic sector gives more value to ecology and COVID-19 than others; private sector stresses the role of consumer requirements.

**Figure 20: most influencing factors by sector**



### 2.3.5 Needs and challenges in the private and public sector

Overall, urban freight transport has to deal with challenges and needs linked to two types of issues: the first one is related to external costs of logistics (greenhouse emissions, polluting emissions, congestion); the second one to economic efficiency (reduction of cost, high returns, high quality services).

Challenges and needs, however, are different, in relation to the background of the respondents (public, private, academics) and if we consider separately the issues of private and public sector. Based on their opinions and perspectives, respondents were asked to briefly describe the main UFT-related current needs and challenges faced by both the public and private sector.

The main difference between public and private sector is the larger importance given to the reduction of external costs of logistics in the public sector in comparison to the private. On the contrary, private stakeholders consider economic efficiency the most relevant aspect. A remarkable fact is the different vision that public and private have concerning external costs of logistics: while for the public sectors reduction of costs is a target, for the private is usually a challenge to overcome to remain competitive.

Measures to be implemented to fulfil the needs of the public sector vary according to the different perspectives: public sector’s and academics respondents stress the importance of green solutions, whereas private sectors consider often more crucial to implement clear and harmonized regulation across cities.

The same consideration is valid for need and challenges of the private sector. In this case, respondents from the public sector and academics give value more to public incentives and zero emissions solutions than private sector, which considers challenging to comply with regulations, and to deal with reduced profit margin under a highly competitive and demanding market that implies to face increasing operational issues (same day delivery, load factor, low emission zones, time windows, critical mass of clients to reach).

In addition, academics mention the lack of data and tool for efficient planning in both sectors: the aim is to foresee and anticipate the future effect of policies. From their perspective, private players empathize the importance of technology to offset the technical limitations of the sector.

Despite the differences, every stakeholder group empathizes the need of good management of the street (efficient use of the street, land for logistics, loading/unloading bays, parking) and the need for enhanced coordination and integration between stakeholders in the creation of solutions.

This last point seems to reinforce the idea that the Living Labs implemented in LEAD, but also in other cities, can foster, through experimentation, a growing knowledge of mutual challenges and needs. This allows to co-create new solutions and regulation, to anticipate any undesirable effects on one or another category of stakeholders of the on-demand urban logistics system.

### 3 Typologies of agile storage & last-mile distribution schemes

The last mile is not only the most expensive and inefficient part of logistics (**SOTI, 2020**), but also a source of negative externalities that affect the future of cities. In the light of an increasingly focused global orientation on a sustainable economy, a reflection on the entire transport sector has developed in the EU, leading to the development of guidelines (e.g. The White Paper on Transport), governance projects (e.g. ALICE) and the destination of research funds (e.g. Horizon 2020). The last mile is considered one of the central elements of the *green* revolution in transport and there have been many projects whose core was and is precisely the improvement of the last mile distribution schemes.

Last mile logistics solutions range from improving and upgrading infrastructure to introducing new technologies, from replacing vehicles to changing the supply chain through economically, environmentally and socially sustainable logistics schemes. These changes require the coordination of many actors. The movement of goods and services is inextricably linked to the movement of individuals, so new logistical model shall be integrated into the overall urban transport system.

The road, where the vast majority of inland freight transport takes place (**Eurostat, 2020**), is a space where ordinary citizens carry out their traditional activities and is the scene of fierce competition for different uses. Motor vehicles, pedestrians, public transport compete for the limited space reserved for them. New logistics solutions should take into account the road space and all its users. Moreover, rethinking the road may mean changing the entire urban space in certain areas.

The actions to be taken also require active intervention by the administrations in harmonising the different interests of stakeholders, creating easy regulatory frameworks, reserving space for logistics, providing incentives, subsidies and sometimes directly financing logistics projects. In addition, new technologies and models require extensive research, the creation of dedicated infrastructures and complex regulatory frameworks. For example, consider the introduction of electric cars/vans, the use of drones or unmanned vehicles.

Changing the last mile delivery not only implies turning vehicles carrying goods into zero-impact ones, it also involves rethinking freight and passenger mobility within an integrated framework. This translates into spatial, temporal, and organizational changes of the interaction between logistic actors (e.g. consumer, receiver, courier, shipper). CITYLAB<sup>11</sup>, STRAIGHTSOL<sup>12</sup>, BESTUFS<sup>13</sup>, C-LIEGE<sup>14</sup>, CITYLOG<sup>15</sup>, NOVELOG<sup>16</sup> are some of the many examples of European last mile research projects which have experimented with innovative and integrated solutions to reduce the negative impacts of logistics on the urban transport system in European cities. The innovations previously and currently

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<sup>11</sup> <http://www.citylab-project.eu>

<sup>12</sup> <http://www.strightsol.eu/>

<sup>13</sup> <http://www.bestufs.net/>

<sup>14</sup> <http://www.c-liege.eu/home/>

<sup>15</sup> <https://cordis.europa.eu/project/id/233756/reporting/it>

<sup>16</sup> <http://novelog.eu/>

tested can be allocated into four separate categories: 1) delivery locations, modes and time, 2) loading and unloading area management 3) consolidation and 4) new technologies. These are different but complementary and must be investigated and validated through an integrated approach to define policies for rationalization, efficiency and cleaning of on-demand logistics. **Error! Reference source not found.** summarizes them briefly and sections 3.1 to 3.4 describe them in detail.

**Table 2 Innovation and solutions for agile storage & last mile distribution schemes**

Delivery locations, modes and times	Loading and unloading area management	Consolidation	New technologies
Innovations and solutions to improve the delivery process, i.e. where the goods are delivered, how and at what time.	Innovations and solutions to improve the management of scarce urban space, in a flexible and integrated way, and of the contested kerbside.	Innovations and solutions to better consolidate and improve the management of flows. It includes both delivery and demand consolidation.	Technological innovations and solutions that can make the freight distribution process more efficient through automation and data analysis.

### 3.1 The organization of deliveries

#### 3.1.1 Delivery locations

##### 3.1.1.1 Parcel Lockers

The Parcel Locker is one of the most successful tested schemes so far as it is an easily applicable solution in the short term and effective in addressing the problems that last mile transport poses (Cagliano et al. 2020). These are automatic lockers located near different public places (posts, supermarkets, petrol stations, commercial roads, metro stations, railways, parking lots, etc.). It is becoming very popular in neighbourhoods as it promotes contactless deliveries, suitable practice in time of COVID-19. The examples in public spaces as metro stations are less common as the deployment of these services may require some authorization to use public land.

The typical operation of a Parcel Locker is very simple as described by Iwan et al. (2016). The online buyer selects the Parcel Locker, as delivery point, then s/he receives a confirmation email and a text message with a QR code and the corresponding number of the locker to be opened which s/he will use in the place where the Parcel Locker is located.

The terminology used to describe the Parcel Locker is rather ambiguous. For Parcel Locker, in this case, we mean automatic lockers attended or not attended, although in literature we often refer to the

term Parcel Locker meaning in fact the Automated Parcel Locker or Unattended Collection Delivery Points, i.e. Parcel Locker not attended.

The automation feature differentiates Parcel Lockers from other delivery modes such as attended collection delivery points, which were manually operated by operators.

There are many reasons why Parcel Lockers are one of the most viable solutions. First of all, it is a fairly simple technology that is in a mature phase and already widely used in some countries, such as Poland and Germany (**Parcel and Postal technology international, 2017**). They are not a scheme that requires huge regulatory interventions compared to other schemes (urban consolidation centres - UCC) or the coordination of many actors.

Similarly, parcel lockers have a well-established and profitable business model for those who use it (DHL in Germany or InPost in Poland), with a medium-high but sustainable initial investment (**Iwan et al., 2016**). Finally, parcel lockers do not present huge cultural and social barriers to use as could be automatic vehicles, droids or drones.

The economic and environmental benefits of The Parcel Locker lie mainly in the elimination of courier-consumer contact, which is further relevant considering the COVID-19 pandemic. The lack of physical presence of the consumer when the package arrives virtually cancels the missed deliveries, which in general range from 2% to 35% of deliveries (**Maere, 2018**). Similarly, Parcel Locker Lockers facilitate the reverse logistics process by avoiding expensive trips for the return of goods. Finally, delivering to a few predefined places rather than to single homes allows to consolidate freight deliveries and prevent freight vans from operating frequent stops.

However, Parcel Lockers are critical of both the supply and demand side.

In the first case, the main weakness of the Parcel Locker lies in the use of several private networks. This could create excess demand and/or supply by undermining quality of service on the one hand and efficiency on the other.

On the demand side, the consumer's participation in the pick-up of the product purchased is crucial. On the one hand, the consumer may be unenthusiastic in choosing the Parcel Locker, preferring the most convenient home delivery. On the other hand, he/she could make the home-to-locker route with a dedicated trip through a private motor vehicle, affecting the environmental gains given by parcel lockers.

Nevertheless, the use of parcel lockers is rapidly rising, as shows the creation of their own Parcel Locker by Amazon and Google. Even more striking examples of the spread of Parcel Lockers are the 340000 DHL parcel lockers in Germany, which reach about 90% of the population (**Parcel and Postal technology international, 2017**) and the strong growth in China, where the mode of delivery of the Parcel Locker corresponds to 6% of deliveries (**Bouton et al. 2017**).

The market push towards the Parcel Lockers is supported by solid scientific literature on economic and environmental benefits. There are several theoretical and empirical studies that highlight these advantages over the traditional home-delivery mode.

**Bouton et al. (2017)** produced research on Parcel Lockers where it is estimated that emissions could be reduced by 70% due to lower overall mileage and cost reductions of 35% in more densely populated cities than in a home delivery scenario. Research by **Iwan et al. (2016)**, conducted in Poland, shows that the parcel locker delivery mode of the company InPost pollutes one third less of home delivery on equal terms, with a reduced total mileage of half and ten times more deliveries. Simulations of **Giuffrida et al. (2016)** in an urban scenario, on the other hand, show in the best-case scenario a reduction in emissions of 2/3 and a reduction in delivery costs for Third-party logistics (3PLs) of 89%, corresponding to a saving of almost two euros per delivery. Similarly, **Gevaers et al. (2014)** predict a 25% to 71% reduction in delivery costs. Finally, **Belet et al. (2009)** estimates an 83% reduction in emissions. These researches are based on a series of general assumptions such as distance from the depot, delivery window, missed deliveries, return rate of goods, delivery density, size of the Parcel Locker and finally some assumptions related to consumer behaviour, namely travel mode and trip chaining to pick up at the Parcel Locker. For example, with the same route, a population density of 0 to 50 inhabitants per square kilometre compared to a density above 1,500 inhabitants is associated with a cost of delivery almost three times higher (**Gevaers, 2013**). Even bigger is the impact of missed deliveries, being 2% to 35% of total deliveries and, if they involve the consumer's journey to the depot to pick up the missed package, the costs can be considerably high (**Edwards et al. 2009**). The interpretation of the value of the difference between home-delivery and parcel locker should therefore also be depending on how polluting or expensive home-delivery is. Consumer habits also have a very big impact on the relative convenience of the Parcel Locker. Travel mode and trip chaining are likely to make the Parcel Locker environmentally unsustainable: **Giuffrida et al. (2016)** quantify the threshold beyond which parcel locker delivery is no longer sustainable of 0.94 kilometres of total distance travelled per package with a private motor vehicle. As a result, the overall mobility habits of a city's population determine whether Parcel Lockers succeed or not, and whether it is sustainable or not. A large city with inefficient public transport and/or a poor tradition of cycling is unlikely to provide a sustainable use of parcel lockers.

The literature on Parcel Locker, in addition to showing its environmental and economic benefits, highlights the characteristics that favour its use by the consumer.

Availability throughout the day, low delivery cost and speed of delivery seem to be the three deciding factors for choosing the Parcel Locker (**Moroz & Polkowski, 2016; Iwan et al. 2016; Lagorio & Pinto, 2020**). However, other research also highlights other attributes such as the safety and the convenience of the place where the Parcel Locker is located and other general safety issues (**Oliveira et al. 2017**). Variables such as the certificate of environmental sustainability and assisted delivery seem to have been overlooked by the literature.

However, the study of consumer preferences towards Parcel Lockers is likely to be of relative relevance as consumer preferences can vary from country to country as from city to rural areas. The influence of several social factors therefore prevents its generalisation.

As for the supply side of the Parcel Locker, although the initial investment is not low, it does not seem to be a particular issue (see **Iwan et al., 2016**) unless the market share of the operator is very low (**Zurel et al. 2018**).

The regulatory aspect, on the other hand, may present some problems.

As regards the lockers on public land, the authorities must share or rent out public space for the Parcel Lockers and provide planning and construction permits (**Iwan et al. 2016**). This may not always be easy as publishing a tender to build Parcel Locker in a meter or along the road involves different levels of difficulty. Some areas that are particularly suitable for Parcel Lockers, such as metros and stations, may also present a safety issue. In Italy, for example, due to terrorism, it is illegal to leave packages unattended. In particular, in the collection or return of packages, a bomb or any dangerous object could be placed inside the Parcel Locker.

Another issue is the ownership of the Parcel Locker. The best way to maximize efficiency would be to have public Parcel Lockers that can be used by all operators (**Baksa et al. 2017**). However, several logistics operators have expressed their opposition to the use of public Parcel Lockers. The risk would be the loss of customer confidence, as they would be unable to guarantee the availability of the Parcel Locker itself. The presence of public Parcel Lockers could generate a saturation problem, as all operators would guarantee the packages on the same day, making many Parcel Lockers unavailable indeed. An agreement to secure a certain number of lockers for each individual logistics operators is difficult to reach.

Nevertheless, the Parcel Locker also offers different types of opportunities: rental income from companies that manage Parcel Lockers, sale of previously unused spaces, using the Parcel Locker as advertising opportunity, and increased shopping flow in stores or facilities that house the Parcel Lockers.

Even if the Parcel Lockers do not spread on a large scale, they could still be very present for the exclusive use of particular social groups such as members of businesses, universities and buildings. A pilot experiment at Seattle's Municipal Tower (a skyscraper) showed how placing Parcel Locker inside the building can reduce parking time by 80% (**Goodchild, 2018a**).

### **3.1.1.2 Pickup Points**

Pickup Points for online purchases are stores authorized to receive packages from e-retailers and deliver them to the customer. Similarly to parcel lockers, they are inspired by the principle of the consolidation of goods and the goal of minimizing missed deliveries. Unlike Parcel Lockers, they are not a new concept: in France, they have been present for several decades (**Morganti et al. 2014**). In general, pickup points are widespread in the UK, Germany and France, with as many as 20% of parcel deliveries in France and 91% of the population having access to a pickup point with less than 10 minutes driving or walking distance (**Morganti et al. 2014**).

Pickup Point networks are composed of tobacconists, bookshops, gas stations, clothing stores, and other types of shops that lend their stock space to logistics companies in exchange for a cash payment. According to **Morganti et al. (2014)**, the growth of these networks, from the perspective of the logistics operator, depends on external and internal factors (population density and proximity to transport nodes), socio-economic centers, which provide parameters of mobility and accessibility, and finally by the distribution of flows through the network.

While pickup points can be economically and environmentally beneficial, they are bound by a number of factors: retailers' willingness to become pickup points, and transport system such as traffic, public transport and roads are important limitations.

The key aspect of the networks is the stability of parcel flows and the ability to adapt to changes in flow, which requires control of retailers acting as pickup points. Retailers are first convinced to be part of the network, and it is not always easy, since for reasons of space, time lost for deliveries or simple disinterest they may not consent to be part of a pickup point network, and then it is necessary to have a quick turnover in case of defection (store sale or simple exit from the network).

There are several researches that have investigated the possible economic and environmental benefits of pickup point networks as different factors vary **McLeod & Cherrett, (2009)** consider a single pickup point (a station) and compare it to a basic home delivery option, as the proportion of people using pickup point changes. Assuming a rate of missed deliveries of 12%, an average distance from the pickup point of the consumer of 2.1km and a distance from the depot of 12.1 km, a reduction in CO2 emissions of 33% is estimated in the case of using pickup point as the only method of delivery. Environmental estimates predict a CO2 reduction of around 30% (**Song et al. 2013**). Data shows that there is no environmental advantage if missed deliveries are less than or equal to 20%. The main limitations to the benefits of pickup points are the means of moving to reach pickup points by the consumer and the increase in costs for the courier. However, most of the studies examined see pickup points as a supplementary solution to home delivery, while today they have increasingly established themselves as an independent delivery mode and not a post-home delivery. Therefore, the supposed non-convenience for the courier is no longer an issue.

A further issue that also emerges considering the system of pickup point networks independent of home delivery are the different preferences of public authorities, consumers and logistics operators. As the number of pickup points increases, consumer satisfaction increases, but at the same time the benefits for 3PLs are reduced and externalities increase, since this forces operators to make more delivery routes and stops. **Cárdenas (2019)** estimates the optimal number of pickup point to achieve efficiency and shows how more environmentally friendly solutions are difficult to achieve.

In conclusion, compared to Lockers, pickup points have the advantage of having lower costs and being easier to implement, but they can present the problem of network instability, are not usually accessible 24h/7 and have a more limited range of products. Parcel Lockers can also potentially handle larger packages and could theoretically also be refrigerated to contain the grocery purchased online. Pickup points management in general may be more complex as it requires the involvement of more actors (all pickup point store owners), sometimes with conflicting preferences.

In any case, Parcel Lockers and pickup points could represent two complementary solutions, especially if they are part of integrated planning.

### **3.1.1.3 Door to Car**

Pickup Points and Parcel Lockers contribute to solve the missed deliveries issue and can, but not necessarily do, reduce pollution and traffic problems. Another innovative solution is to deliver the products directly to the consumer's car. The mechanism is simple: through a smartphone app the

courier receives the location of the car, the license plate and a code with which it can access the boot once, all through blockchain technology. Pilot projects were conducted by Volvo, Skoda, Volkswagen in collaboration with DHL (**2018**) and by Smart which also created a prototype machine designed specifically for door-to-car deliveries. The system would also allow the possibility of the return of the product. The advent of Internet of Things (IoT), which already allows integrated management of private cars via an app, could lead to the sharing of a security system with couriers and postmen in the future.

### 3.1.2 Delivery mode

#### 3.1.2.1 *Click & Collect and Try & Buy*

The models seen so far, although based on a participatory approach, see logistics operators as key players. However, there are several last mile logistics schemes where these actors do not often have a central role, which is played by the retailer or e-retailer.

The two schemes in question are click & collect and try & buy. In the first case, it is a purchase of a product online and consequent pick up in the e-retailer store. On the contrary, the second case involves ordering one or more online products, testing the product in a physical store, and purchasing it. The two models have a very different level of diffusion: the first one is already very practiced, in Europe it is chosen by 36% of online consumers, with peaks of 42% (**Casaleggio Associati, 2018**), while the second is present sporadically in a few countries. Another significant difference between the two models is the only applicability of try & buy to the clothing branch.

Both models were born with the idea of cutting the costs of the last-mile. Click & collect aims to limit home delivery, by bringing customers to special stores, and secondly aims to encourage online buyers make new purchases once they arrive in store. According to **Verdict (2016)**, 11% of individuals always make an additional purchase at the store and 60% do it sometimes.

On the contrary, try & buy was born with the idea of avoiding the return of products and subsequent reverse logistics. This mode is based on the online purchase of products that are then shipped to special stores where you can only try the products already purchased. The Czech company Zoot is a forerunner (**Allen et al., 2018**), having noticed that try and buy encouraged higher value-added purchases.

Again, there are important limitations, in detail regarding click & collect. The functionality of this option from a logistical point of view is linked to the choices of mobility of the consumer: the choice of the car reduces or cancels the benefits of the renounce to Home Delivery. It should also be noted that many companies combine different purchasing schemes (Home Delivery, click and collect) and also encourage the shift from one to another, offering free delivery to those who use the click & collect service, reducing the environmental effects.

Try & buy and click & collect fit into a reality of e-commerce that increasingly aims at omnichannelity, that is, the presence of companies on a physical and virtual level integrating the different methods of shopping available to consumers (**Casaleggio Associati, 2018**). An example is offered by Boggi which offers the Boggi Omnichannel experience that allows the customer the click and collect, but also to book, try, buy at the store and receive the product at home. Zara has instead opened pop up

stores, where you can try products in store, buy them online from the store and receive them at home. These new multi-channel experiences are not necessarily more sustainable.

However, a combination of click & collect and try & buy can be more sustainable than all the modes seen here. In this regard, the parcel delivery company DPD has opened in Amsterdam, next to its urban depot, a shop where you can pick up your parcel (click and collect), but also try in a dressing room your purchases (try and buy) and finally receive the product at home through a more traditional Home Delivery made with electric vehicles.<sup>17</sup>

### 3.1.2.2 Crowdshipping

Crowdshipping, unlike the previous two delivery modes, is not about the retailer or the e-retailer but about the actor who delivers the package.

Crowdshipping is a concept that indicates, at the most essential level, a freight transport system that operates by outsourcing deliveries to a fleet of non-professionals (**Simoni et al., 2020**). A restrictive interpretation of this concept focuses on the delivery of the goods as an event within the predefined route and a recurrent action of an individual.

If we consider the total number of kilometres travelled by a number of individuals such as the sum of passenger mobility and the mobility of goods, the inclusion of a delivery action in the predefined route of an individual not involved in logistics, thus minimizing deviations from the original route, reduces the distance travelled overall by all individuals and goods. Crowdshipping would also offer an economic advantage related to the non-need for a regular salary for shippers and a regular fleet of vehicles (**Goetting & Handover, 2016**).

**Simoni et al. (2020)** show how crowdshipping carried out through a public means (in the example the metro in Rome) can have positive effects on the reduction of negative externalities (traffic, pollution, accidents), while crowdshipping carried out through a private means can result in negative externalities that can only be partially compensated according to the deviation from the original route, the time at which the delivery is made, and the availability of parking spaces.

A key element in crowdshipping is the induced supply: the market possibility of earning from the transport of goods would inevitably lead a number of individuals to the offer of the delivery service by private means, distorting the original idea of crowdshipping. There would be an "uberisation" of the service, with minimal or no effects on sustainability (**Mckinnon, 2016**). Other critical issues of crowdshipping are the absence of a regular contract for crowdshippers (**Marcucci et al., 2017**), the potential demand for dangerous or illegal goods (**Goetting & Handover, 2016**), an insurance system in case of damage or loss of the package and the lack of trust in a similar system especially if it is sensitive goods (e.g. medicines).

To date, there is no successful model developed for crowdshipping, rather several startups with a very short life, with limited but remarkable exceptions. An example is NIMBER which is a successful and

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<sup>17</sup> <https://www.dpd.com/nl/nl/city-store-rotterdam/>

growing crowdshipping start-up<sup>18</sup>. The current business model targets peer senders (end-users) and uses peer bringers (everyday commuters) to deliver. The platform matches the two and charges a matching fee. With the participation in LEAD, NIMBER envisions the development of new 'offerings' and business models (P2P, B2P, P2B and B2B delivery) and growing the bringer community by promoting the company as a sustainable alternative delivery channel.

Other examples are the two Italian startups Take my Things and iCarry that offer a refund of expenses to crowdshippers. In their case, the service is seen as a favour between users and as a voluntary service, so crowdshippers are neither employees nor self-employed and therefore there is no insurance system in case of damage to the goods and legal protection for crowdshippers.

Crowdshipping could potentially be an interesting and complementary solution to the Parcel Locker. Individuals who make the commute to work via the metro, for example, could pick up parcels in the Parcel Lockers within the metro and deliver them to the recipient or to another Parcel Locker or pickup point at the exit of the metro station.

### 3.1.2.3 *Instant delivery*

The employment of self-employed couriers or improvised delivery drivers it is becoming common practice. They actively engage in ultrafast (instant) deliveries, in a delivery window that goes up to 2 hours, via digital platforms that connect shippers, couriers and consumers (**Dablanc et al., 2017**). Examples are Amazon Prime Now, Mercadona, Dia, FNAC. Amazon Flex enables anyone through an app and a means of transportation to make deliveries, although the system requires a self-employment status and it has generated several labour law-related issues in different countries.

Instant delivery applies not only to the delivery of small packages, but especially for the instant delivery of food. Foodora, Deliveroo, Glovo, UberEats are some of the many companies that deliver ready meals through bellboys (now called 'riders') in major European cities, connecting restaurants, bars, ice cream shops with consumers. There is also a similar business model such as JustEat where the platform connects consumer and shipper, without offering the delivery service that is offered by the restaurant/pub.

To date, instant food delivery is widely used, just think of how in Manhattan 31.8% of the population declares to use a food app at least once a week, while in China you get to almost 10% of people who claim to take advantage of such an app almost every day (**Dablanc, 2018**). The benefits of instant delivery are obvious from the point of view of some of the actors involved. Firstly, there is the satisfaction of the consumer who through instant delivery sees the possibility of a smart and 'on the move' lifestyle. The delivery platform manages to make big profits from the low cost of labour. For retailers, there is the possibility of outsourcing delivery costs, gaining in speed and traceability, and there would be the possibility of becoming distribution centres for online products, thus offering different channels to consumers. There are also cases where restaurants have turned into real

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<sup>18</sup> <https://www.nimber.com/>

kitchens solely for the service of online sellers. Finally, on the environmental level there can be an advantage: for example 65% of riders in Paris use the bike to deliver (**Dablanc, 2018**).

However, there seem to be many disadvantages. The mode of delivery provides for an increase in the urban transport flows.

Riders have very tight timelines, very often do not comply with the rules of the road and it seems that this is leading to an increase in accidents, even if there are few and inaccurate road accident data (**Dablanc, 2018**). The same environmental benefits, rest on an absolute increase in the kilometres travelled and emissions that is only compensated by the use of the bike by riders. However, the issue that raises the most concerns about the sustainability of instant food delivery is social sustainability. Riders are for the majority (50% in Paris) (**Dablanc, 2018**) people who do the job as their first job, often from ethnic minorities and/or from more deprived neighbourhoods, or students who seek to supplement their income. Their uncertain working status, lack of clear rules on riders' contracts and the absence of trade unions often subject them to poor working conditions. There have been several disputes over their work status and protests of the riders themselves. The issue of low wages is mixed with the low willingness to pay of consumers for instant deliveries, which also threatens to undermine the economic sustainability of the business, as revenues tend to remain constant while costs could rise and with these the subsequent risk of withdrawal of investment by partners. New collective and cooperative organisations such as CooCycle<sup>19</sup> aim to tackle this issue, by socializing bicycle delivery.

Finally, one of the biggest limitations of instant delivery (both the food and other sectors) is the difficulty in consolidating deliveries. There are some alternatives: on the one hand, Amazon, which, given the number of deliveries, is able to partially consolidate Amazon Prime deliveries; on the other hand, pure crowdshipping, for example that carried out by the *DHL My ways* pilot project in Stockholm, where deliveries were made by people who did not deviate from their usual route and were not workers.

### 3.1.3 Delivery times

#### 3.1.3.1 Night deliveries

Night deliveries are not so much a new last-mile logistics scheme, rather a way of applying logistics to different last-mile schemes. For many logistic players, such as Citylogin - FM Logistic<sup>20</sup>, the night delivery is only viable for B2B distribution.

Off-hours deliveries could be combined, for example, with the use of Parcel Lockers and the use of electric vehicles or (UCC) (**Gatta et al., 2019**). **Bouton et al. (2017)** foresees a 70% reduction in the number of kilometres covered in densely populated cities, a halving of delivery times and a 40% reduction in logistics costs, whereas **World Economic Forum, (2020)** estimates a reduction of delivery costs of 28% and a decrease of congestion of 15%

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<sup>19</sup> <https://coopcycle.org/en/>

<sup>20</sup> <https://www.fmlogistic.com/eng-gb/Our-business/Supply-Chain-Optimisation/Citylogin>

At night, heavier vehicles with no daytime access could circulate, at higher speeds, with a lower risk of accidents and with ease of access to loading and unloading areas.

There are many disadvantages that can limit the application. While it is true that the noise problem can be solved by electric vehicles or noise-blocking devices, it is also true that such devices are expensive and employing workers at night has a higher cost, without considering the problem of encouraging businesses to get work or hire staff to work at night.

**Oliveira et al. (2010)** and **Holguín-Veras et al. (2014)** show that it is first essential to evaluate what makes normal daily deliveries sub-optimal. Then, it is necessary to involve all stakeholders and in particular businesses, understand their interests and carry out pilot tests. The role of the administration is crucial since stakeholders may not see the long-term benefits, but focus only on short-term losses. The public regulator's commitment is needed to create public and private partnerships, to support the initiative with subsidies and incentives, in particular to convince retailers to accept the choice of off-peak delivery, and to convince hauliers to equip themselves with noise-reducing equipment.

An example of success is in Barcelona, from which project has expanded throughout Spain. In the Catalan city two large trucks, equipped with devices to reduce sound, are able to replace 7 day trucks going at three times the speed of a standard time (**Bouton et al. 2017**). Other examples of night delivery schemes have been successfully applied in New York, London and Stockholm (**Holguín-Veras et al. 2014; Sánchez-Díaz et al. 2017**).

### 3.2 Management of loading and unloading areas

Improving delivery times, locations and modes cannot neglect considerations of loading-unloading areas. To date, the competition kerbside space is extremely intense, emblematic of the fact that traffic depends between 13% and 18% from the search for parking in the main cities (**Hampshire & Shoup, 2018**). The lack of loading or unloading space or the fact that it may be not convenient (in London 62% of the time of a typical daily delivery and 40% of the distance travelled depend on the courier's walking shift) (**J. Allen et al. 2018**), prompts the transporter to look for a *do-it-yourself* solution that consists of putting the van or truck in double row, generating traffic and leading to increased accident risk. The solution to this issue is not so simple since it is necessary to balance the demand of the loading and unloading areas of logistics with the needs of the other actors who use the road. Active mobility, geared towards cycling and walking, despite the proven improved safety and urban liveability, with positive effects on employment, has often created concerns on part of businesses and citizens about accessibility for those who have to use the car, and the availability of loading and unloading areas and traffic (**Lee, 2020**). All-encompassing plans are therefore needed, with the participation of the different stakeholders who directly concerned by the kerbside management (e.g. in Toronto (**Lee, 2020**)).

Solutions are manifold and relate to both the generic parking of cars and the management of the loading-unloading areas.

A first step was taken in Seattle **Goodchild, (2018)**, where public and private loading-unloading areas have been georeferenced.

As for parking, local authorities are increasingly trying to move the choice of parking from on street to off street locations (e.g. commercial garages, private spaces). One of the most innovative approaches is to predict the demand for parking on the road and, on the basis of this, defining the price<sup>21</sup>. The initiative has been tried in the United States, in San Francisco, where its application in congested areas of the city has led to increased availability of parking on the street and reduced the time lost in seeking parking, therefore reducing urban congestion **(Lee, 2020)**.

In the same way, it may be useful to set limits on the duration of parking and to guarantee or prohibit parking for certain types of vehicles at different times of the day, giving advantages to green vehicles, for example by preventing on-street parking at times when you have the peak of daily traffic. Fundamental to this purpose is the design or prediction of the city authorities of the ways in which the curbside space in the main urban streets (e.g. commercial streets) will be used **(Lee, 2020)**.

As for freight, some initiatives aim to apply a fee on loading-unloading areas. In Washington, this initially saw a hostility of hauliers, but once it led to a 50% decrease in double-row parking, the hauliers noticed the time and safety benefits of the unloading area. Such a policy, suggests the report of **(Lee, 2020)**, could be even more effective if accompanied by an increase in off-the-road parking and a reduction in parking time at the kerbside.

If one looks at the overall issue of parking, it is important to remark that cars are parked 95% of the time during the day. For about half of this time fraction, cars are parked in the work area of their owners, often in parking lots provided by the companies themselves.

Reducing or cancelling this company policy could limit the use of the cars as a means of transport for commuting, improving the overall availability of parking. **Evangelinos et al. (2018)**<sup>22</sup> show the possibility of an increase in available parking spaces, through the monetization of the company parking space, in particular through the reward equivalent to the monetary value of parking in case of voluntary renunciation of the parking space.

## 3.3 Consolidation

### 3.3.1 Urban Consolidation Centers

Urban consolidation centers (UCC) are “logistical facilities located relatively close to the area they supply (city centre, entire city, or specific location) from which consolidated deliveries depart”**(Allen et al. 2007)**. These facilities may vary according to participants, activities carried out and funding methods.

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<sup>21</sup> <https://www.ite.org/pub/?id=C2D66E96-FF01-0BA8-68C3-65CC9116A5AE>

A UCC can be managed by a single company or consist of several companies, be financed or co-financed by the public sector or other funds and ultimately only be financed by the logistics operators themselves.

Although often the first purpose of a UCC is the delivery of goods (B2B or B2C), they can perform various functions such as the storage of stocks of products, labelling and pricing, the return of goods and services and waste collection. There are also UCCs that do not include the delivery of goods, for example they only deal with the transport of building materials.

The UCC does not necessarily supply an entire city, rather it is easier to serve a specific site or area, see the case of London Heathrow Airport (**Allen et al. 2007**).

The traditional benefits of freight consolidation (reduction in the number of trips and mileage, increased vehicle load capacity and lower environmental pollution) are also complemented by improved planning capabilities and inventory control.

According to **Bouton et al. (2017)**, an effective UCC system could reduce delivery costs by 25% or 30% (depending on whether the vehicle is electric or not), CO<sub>2</sub> emissions by 45% and mileage by 45%. There are also other studies confirming some of these effects and in particular a reduction in the kilometers travelled from 30% to 80% (**Allen et al. 2007**). However, there are some studies, such as **World Economic Forum, (2020)**, that highlight only a possible slight improvement, namely a reduction of emissions, delivery costs and congestion, respectively of 2%, 3%, 5%.

In general, the UCC, by making the supply chain more visible, could encourage its improvement, not to mention that the possibility of concerted action for the creation of a UCC lays the groundwork for broader policies in the logistics sector. A very interesting aspect is the possibility of using green vehicles from the UCCs to further improve environmental sustainability.

The UCC has also significant disadvantages. The main problem is the high investment and operational costs that often require subsidies in order to be covered. Such a logistics system requires considerable organizational efforts, since different goods require different methods of storage and handling. UCCs also require very large spaces and tend to create traffic near the location (**Stefanelli et al. 2015**). The complexity is also linked to very frequent contractual issues. Finally, a further risk is the possibility of a monopoly.

These issues have often been accompanied by unexpectedly low demand, excessive distance from the city and the lack of participation of logistics operators, doubtful of the profit opportunities of the initiative, institutional commitment and partners or simply not interested in the scheme given their already consolidated distribution system (**Van Rooijen & Quak, 2010**).

Although most of UCC's projects have ended due to failure (**Allen et al. 2007**), there are several examples of successful plans that have been completed or are still in progress.

One example is the *London Borough Consolidation Centre*, where 224 suppliers supply 300 local shops, generating a 69% reduction in kilometres travelled, 67% reduction in CO<sub>2</sub> emissions and a 7.5% cost reduction (**European Commission, 2016**). The success of this UCC is primarily linked to the focus on a geographical area that is not overly extensive, the requirement of a certain number of goods to be unloaded per delivery, the obligation to use the UCC in public tenders concerning the

delivery of goods and the separation of public tenders concerning the supply of an asset and its delivery.

Another example is Broadmead in the United Kingdom, where a consolidation system supplies Bristol's commercial district with medium-sized and non-perishable goods, in particular by supplying 51 shops in the city's central areas (**Allen et al. 2007**).

A new model of UCC are the so-called logistic hotels in Paris<sup>23</sup> (**Dablanc, 2019**). These are based on a standard business model, where an owner of an area within the city offers the space for rent to different logistics operators and other stakeholders for other uses, in order to compensate for the possible exit from the hotel by some logistics stakeholders. This avoids the logistic sprawl and both the companies that carry the goods (renters) and the owner can make profits. However, this model also presents significant organizational challenges, the overcoming of which will be assessed in the coming years.

Ultimately, UCCs need different geographical, infrastructural, spatial and player conditions to function. Geographically, it is an advantage to be located in areas with significant transport problems (traffic, difficulty in access), with inadequate and unsuitable infrastructure to deal with the growth of freight traffic, with historic centres and neighbourhoods suffering from commercial vehicle traffic and where there is a common interest in improving the urban environment. A location at the edge of an urban access zone could also be convenient, such as in the case of the low emission zone for the Logistic Hotel developed in Lyon and expected to open in 2023. At the actor level, the presence of many independent businesses and retailers with a dedicated and complex supply chain can favor a UCC.

The interests of different actors (retailers, couriers, public sector, citizens) should be aligned. Public and private support is needed, as well as institutions able to put together the various preferences of stakeholders. Public support is particularly necessary both to support UCC projects economically, at least at the beginning, and in the proactive phase to reverse harmful trends for entire cities, for example the logistic sprawl, offering long-term solutions, like in London and Gothenburg (Orving et al., 2019). In order to have a project that is self-sufficient from an economic point of view, an approach that is not top-down is extremely important (**Allen et al. 2007**).

Finally, another aspect to consider is the integration of logistics into urban plans, ensuring that a sufficient amount of logistics areas in the city are reserved before they are occupied for other purposes. This issue is particularly important given the normal scarcity of available and low-cost urban spaces. (**Ørving & Eidhammer, 2019**).

### 3.3.2 Micro-hubs

Following several failures of the large UCCs of the 1990s, the idea of UCC has in some cases evolved: the new UCCs have become smaller, with a more limited range of delivery (**Janjevic & Ballé, 2014**), more like places of trans-shipment than urban consolidation centres and with limited functions than UCCs (**Verlinde et al. 2012**). These new logistics facilities have been called micro-hubs or micro-

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<sup>23</sup> <http://www.sogaris.fr/plateforme/paris-18eme-chapelle-international/>

consolidation centres. Micro-hubs are characterized by the use of light vehicles (small vans, walking or cargo-bike) and with low environmental impact.

Their advantages, beyond the reduction in emissions, can be manifold.

The apparent time lost by new low-emission vehicles is more than offset by less loading and unloading time, making logistics costs lower (**Lee et al. 2019**). The combination of micro-hubs and sustainable vehicles also fits very well with other logistical combinations such as off-hours delivery, which requires non-noisy vehicles. New city policies that create access windows for freight delivery, restricted traffic areas and areas accessible only to sustainable vehicles, offer an ever-increasing incentive for this new type of logistics scheme. In addition, new electric vehicles are perceived as suitable for the central tourist areas. These facilities are usually cross dock centres with not or limited space for storage and handling operations. Therefore, synchronization between inbound and outbound flows needs to be well planned.

As with other types of models, the operation of the hubs is linked to intense collaboration between the various actors whose possibilities must be evaluated at a preliminary stage also through field research. Public authorities must then provide an appropriate environment for the hub and electric vehicles. This means restricting access to heavy vehicles, parking space on the road mainly for small vehicles and with preferential access to green vehicles, widespread electric grids, incentives to switch to green vehicles, and economic support where necessary. In general, a policy more favorable to pedestrians and cyclists is better associated with freight transport based on light and zero-emission vehicles. Another very important and often overestimated aspect is the willingness of couriers to join a similar scheme (**Quak, 2014**). Finally, the delivery area must be profitable in itself, i.e. there must be a high demand for freight transport, because the long-term profitability of the project depends on that (**Verlinde et al. 2012**).

The study of **Urban Freight Lab (2020)** observes different types of micro-hubs, considering whether the consolidation mechanism is through one or more operators.

The simplest model consists of a transport company that consolidates deliveries to urban stores, such as the case of the Brussels mobile depot. Another mechanism, based on only one company, is that of UPS with its *Pickup Points*.

Models where microhubs consolidate deliveries of multiple carriers are more complex because they require more cooperation. One of the most recent, but most successful cases, is that of the logistics company Binnenstadservice (BSS) in the Netherlands. BSS provides a service reserved to small retailers. At the request of the latter, the goods are transported by external couriers, rather than directly to the store, to the BSS hub, from where they will then be delivered with electric vehicles to the retailer (**Van Rooijen & Quak, 2010**). In this way the retailer, rather than receiving many separate deliveries from different suppliers, receives a consolidated one at the time requested, saving time and money. Similarly, couriers avoid frequent and near-empty deliveries in the city and share (on a voluntary basis) some of the costs saved with BSS. The Dutch company also offers additional services such as reverse logistics and storing products in stores in exchange for extra costs, the only source of BSS revenue along with shared courier savings. Nowadays, the strategy upscaled: in fact, the focus is on the larger retailers and logistic services providers as BSS now organises also (city) logistics operation more at national scale (**Quak et al. 2020**).

Another interesting and in some ways alternative example is the case of Yokohama (**Browne et al., 2012**), where an association of sellers of a commercial street runs, with the partial help of the local government, a microhub. The case is interesting because it is the first case of management entrusted directly to a retailers association in Japan. The creation of the hub was accompanied by the use of low emission vehicles, ensuring space for parking freight vehicles, eliminating illegal vehicle parking and improving urban road signs.

Finally, there are also hybrid cases where companies have their own microhubs, but they share others with other companies: it is the case in London, where Gnewt Cargo, a logistics company based on an 100% electric fleet, also consolidates part of the deliveries of Hermes and TNT (**London City Hall, 2018**). The success of the initiative was helped by the creation of a low-emission zone in London and the improvement of the electricity grid.

A similar example is the KoMoDo Project in Berlin, where five logistics companies shared an urban micro-hub<sup>24</sup>, delivered 160,000 parcels in an area of 2-3 kilometres reducing emissions and noise levels and double parking. Following the success of the pilot project, 3-5 new city hubs are planned to open in Berlin in 2020<sup>25</sup>.

### 3.3.3 Mobile Depot and small electric vehicles

Mobile depots are one of the most innovative initiatives in the field of urban logistics. The basic idea is a mobile means of transport (a bus, a caravan, a container), present within the city from which goods are loaded on light vehicles, which can be cargo-bikes, van-electric or electric tricycles.

The trial of mobile depots is generally associated to the testing of small and electric vehicles. Cargo bikes and electric tricycles have been tried in several cities, including London, Paris, Stuttgart, Utrecht, Yokohama and have become quite popular. Only later, in 2013 in Brussels, the use of cargo bikes with a caravan as a mobile depot was trialed for the first time.

The benefits associated with the mobile depot and electric vehicles are numerous and go beyond reducing environmental pollution and traffic. The vehicles mentioned provide flexibility and accessibility to different infrastructures such as pedestrian areas, bus lanes (when allowed), a faster flow through traffic and better parking possibilities. Small electric vehicles are less expensive in terms of purchase price, tax, insurance, storage, depreciation, running costs, and there are no parking and traffic charges, they are faster in the event of traffic and drivers do not need specific training of license to drive the vehicle. Light vehicles are also a much lesser threat to the safety of pedestrians and passengers (**Arvidsson & Pazirandeh, 2017**).

Despite these advantages, mobile depots also have issues that mainly affect their economic viability.

As several cases in Europe show, these logistics schemes have relied on very expensive distribution centres. In the case of Brussels and Berlin, an additional loading and unloading phase was required

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<sup>24</sup> <https://nationaler-radverkehrsplan.de/de/aktuell/nachrichten/paketauslieferung-lastenrad-erfolgreich-erprobt>

<sup>25</sup> <https://www.velove.se/news/komodo-city-hub-project-in-berlin-it-works-its-fun>

with expensive intermediate storage (**Arvidsson & Pazirandeh, 2017**). All this makes the subsidies necessary to make these projects feasible.

In the case of Brussels, for example, costs for TNT (the logistics company operating in Brussels) have doubled: costs for bikes, for transshipment on bikes, maintenance of the depot, the management of additional warehouses and packages beyond the maximum weight that can be managed by bikes - all these elements represent barriers to the competitiveness of the service in terms of costs, not to mention the initial investment to create a mobile depot (**Verlinde et al. 2014**).

However, ad hoc scenarios for the Brussels case showed that a substantial improvement in the depot's capacity (from 40% to 90% of use) and an improvement in the delivery density of goods can make the model more competitive (**Verlinde et al. 2014**).

There are other examples of a theoretical production application of the mobile depot that are pushing for further experimentation. One example is a mobile depot that moves around the city following the city's transport networks, directly connected to electric carriers and with standardized loading units, in order to reduce intermediate storage costs and facilitate transshipment (**Verlinde et al. 2014**). In a similar scenario, assuming a sufficient level of capacity to use the depot, competitive advantages can also be obtained by the investment company. Another important aspect to consider is again the need for coordination between different stakeholders, in particular a fair sharing of risk and benefits that can overcome resistance.

## 3.4 New technologies

### 3.4.1 Automated and Autonomous delivery systems

An entire logistics industry is emerging or in the process of doing so and is based on ongoing technological advances in automation. In the field of logistics, automation means the ability to use for deliveries drones, droids, automatic vehicles and automatic vehicles with built-in *Parcel Locker*.

One of the first examples of using automated delivery systems was in 2011, when Amazon completed the delivery of a package through the use of a drone.

Drones would cut labor costs and package arrival times, allowing a cost delivery reduction of six times compared to traditional van **D'Andrea (2014)** and enabling the most urgent deliveries.

According to **Goodchild & Toy (2018)**, drones would reduce CO2 emissions, even though the best-case scenario would be a mixed delivery system based on integration with vans, so that drones would be used only for the very last-mile.

The main problem of drones that makes them unattractive between the various automated solutions is the extremely small load they can carry (15-16 drones needed to replace one van) (**Paddeu et al. 2019**), the need for a minimum space of two square meters for landing, (not available in most of city apartments), lack of security (theft, in particular the possibility to be hacked for malicious uses, accidents, privacy), acoustic pollution (a negative ecological impact on birdlife), the need for good weather conditions, lack of energy efficiency and existence of regulations preventing them from

circulating freely in the air (**Bouton et al. 2017; Paddeu & Parkhurst, 2020**). Furthermore, stakeholders declared their negative perception on drone utilization in urban areas (**Paddeu & Parkhurst, 2020**).

Despite these hardships, the idea of adopting drones to deliver goods has generated significant interest among logistic players, as several pilot tests have been conducted by DHL, Amazon, UPS, Google<sup>26</sup>).

One system that is considered to have the greatest potential is the one based on automated vehicles (AVs). AVs can be road-based (driverless car or trucks) or ground-based (droids).

While a few studies have been conducted on the impact of road-based AVs in urban last-mile delivery (**Paddeu & Parkhurst, 2020**), there are several pilot projects on-going: Robomart, an American startup, claimed to be the first self-driving store, Ford is testing autonomous pizza delivery in partnership with Domino's, Nuro, an American startup, is testing grocery delivery and medical supply delivery<sup>27</sup>.

**Bouton et al. (2017)** considers this scheme able to reduce delivery costs by 50% and reduce congestion due to automatic navigation systems and better driving habits, while **World Economic Forum (2020)** deems this solution able to reduce costs by 4% and congestion by 4%. The possible electrification of the vehicle would be an additional plus to the use of such a system. However, improvement depends on level of automation (**CoExist, 2020**) and nowadays, enterprises have not reached yet a complete level of automation (**Paddeu & Parkhurst, 2020**)<sup>28</sup>.

When it comes to speaking about ground-based, the situation is similar: there are several pilots delivery solutions such as Eliport, a new start up, based in Barcelona, Jingdong, China's second-biggest e-commerce company after Alibaba and Starship<sup>29</sup>, a startup that deployed his robots in 8 cities around the world<sup>30</sup>.

Starship, in particular, offers a service where the autonomous robot drives itself from the origin to the destination, using a path algorithm to find the quickest and safest path, traveling at an average of 6.5km/h speed (up to a maximum 16km/h) and guaranteeing security with microcameras and alarms (**Paddeu & Parkhurst, 2020**).

On-demand solutions similar to the one developed by Starship, could reduce drastically failed deliveries and indirectly congestion, polluting emissions and operational costs for logistic operators (**Paddeu & Parkhurst, 2020**), in this regard **World Economic Forum (2020)** quantifies a reduction of emission, delivery costs and congestion respectively of 6%, 20% and 25% while **Toy (2020)** states

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<sup>26</sup><https://circuitdigest.com/article/drone-delivery-future-of-shipping-industry>

<sup>27</sup> <https://www.roboticstomorrow.com/article/2018/06/the-top-ten-autonomous-delivery-solutions-of-2018/12156>

<sup>28</sup> <https://www.allthingsupplychain.com/autonomous-vehicles-in-logistics-part-1-opportunities-and-risks/>

<sup>29</sup> <http://www.reuters.com/article/jdcom-results-idUSL3N1GF3GQ>

<sup>30</sup> <https://www.roboticstomorrow.com/article/2018/06/the-top-ten-autonomous-delivery-solutions-of-2018/12156>

that a few cents paid by the customer as a delivery surcharge can make the last-mile delivery of e-commerce items and groceries nearly free.

However, other studies, shows that commercial viability is not demonstrated: low compatibility of tools/equipment at the destination points, safety and security issues due to human backup being remote than proximate, could increase delivery costs (**Kunze, 2016**).

Furthermore, the implementation of droids is limited by regulations that not allow to circulate on roadway or footway and by a resistance among professionals to the sharing of public space with droids, especially during the day (**Paddeu & Parkhurst, 2020**).

Finally, there is also the possibility of autonomous vehicles with *built-in Parcel Locker*. The idea, although not yet deployed, has attracted considerable interest, so much so that Google acquired the patent for this technology in 2016. In theoretical hypotheses, these vehicles would be stationary in certain areas communicated to consumers or *on the go*, by making home delivery. Similar to the traditional Parcel Locker, the recipient would be notified of the arrival date, location, how to open the Parcel Locker and the opening code. Lower labour costs would also lead to a halving of costs (**Bouton et al. 2017**), but there would be an increase in the number of kilometres travelled, bringing about an increase of delivery costs and congestion of 8% and 25% (**World Economic Forum, 2020**): as these vehicles/Parcel Lockers are smaller than normal vans, with the same amount of goods transported, more deliveries would be needed. This makes electrification an essential element for the sustainability of this means of delivery.

Technology still needs to reach complete automation in order to ensure safety and reliability. Moreover, public institutions have to support trials, as profitability of these solutions has not proved and help to remove barriers to the use of automation (e.g. procurement of equipped-roadway infrastructures, funding of ICTs technologies, specific regulatory framework to ensure safety, security, and address responsibility in case of accidents, fostering collaboration between stakeholders). In third place, lack of economies of scale and stakeholders opposition (e.g. drivers) has to be managed (**Paddeu & Parkhurst, 2020**).

### 3.4.2 Cloud Computing, Artificial Intelligence and Data Collection through the Internet of Things

In addition to the aforementioned futuristic autonomous vehicles, still far from being realized, automation is already largely spreading in the world of logistics. Cloud Computing, Artificial Intelligence and data collection through the IoT are now the basis of the supply chain and central tool to face new challenges, such as selling more, delivering faster and predicting the ever-increasing demand for goods. These new technologies enable real-time data analysis that is then used in *machine learning* for robotic warehouse management, demand planning, peak management, and finally for inventory management (**DHL, 2018**).

An example of the logistical application of the practices described is the use of augmented reality (AR) technology. This offers several uses that directly and indirectly affect the last mile: on the one hand, it allows to increase the productivity of the warehouses, allowing operators a visual representation of

the information present within the hubs. On the retail side, on the other hand, it would offer the consumer the opportunity to improve the ability to display a product within a given environment or directly on his own body, thus allowing to limit the return of products deemed unsuitable.

A first movement in this direction is given by the Ikea app, Ikea Place, which allows you to select a piece of furniture and see how it fits the customer's environment before making the purchase, and by the fashion company Gap which offers an app that allows you to simulate the dressing fit at home or at the store<sup>31</sup>. In the future, the use of augmented reality seems to be able to extend to other logistics subjects including couriers with the use of 3D glasses for a better view of the routes (**DHL, 2018**).

The most classic and most effective examples of artificial intelligence, cloud computing and real-time data are all those technologies that can plan real-time routes and improve driving sustainability based on traffic, weather, road closure and opening (e.g. GPS, GALILEO) (**Mckinnon, 2018**). It incorporates the efficiency of courier routes and the modernisation of vehicles through these technologies,

Among these technologies, *load pooling* is the application in the field of logistics of Uber. *Load pooling* consists of matching, through an online platform, the commercial vehicles of couriers with available space for goods with the needs of shops or logistics companies to ship a package. The algorithm receives information from the couriers about the available space, the route, the limitations to the receivable goods and the route of the courier, and from the customer the characteristics of the asset to be shipped, the delivery windows, the destination and the place of arrival of the package to be shipped. After receiving the information, it provides both with an optimized route and dynamic pricing based on the alternatives chosen. The benefit of this practice for the couriers is to operate at full load and to maximize the density of delivery of goods (drop densities). **Bouton et al. (2017)** evaluates the benefits of this practice in reducing the number of kilometres travelled by 30%, reducing emissions by 30% and reducing delivery costs by 25% while **World Economic Forum (2020)** estimates a reduction of emissions of 5% and a reduction of delivery costs of 8%. The great advantages of *load pooling* are the absence of technological barriers and the limited cost of infrastructure. This mode is now spreading: Uber, for example, is moving from people to goods, DHL has its own digital platform, UPS has bought companies that ran these algorithms and finally the outsourcing of Amazon services also moves in this direction.

The use of these technologies serves not only to directly improve the supply chain but also to monitor everything that happens on the road and indirectly influences logistics. Through geofencing, namely the creation of a virtual perimeter ('fence') associated to a real geographic area, it is possible to collect data on moving vehicles and use them to control access to certain areas, for commercial purposes, to control and book unloading areas, to assess traffic and finally to control the operation of freight delivery mechanisms.

This huge stream of data is then used for scientific research and to produce evidence, to strengthen enforcement mechanisms and to control and also to directly improve the productivity of deliveries, regardless of the mode.

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<sup>31</sup> "Gap Tests New Virtual Dressing Room." Gap Inc., [corporate.gapinc.com/en-us/articles/2017/01/gap-tests-new-virtual-dressing-room](https://corporate.gapinc.com/en-us/articles/2017/01/gap-tests-new-virtual-dressing-room).

The biggest limitation of geofencing is privacy: data transfer in fact requires a consensus of the parties and complex legal mechanisms. However, the effects of these technologies are potentially enormous, as they may be able to share information in real time among all stakeholders in logistics. These new technologies merged together will do even more: they will allow to create dynamic simulations of reality (digital twins), or even real digital copies of real objects that are able to update in real time according to the changes of the objects from which they derive, thus offering not only the opportunity to know and predict any logistical process, but the possibility of completely revolutionized logistics.

The final goal is to transform logistics according to the paradigm of the "Physical internet" (presented in Chapter 4), moving from the private logic of the distribution chains to the idea of passing through intermediate, shared distribution nodes. In the world of logistics, this would result in the movement of standardized modular blocks on various means of transport, according to a logic of intermodality that aims for maximum efficiency, through a unique global logistics platform able to coordinate and synchronize all the operations. With this in mind, the EU innovation platform ALICE has been established<sup>32</sup>. The first examples of projects inspired by this new paradigm are ESE3, the largest and most extensive automated and shared distribution centre in York, and CRC Services, that has started in France to put on the market a national network consisting of open hubs, offering significant cost reductions and with excellent performance also in environmental terms<sup>33</sup>.

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<sup>32</sup> <https://www.etp-logistics.eu/>

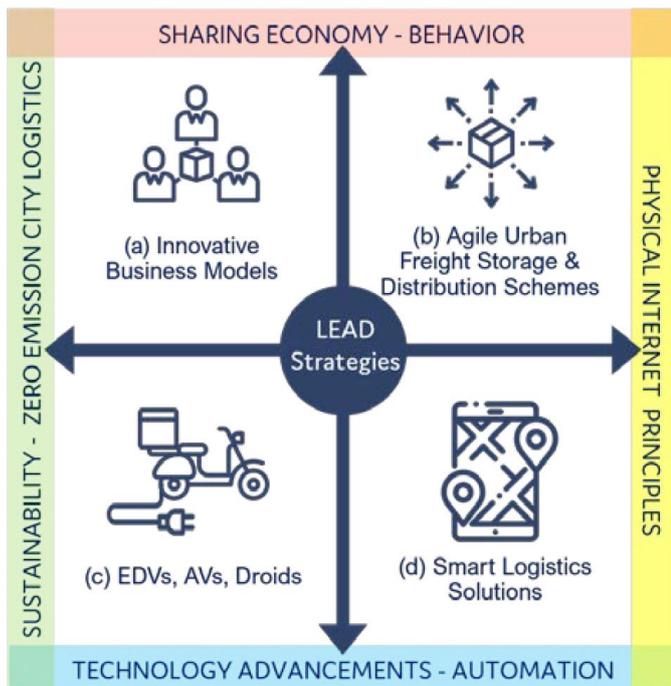
<sup>33</sup> <https://www.fitconsulting.it/la-physical-internet-dallintuizione-delleconomist-ai-primi-business-disruptive/>

# 4 The Physical Internet: State-of-the art and new trends

## 4.1 LEAD and the Physical Internet concept

The LEAD value case scenarios will incorporate opportunities for shared, connected and low-emission logistics operations by considering four innovation drivers: i) Sustainability - Zero Emission Logistics, ii) Sharing Economy and behaviour, iii) Technology Advancements and iv) the emerging PI paradigm (Figure 21)

Figure 21 : LEAD Strategies and Innovation Drivers



The PI aims at realising full interconnectivity (information, physical and financial flows) of several (private) freight transport and logistics services networks and make them ready to be seamlessly usable as one large logistics network. PI concepts applied to urban logistics will ultimately lead to an optimised specification for the location and capabilities of 'city PI eco-hubs'<sup>34</sup> and the use of low-emission, connected and automated delivery vehicles. The PI approach will also provide support to automate routing, optimising the use of transport resources and storage facilities towards zero emissions solutions, while catering for the needs and wishes of contemporary consumers. LEAD is aimed at optimising the operation of fleets of emerging Electric Delivery Vehicles (EDVs), cargo bikes

<sup>34</sup> In PI-inspired city logistics networks, the notion of an eco-hub implies its optimal operation, considering also environmental performance.

and other innovative vehicles operating from urban/inner-city eco-hubs, supporting last mile delivery logistics with superior economic and environmental performance. The eco-hubs will be modelled on the basis of PI concepts which totally transform the ways physical objects in the future will be packaged, transported, distributed and delivered. This section provides an overview on the state-of-the-art and new trends on PI developments.

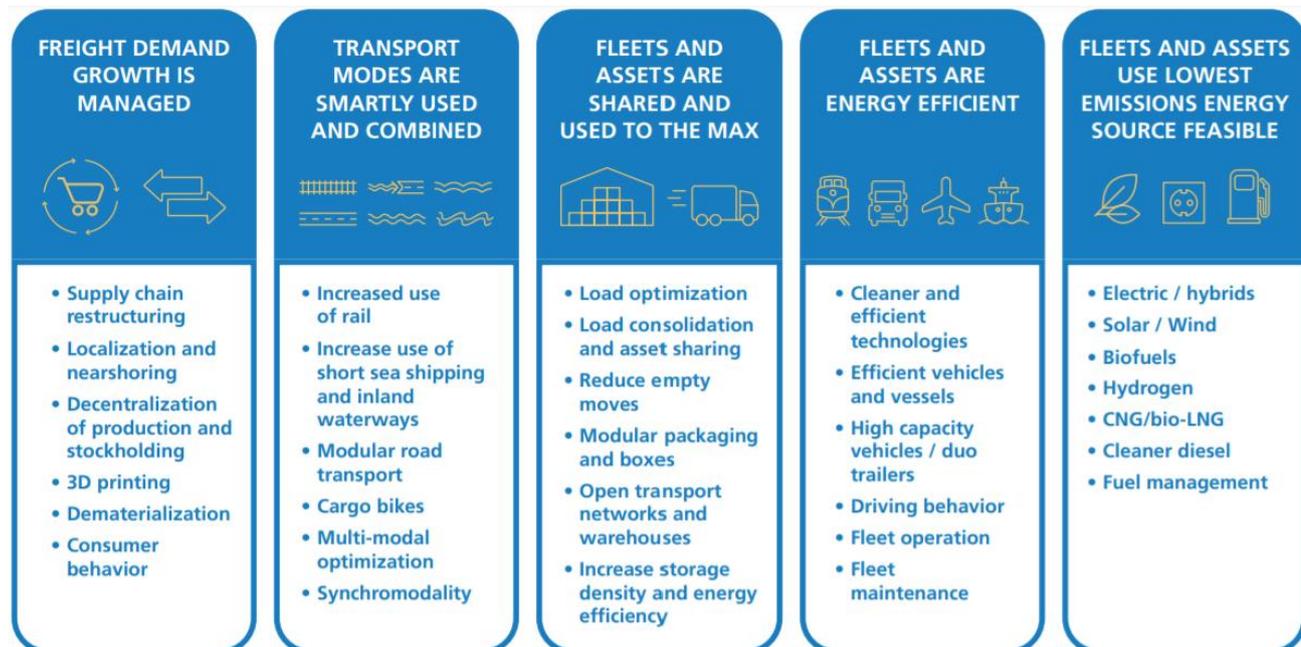
## 4.2 PI theory and applications

The EU, following the Paris Agreements, is committed to being the first zero-emission continent. The process to achieve this goal involves reducing emissions for each economic sector. In the field of transport and logistics, the obstacles are even greater, as transport demand is expected to triple, with a consequent doubling of emissions by 2050 (**International Transport Forum, 2019**).

In Europe, CO2 emissions related to freight transport account for 6% of the total and about 30% of total transport emissions (**European Commission-Directorate-General for Research and Innovation, 2018**).

To try to solve the problem, several *roadmaps* have defined areas of interest and priorities for action. The *ALICE Roadmap towards Zero Emissions Logistics 2050* **Punte et al. (2019)** provides a framework for a decarbonisation roadmap (see Figure 22), consisting of five solution areas:

**Figure 22: Solutions for freight transport and logistics decarbonisation**



Source: ALICE-ETP (2019)

These objectives are based on a series of priority interventions ranging from consolidation, load optimization and efficient management of freight fleets, to multimodal optimization, synchromodality<sup>35</sup>, energy efficiency and low vehicle emissions.

The majority of these solutions depend on a collaborative approach between the different stakeholders, based on the continuous exchange and sharing, not only of information, but also of assets and on a standardization of the entire logistics chain.

The point of arrival of this process of exchange and sharing and the ideal vision to which collaborative transport and logistics management aspires can be summarized in the concept of *Physical Internet (PI)*. This is, ideally, the full interconnection of transport and logistics networks for their use in a single large global logistics network (**Ballot et al. 2020**).

The interconnection consists of three dimensions: physical, digital, and operational. The first relates to the possibility of moving, managing and storing goods everywhere and in a seamless way, passing them easily from one means of transport to another within the network. The second is the continuous and transparent exchange of information within the network. The third is the fluidity of operational processes, including the financial ones (**Iconet, 2019**). For a full interconnection, encapsulation, interface and common protocols according to the OLI model<sup>36</sup> are needed.

The concept of PI arises from the analogy with the digital internet, in which the exchange of information takes place minimizing the path of data through the division into information packages and the passage into different nodes according to standardized and automated procedures. Similarly, the use of modular and intelligent container standards and systems that can be easily moved, decomposable and transportable would allow the minimization of the route of goods and the maximization of economic and environmental efficiency.

The real change from the rest of the logistics innovations is that, for the first time, the very principles of handling of goods change and the movement of goods becomes independent/indifferent to the means of transport and the logistics process used, in the same way that one is indifferent to the unpacking of data and their path to reach the recipient of a message on the internet (**Kubek & Więcek, 2019**).

According to ALICE, in 2040, the logistics process will be fully automated: transport and handling of goods (standardized containers connected to the network) will be completely autonomous on the basis of defined rules and an optimized logic, in the same way that the digital internet works today. With the PI, shippers and cargo owners, therefore, will only have to enter their shipping data within the system itself (**Ballot et al. 2020**).

In summary, the PI is an open and global network of networks that connects goods, modes of transport, the different players of transport and logistics (freight forwarders, couriers, transport

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<sup>35</sup> Defined as the synchronization of intermodal services between modes and with shippers with different speeds and lead times.

<sup>36</sup> The OLI model (Open Logistics Interconnections property) describes how information about the flow of goods should be processed. It is divided into 7 levels of abstraction.

operators, consumers) through the connection of the goods, standardized in modular container systems, through the IoT and other technologies with the aforementioned network.

The implementation of the PI will be based on the technological advances in progress and/or planned for the not too distant future (automation, IoT, robotics, Big Data), on the rapid evolution of interoperability towards a greater interconnection between ICT systems and on the achievement of consensus between the various stakeholders in the field of transport and logistics (**Iconet, 2019**).

To date, however, there are various challenges hindering the creation of the PI.

Firstly, little investment is made in innovation in the logistics sector and, lacking recognized positive examples of collaborative business models, there is little confidence in the share of information, services and systems.

Technical difficulties are also a major obstacle: the lack of modular loading units for all means of transport, appropriate transshipment techniques, appropriate data collection standards, data collection systems to report important commercial and social information and data quality monitoring are a major problem. Finally, the presence of too many regulations hinders innovations (**Iconet, 2019**).

Although the PI is a concept that tends to be global, the potential of this vision is intuitable even on a small scale, for example within a city and more specifically in the last-mile delivery. The concept of PI, first of all, would allow the updating of the collaborative idea of the consolidation of goods through urban hubs, Pickup Points and Parcel Locker. These would become nodes within an integrated platform (logistics network system) of services based on full control of the surrounding urban realm.

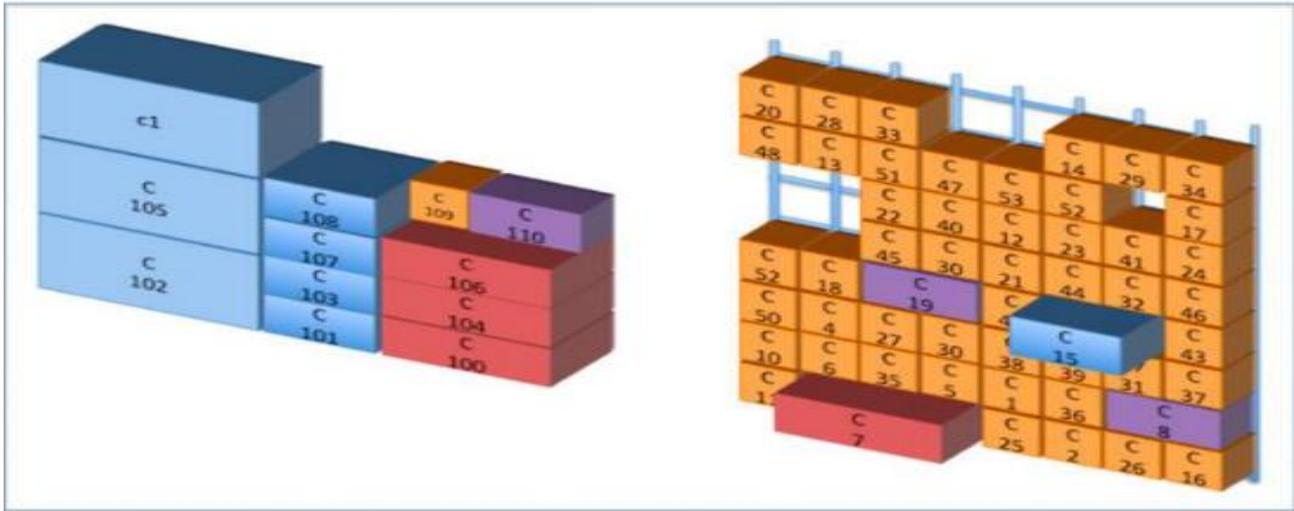
With the PI, goods would be consolidated and deconsolidated and commercial vehicles fully loaded thanks to the full interconnection of networks, while the containers, structured in standardized separable modules, would allow the consolidation of previously incompatible loads. This would be an advantage from the point of view of last mile logistics. Finally, the reverse logistics process would be improved since it would be integrated within the entire supply chain.

Moreover, the entire urban environment would take advantage of the indirect benefits of PI, due to the improvement of the entire supply chain. In a scenario of full application of the PI, intermodality would be fully used, so the flow of road freight transport would be reduced, thus reducing urban congestion.

In a similar system, last-mile logistics solutions such as Parcel Locker, Pickup Points, Click and Collect and micro-hubs, thanks to system integration, would benefit from the optimal choice of a given delivery mode and greater efficiency of the delivery system itself,

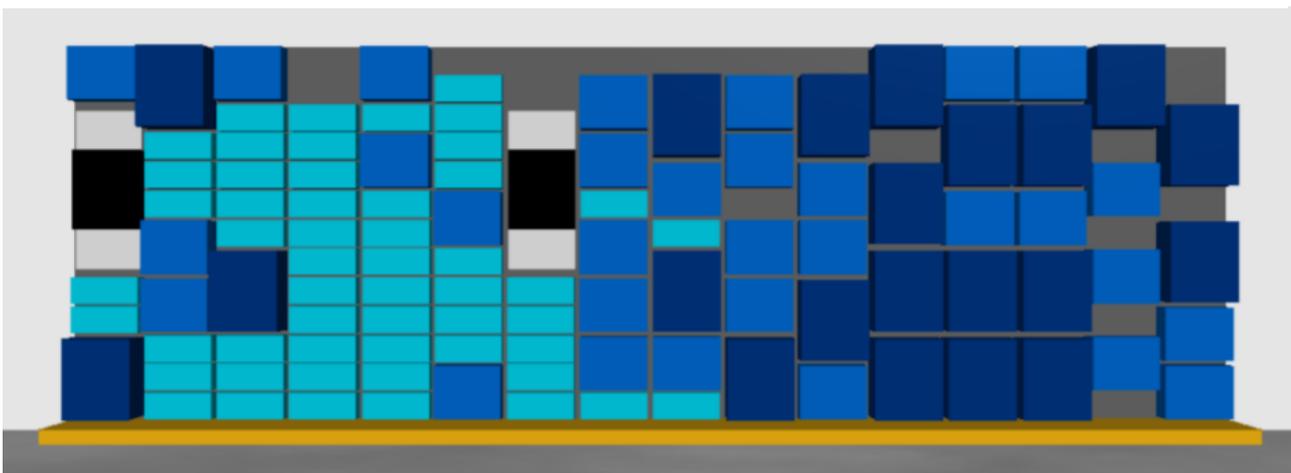
As far as Parcel Lockers are concerned, for example, the PI has the potential to make them more efficient. Today they are fixed structure or modular towers, but with the PI they could be composed of  $\pi$  boxes that can be instantly pulled out and moveable inside the grid (see Figure 23). In this way, a large number of configurations of the  $\pi$  boxes would be possible and there would be full adaptability to demand in real time, a greater speed of delivery and reception of the package; moreover, the Parcel Locker would not require specific resources as the  $\pi$  boxes would be part of the network and moving in the supply chain; finally, it would have a very low environmental impact and a limited initial investment cost (**Faugère & Montreuil, 2017**).

Figure 23 : Illustrating  $\pi$  containers Snapping as Pickup/ Delivery Lockers



Source: (Faugère & Montreuil, 2017)

Figure 24: Illustration of a  $\pi$  container Based Smart Locker Bank at Some Punctual Time



Numerous criticisms have also been directed towards the studies made on the effects of PI, since most simulations do not consider the return flow of containers (50% of the flow), the cost of handling



and storage of  $\pi$  containers and also simplify the aggregation of thousands of different products into one only (**Sternberg & Norrman, 2017**).

Finally, there is the controversial issue of the social sustainability of the entire system, since transport in the PI would seem to be entrusted to an auction system, thus increasing the risk of a race to the bottom of wages between the various companies(**Sternberg & Norrman, 2017**).

## 5 Green vehicles classification and integration in urban logistics

The innovations introduced in the vehicles market have been disruptive, especially new engine technologies and driverless vehicles. Green vehicles are needed for decarbonising transport, reducing air pollution and increasing the efficiency of the system, especially when dealing with on-demand logistics<sup>37</sup>. In this last section, green vehicles are classified and evaluated in terms of requirements for their effective integration in city logistics. An enablers/barriers map for their integration in urban logistics defines what are the necessary technological, organizational and regulatory conditions for their uptake. The investigated elements include: policy and legislation; technology and innovation; infrastructure; consumer acceptance.

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<sup>37</sup> For an in-depth discussion, please see a review by *Patella et al. (2021)*.

Typology of vehicle	Suitable logistic segment	Requirements for integration in city logistics				Enablers/barriers	
		Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance	Enablers	Barriers
<b>e- vans</b> 	Parcels, retail, services (maintenance, cleaning, installation and repair). food delivery (grocery)	Preferential access to Low /Zero Emission Zones (LEZ/ZEZ). Reserved Parking Areas. Access to bus lanes. Fiscal measure: exempt from city tolls, subsidies, and tax incentives. Planning measures: Tender for e-vans for city fleet. Charging Infrastructure, UCC, Repair Network <sup>38</sup> .	Further improvement in battery technologies (so far prices of batteries dropped 80% since 2010) <sup>39</sup> Commercial e-van are already available on the market. Net connections and electric network must be adapted.	Dedicated charging infrastructure needed (at home and public). Charging strategy depends on location (where to charge and how often charging can or should take place), type of charger vehicle battery size <sup>40</sup> . 80% of the energy used for electric truck charging will come from private stations at depots, 15% from destination chargers, and 5% from public charging stations. Commercial vans largely will charge at home (45%) or	Positive brand image.	Incentives and subsidies such as tax rebates and exemptions and other regulatory advantages. Enhanced user experience. Positive Marketing image. Lower maintenance <sup>42</sup> needs. Positive Total Cost of Ownership (TCO) (under some conditions).	Higher purchase price (20,000-30,000k) wrt ICEVs, due mainly to battery prices <sup>43</sup> . No higher revenues (limited number of customers paying more) for EV deliveries. Charging time (up to 8 hours, or 20-45 minutes in high power charging points). Grid issues with large fleet. Battery performance limitation (determines range and weight of vehicle). Limited and expensive after-sales support <sup>44</sup> . High load, urban driving with frequent stop-and-go, hot or cold days, road profile (slope) and driver

<sup>38</sup> The use of Environmentally Friendly Freight Vehicles. Non-binding guidance documents on urban logistics N° 5/6

<sup>39</sup> <https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/>

<sup>40</sup> Transport Decarbonisation Alliance (TDA), C40, POLIS, How-to Guide Zero-Emission Zones

<sup>42</sup> The use of Environmentally Friendly Freight Vehicles. Non-binding guidance documents on urban logistics N° 5/6

<sup>43</sup> T. T. Taefi, "Viability of electric vehicles in combined day and night delivery: a total cost of ownership example in Germany," 2European J. Transp. Infrastruct. Res., vol. 16, no. 4, pp. 600–618, 16AD

<sup>44</sup> The use of Environmentally Friendly Freight Vehicles. Non-binding guidance documents on urban logistics N° 5/6

				at the depot (44%) <sup>41</sup>			behaviour reduce significantly the daily range <sup>45</sup> Fast charging on public road is expensive.
<b>e-trucks</b> 	Construction, services (maintenance, cleaning, installation and repair), non-food retail and food retail (supermarket, grocery shops).	A zero-emission vehicle (ZEV) mandate for trucks manufacturer. Redesign charges, tolls, and fuel taxes. Electricity pricing <sup>46</sup> . Creation of infrastructures.	Need to improve battery technologies. Recent improvements on charging modes (opportunity charging <sup>47</sup> ). Commercial e-trucks not massively available on the market <sup>48</sup> . Recent innovation in range and speed claimed by CEO of Tesla (800km, and 1-100km/h in 20sec) <sup>49</sup>	e-highway and related infrastructure <sup>50</sup> . Dedicated charging infrastructure (depot, OppChrging). Grid network expansion, smart energy management systems.	Positive brand image.	EU legislation on CO2 standards. Infrastructure improvement. Urban access regulation schemes favouring access of ZEVs.	Higher purchase price (from 100,000k) wrt ICEVs. TCO (even supposing subsidies and 10 year of duration of the battery) <sup>51</sup> range issues. Same problems of e-vans + more hardships in charging phases due to lack of infrastructure for long distances

<sup>41</sup> Transport Decarbonisation Alliance (TDA), C40, POLIS, How-to Guide Zero-Emission Zones

<sup>45</sup> O.Castillo, R.Alvarez, R.Domingo, Opportunities and Barriers of Hydrogen – Electric Hybrid Powertrain Vans: A Systematic Review, 2020

<sup>46</sup> Analysis of long haul battery electric trucks in EU Marketplace and technology, economic, environmental, and policy perspectives. Thomas Earl \*, Lucien Mathieu, Stef Cornelis, Samuel Kenny, Carlos Calvo Ambel, James Nix European Federation for Transport and Environment (T&E)

<sup>47</sup> ibid.

<sup>48</sup> <https://frevue.eu/wp-content/uploads/2017/09/Upscaling-Electric-Freight-Vehicles-Factsheet-version-4.pdf>

<sup>49</sup> Analysis of long haul battery electric trucks in EU Marketplace and technology, economic, environmental, and policy perspectives. Thomas Earl \*, Lucien Mathieu, Stef Cornelis, Samuel Kenny, Carlos Calvo Ambel, James Nix European Federation for Transport and Environment (T&E)

<sup>50</sup> Analysis of long haul battery electric trucks in EU Marketplace and technology, economic, environmental, and policy perspectives. Thomas Earl \*, Lucien Mathieu, Stef Cornelis, Samuel Kenny, Carlos Calvo Ambel, James Nix European Federation for Transport and Environment (T&E)

<sup>51</sup> <https://frevue.eu/wp-content/uploads/2017/09/FREVUE-Total-Cost-of-Ownership-for-Rigid-Electric-Trucks-Factsheet.pdf>

<p><b>e-bikes</b></p> 	<p>Instant delivery (food delivery, micro parcel).</p>	<p>Allow access to pedestrian areas and LEZ, bike Lanes.  Allow the use of bus lanes.</p>	<p>Improve performance of e</p>	<p>Mobile depot. Micro hub/transshipment point. Bike lanes.</p>	<p>Social issues related to workers. Highly convenient for customers.</p>	<p>Low maintenance and repair costs. Subsidies or tax reduction to buy e-bikes. Autonomy of e-bikes is adequate to most of instant deliveries<sup>52</sup>. Can access delivery areas where vehicle speed or access is limited<sup>53</sup>.</p>	<p>Lack of bike lanes<sup>54</sup>.</p>
<p><b>Cargo-bikes</b></p> 	<p>Parcels, services (maintenance, cleaning, installation, and repair), food delivery (grocery)</p>	<p>Allow access to pedestrian areas and LEZ, bike lanes, use of bus lanes.  Use of loading and unloading areas.  Fiscal measure: exempt from city tolls, subsidies and tax incentives.  Saving land for shared Micro-hubs.</p>	<p>Maximum 350 kg of load capacity. Lack of cooling capabilities. Lack of containerisation. Need for compromise between maximum payload and manoeuvrability<sup>55</sup>.</p>	<p>Mobile depot. Micro hub/transshipment point. Bike lanes.</p>	<p>Positive brand image.</p>	<p>Lower average total cost than a van (25%). Subsidies or tax reduction to buy cargo-bikes. Low operational costs. Can access delivery areas where vehicle speed or access is limited<sup>56</sup>.</p>	<p>Lack of bike lanes<sup>57</sup>. Urban infrastructure and traffic rules are not yet prepared (which part of the streetscape will be allowed to drive, load and unload) <sup>58</sup></p>

<sup>52</sup> The use of Environmentally Friendly Freight Vehicles. Non-binding guidance documents on urban logistics N° 5/6

<sup>53</sup> CITY LOGISTICS: LIGHT AND ELECTRIC , LEFV-LOGIC: RESEARCH ON LIGHT ELECTRIC FREIGHT VEHICLES, Walther Ploos van Amstel Susanne Balm Jos Warmerdam Martin Boerema Martijn Altenburg Frank Rieck 13 Toin Peters

<sup>54</sup> An ex ante evaluation of mobile depots in cities: A sustainability perspective, Niklas Arvidsson, Ala Pazirandeh Arvidsson, 2017

<sup>55</sup> CITY LOGISTICS: LIGHT AND ELECTRIC , LEFV-LOGIC: RESEARCH ON LIGHT ELECTRIC FREIGHT VEHICLES, Walther Ploos van Amstel Susanne Balm Jos Warmerdam Martin Boerema Martijn Altenburg Frank Rieck 13 Toin Peters

<sup>56</sup> *ibid.*

<sup>57</sup> *ibid.*

<sup>58</sup> *ibid.*

<p><b>Autonomous vehicles (on street)</b></p> 	<p>Parcels, food delivery (grocery + instant food delivery)</p>		<p>Under trial. There are already several company on the market in US (Robomart, Nuro R2. Auto X) testing these vehicles. Level 4 of automation reached<sup>59</sup>.</p>			<p>Low cost of labour Low travel time, higher efficiency.</p>	<p>Lack of regulations Infrastructure change Public perception<sup>60</sup> (Cyber-)security Lack of a profitable business model.</p>
<p><b>Street robots</b></p> 	<p>Small packages, food delivery</p>		<p>Under trial. Some startup and projects are Amazon scout, Eliport in Barcelona.</p>	<p>Proper sidewalks crucial.</p>			<p>Regulations Lack of profitability (Cyber-)security Lack of a profitable business model.</p>
<p><b>Drones</b></p> 	<p>Instant and/or urgent deliveries (medicines, small items). Humanitarian deliveries. Controlling and monitoring.</p>	<p>Regulatory framework for unmanned-Space, low altitude routes, critical and non critical operations, integration with other airspace users<sup>61</sup>.</p>	<p>Under trial (for example Amazon Prime Air).</p>	<p>Landing areas.</p>		<p>Low cost of labour. Fast delivery. Able to reach remote locations.</p>	<p>Landing issues (where, 2 metres square needed). Weather issues. Lack of security (thievery, crash, privacy, terrorism). Lack of regulatory framework<sup>62</sup>.</p>

<sup>59</sup> <https://www.allthingssupplychain.com/autonomous-vehicles-in-logistics-part-1-opportunities-and-risks/>

<sup>60</sup> An integrated perspective on the future of mobility, part 2: Transforming urban delivery, McKinsey&Company,2017

<sup>61</sup> UNMANNED AERIAL VEHICLES IN LOGISTICS,A DHL perspective on implications and use cases for the logistics industry, 2014

<sup>62</sup> An integrated perspective on the future of mobility, part 2: Transforming urban delivery, McKinsey&Company, 2017

<p><b>Environmentally Friendly Freight Vehicles (EFFVs) in inland waterway transport</b><sup>63</sup></p> 	<p>Construction, pallet.</p>		<p>Waterway quays have no advanced equipment or space for storage.</p>			<p>High payload capacity. Greater flexibility in the organisation of delivery scheme. No road congestion.</p>	<p>Usually do not generate revenues (no big retail or constructions areas near the river). Sensitive to weather conditions. Additional organisational complexity.</p>
<p><b>Biofuels vehicles</b><sup>64</sup></p>	<p>Parcels, services (maintenance, cleaning, installation and repair).</p>	<p>Minimum share of advanced biofuels. Promote the limitation of the use of biogeneration fuel (food based)</p>	<p>5% of the total fuels consumed by road transport. Higher blends will require some adaptations to the existing engines and infrastructure and a dedicated distribution system.</p>			<p>Easy retrofitting of ICEVs and refuelling stations. Mature technology (production and vehicles). Renewable sources (feedstock).</p>	<p>Environmental and social concerns (production). Limited amount of refuelling stations.</p>
<p><b>Electric Freight Vehicles (EFVs) in Rail Transport</b></p> 	<p>Construction, food retail and food retail (large retail stores), Services.</p>			<p>Additional road infrastructure needed. Noise equipment needed.</p>		<p>Railway station as UCC.</p>	<p>Only night-time available for freight rail services. Very high expenditures (noise, fee for rail network infrastructure, complexity of railway operation).</p>

<sup>63</sup> The use of Environmentally Friendly Freight Vehicles. Non-binding guidance documents on urban logistics N° 5/6

<sup>64</sup> The use of Environmentally Friendly Freight Vehicles. Non-binding guidance documents on urban logistics N° 5/6

<p><b>Fuel Cell Vehicles (FCVs)<sup>65</sup></b></p> 	<p>Parcels, services (maintenance, cleaning, installation and repair).</p>	<p>Subsides and tax incentives Promotion of Hydrogen refuel stations (HRS)</p>	<p>Developing technologies, no commercial vehicles available</p>	<p>Lack of charging infrastructure (124 HRS in all Europe). Lower infrastructure investment needed for hydrogen refuelling stations based on electrolysis technology using electricity from renewable sources than Battery electric vehicles (BEVs) (provided that there is a high number of light EVs)</p>		<p>Incentives and subsidies such as tax rebates and exemptions and other regulatory advantages. Enhanced user experience. Zero tank to wheel emissions Equivalent driving range to conventional vans &amp; short refuelling time</p>	<p>Very high purchase cost (higher than BEVs) Fuel cell's poor dynamic response. Fuel cell limited service life. High operating costs (H2 fuel, repair and maintenance costs). Availability of raw materials for key elements manufacturing. Higher TCO and operational costs than BEVs. Higher demand of renewable energy than BEVs<sup>66</sup>.</p>
<p><b>Fuel Cell Range extender electric vehicles (FC-EREVs)</b></p> 	<p>Parcels, services (maintenance, cleaning, installation and repair), non-food retail and food retail.</p>	<p>Subsides and tax incentives</p>	<p>Developing technologies, no commercial vehicles available Nowdays, there is no flexibility for vehicle selection</p>	<p>Lack of charging infrastructure (124 HRS in all Europe)</p>	<p>Positive brand image.</p>	<p>Incentives and subsidies such as tax rebates and exemptions and other regulatory advantages. Enhanced user experience. Zero tank to wheel emissions. Useful volume and payload versus range is better than BEVs.</p>	<p>Lack of charging hydrogen infrastructure (124 HRS in all Europe) High purchase costs (more expensive than a FCEVs). Lack of suitable electric infrastructure. Availability of raw materials for key elements manufacturing.</p>

<sup>65</sup> O.Castillo, R.Alvarez, R.Domingo, Opportunities and Barriers of Hydrogen – Electric Hybrid Powertrain Vans: A Systematic Review, 2020

<sup>66</sup> <https://airqualitynews.com/2020/12/07/hydrogen-should-be-prioritised-for-planes-and-ships/>

						<p>Similar lifecycle cost to BEVs (better than BEVs upon 100km).</p> <p>Equivalent driving range to conventional vans &amp; short refuelling time.</p> <p>The lack of public hydrogen infrastructure is a minor matter because delivery trips could be covered without range anxiety<sup>67</sup></p>	<p>Higher TCO and operational costs than ICEVs<sup>68</sup>.</p>
<p><b>Compressed Natural Gas Vehicles (CNGs) and Liquefied Natural Gas (LNGs)</b></p> <p><b>Heavy Goods Vehicles (HGVs)</b></p> 	<p>Parcels, services (maintenance, cleaning, installation and repair), non-food retail and food retail.</p>		<p>Mature technology: Dedicated vehicles are now much more widely available in Europe from manufacturers such as Volvo, Scania and Iveco which have all introduced new gas HGVs in 2017/18<sup>69</sup>.</p>	<p>Availability of refuelling infrastructure is no longer considered to be a major constraint in many Countries<sup>70</sup>.</p>		<p>Cheap than BEVs and with higher payload.</p> <p>Economic case for NG depends on trade-off b/w slightly higher capital cost of the CNG/LNG vehicle and price differential with petrol or diesel. Differential taxation rates can play a much greater role in many countries (in Europe also refuelling infrastructure).<sup>71</sup></p>	<p>Small or negative effect to co2 reduction (up to 15%)<sup>72</sup>.</p>

<sup>67</sup> O.Castillo, R.Alvarez, R.Domingo, *Opportunities and Barriers of Hydrogen – Electric Hybrid Powertrain Vans: A Systematic Review*, 2020

<sup>68</sup> *Ibid.*

<sup>69</sup> C. Le Fevre, *A review of prospects for natural gas as a fuel in road transport*, 2019, *Energy Insight NG 50*

<sup>70</sup> *Ibid.*

<sup>71</sup> *Ibid.*

<sup>72</sup> *Ibid.*

## 6 Conclusions

This deliverable carried out a preliminary analysis of the context, to identify the challenges and trends that influence urban logistics, in particular the on-demand deliveries, as well as the different perspectives and needs of the relevant stakeholders. This exercise is a prerequisite for the definition and success of the value cases to be tested in the Living Labs. In this sense, a literature review and a survey with 125 participants identified the factors that most influence urban logistics, also divided by type of stakeholder. The results show that perceptions of the public, private and academic sectors differ substantially. For example, the private sector is more attentive to consumer requirements and perceives the disruptive impact of new technologies that already present concrete applications. The academia looks with interest at the developments of the Physical Internet and the new ecommerce trends related to COVID-19. The public sector, in general, shows a more cautious attitude, expressing lower votes on average.

Furthermore, to facilitate the identification of different innovative solutions to be tested in the Living Lab and the various LEAD strategies (D1.5), the deliverable identifies and schematizes the typologies of agile storage and last-mile distribution schemes tested worldwide, based on of four categories: i) Delivery locations, modes and times; ii) Loading and unloading area management; iii) Consolidation iv) New technologies. Many solutions are still being tested, and in some cases have proven unsustainable. However, for some there are important lessons learned that could be useful for adjusting and defining new business models, and governance and public-private partnership schemes.

The various green vehicles were analysed according to their possible integration into on-demand logistics operations. The map ranges from bicycles to vessels, passing by electric and hydrogen vans and trucks. Although it is impossible to establish a priori which are the most suitable ones, since it depends on the context, it is possible to grasp the level of maturity and complexity, to be further refined in the context of applications to the specific LEAD cases.

The knowledge developed in this deliverable is essential to contextualize the upcoming analysis of Innovative Business Models, Governance and PPPs (D1.3) and the definition of the reference LEAD strategies to be explored through simulation in the Digital Twins and in real-life urban setting experiments (D1 .5). Understanding the city logistics landscape and stakeholder opinions is crucial to co-create efficient logistic solutions and can lead to an acceleration of successful participated policies.

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# Annex – Survey to capture key challenges, trends and influencing factors

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## Survey to capture the key challenges, trends and influencing factors of Urban Freight Transport

This survey is conducted in the framework of the EU-funded LEAD project (<https://www.leadproject.eu/>), creating Digital Twins of urban logistics networks in six cities, to support experimentation and decision making with on-demand logistics operations in a public-private urban setting.

Cities and industries need new knowledge-driven logistics solutions to cope with the contemporary challenges. As preliminary activity, LEAD collates, refines and further develops existing knowledge and understanding of the city logistics landscape in the era of on-demand economy.

The survey aims at capturing the key challenges, trends and influencing factors characterising urban freight transport (UFT), involving key experts and practitioners.

Your input is vital to our study. We guarantee that your data and answers will be kept anonymous and will only be used for the purposes of this research and will not be shared with other entities, in full compliance with GDPR regulation.

\*Required

Email address \*

Your email address

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 861598

### How this survey works

You are asked to read a short explanation in the next section and successively answer the questions in this form.

The survey will take less than 10 MINUTES of your time.

For any questions and further clarification you may need, please do not hesitate to contact us:

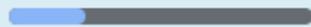
Edoardo Marcucci ([edoardo.marcucci@himolde.no](mailto:edoardo.marcucci@himolde.no)).

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Thank you for your kind cooperation.

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General information

Name \*

Your answer

Surname \*

Your answer

Organisation \*

Your answer

Municipality/region of activity \*

Your answer

Country \*

Your answer

You are \*

- National/regional authority
- Local authority
- Logistics Service Provider
- Couriers - Third-party
- Producer / shipper
- Freight/service receiver
- Real Estate owner
- Service and maintenance provider
- Own account (using your vehicle for self-supply)
- Vehicle manufacturer
- Researcher
- Consultant
- Consumer association
- Citizen
- Other: \_\_\_\_\_

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### Needs and challenges

Briefly describe your main UFT-related current needs and challenges (e.g. you are a retailer and you need frequent deliveries because of limited storage space, or you are a logistics service provider and you can't find dedicated loading/unloading areas for your delivery operations). \*

Your answer

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## Influencing factors

Influencing factors are elements, e.g. economic, demographic, social, operational, etc. that influence both the current and future state of UFT environments.

Building upon the legacy of the EU-funded NOVELOG project, a set of factors influencing the UFT environment has been drawn, including six main categories:

1. Economy & demographics
2. Ecology & social responsibility
3. Consumer requirements
4. New technologies
5. Corridors, nodes and space
6. COVID19.

Participants are asked to assess to what extent each of the following factors will influence the sustainable development of the on-demand, connected and shared urban logistics ecosystem.

Make your assessment based on a 5-scale from 'not at all' to 'a very great extent', or tick the box 'I don't know'.

- 1 = Not at all
- 2 = To a small extent
- 3 = To some extent
- 4 = To a great extent
- 5 = To a very great extent

### 1. Economy & demographics \*

	1	2	3	4	5	Don't know
GDP per city inhabitant	<input type="radio"/>					
Fuel cost	<input type="radio"/>					
Urban population share (% of total regional level)	<input type="radio"/>					
City's population share of over 65 years old	<input type="radio"/>					
Average household size	<input type="radio"/>					
Retail establishment size	<input type="radio"/>					

## 2. Ecology & social responsibility \*

	1	2	3	4	5	Don't know
Demand for environmental-friendly products	<input type="radio"/>					
Demand for ethical sourcing	<input type="radio"/>					
Demand for local sourcing	<input type="radio"/>					
Demand for reduced waste	<input type="radio"/>					

## 3. Consumer requirements \*

	1	2	3	4	5	Don't know
Consumer acceptance and behaviour change	<input type="radio"/>					
Knowledge of what happens to the digital data	<input type="radio"/>					
Information about products & their social & environmental impact	<input type="radio"/>					

#### 4. New technologies \*

	1	2	3	4	5	Don't know
Internet of Things (IoT) and Artificial Intelligence (AI)	<input type="radio"/>					
Big data & advanced analytics	<input type="radio"/>					
Intelligent Transport Systems	<input type="radio"/>					
Driverless and connected delivery vehicles	<input type="radio"/>					
Augmented reality and Digital Twins	<input type="radio"/>					
Blockchain and Physical internet (PI)	<input type="radio"/>					

## 5. Corridors, nodes and space \*

	1	2	3	4	5	Don't know
Logistics sprawl (i.e. relocation of parcel transport's hubs from the urban cores to the outer suburban areas)	<input type="radio"/>					
Urban space management – The way urban space is distributed and designed	<input type="radio"/>					
Resilience of the urban network	<input type="radio"/>					
Urban nodes typology (cross border function, inbound for local consumption/ outbound for export; centric or poly-centric, etc.)	<input type="radio"/>					
E-charging infrastructure and energy grid	<input type="radio"/>					

## 6. COVID-19 \*

	1	2	3	4	5	Don't know
E-commerce massive growth	<input type="radio"/>					
Changing role and function of local shops	<input type="radio"/>					
Mixed mobility & delivery services (e.g. startups / operators using passenger vehicles for delivery services)	<input type="radio"/>					
Contactless deliveries	<input type="radio"/>					
Safety issues	<input type="radio"/>					

Please select the 3 most important categories of the influencing factors. \*

- Economy & demographics
- Ecology & social responsibility
- Consumer requirements
- New technologies
- Corridors, nodes and space
- COVID19

If you have any further comments on the survey, or you want to provide a reference to additional resources, studies and projects, feel free to write it down here.

Your answer

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