DELIVERY OPTIONS ANALYSIS FRAMEWORK

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List of abbreviations and acronyms

Acronym	Meaning
CCAM	Cooperative, connected and automated mobility
GHG	Greenhouse gases
OOH	Out-of-home
ZEZ	Zero-emission environmental zone

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Copyright Statement

Abstract

E-commerce last mile deliveries involve **various types of stakeholders**: **customers,** representing the demand side; **on-line retailers** and **transport operators,** representing the supply side; and **local authorities** representing the context where these deliveries take place.

The goals, needs and constraints of these stakeholders determine the way last-mile e-commerce deliveries are shaped along a wide array of features (or "**attributes**"). Based on these attributes, the perspectives of the various stakeholders on current delivery options can be mapped and used to classify and analyse them.

Released within 'WP1 Analysis of current delivery models' of the CodeZERO Horizon Europe research project, this deliverable illustrates the analysis framework that will be used to classify and analyse delivery options, both the existing ones (as part of Task 1.3), and those that will be developed in the project in Task 4.2.

Executive Summary

CodeZERO is a three-year Horizon Europe research project aiming to co-create **sustainable and zero-emission last-mile delivery and return solutions for ecommerce** that align with **consumers'** preferences while being sustainable for **retailers, logistics operators** and **local authorities**. Additionally, the project is focused on providing clear, consumer-friendly communication and developing tools for local authorities to promote eco-friendly behaviour.

CodeZERO framework for the analysis of e-commerce last-mile delivery options consists of:

- A categorisation of delivery attributes according to four categories: **demand, supply, context** and **impact**.
- A classification of the **relevance** of:
    - **demand-side** attributes by **product type**, **customer type** and **spatial context**.
    - **supply-side** and context attributes by **product type, retailer type** and **spatial context**

  which is useful to highlight which attributes are particularly significant in each case and which ones are less or not important.

- Five matrices showing the **interaction** between
    - demand-side and supply-side attributes
    - demand-side and context attributes
    - supply-side and context attributes
    - demand-side and impacts attributes
    - supply-side, context and impacts attributes.

The analysis of the **interactions between attributes of different categories**, based on experts' judgment, is informative especially considering that some attributes refer to organizational aspects (i.e. instruments in the hands of logistics operators, retailers and local authorities) and others to consumers' requirements (i.e. objectives to be pursued for customers' satisfaction). Therefore, analysing the interaction between demand-side and supply-side attributes it is possible to identify which ones in the latter group should be involved when alternative options are designed aiming at objectives related to the demand-side attribute.

This deliverable is to be approved by the European Commission

Table of contents

List of figures

List of tables

1 Introduction

1.1 About CodeZERO

CodeZERO is a three-year Horizon Europe research project aiming to co-create **sustainable and zero-emission last-mile delivery and return solutions for ecommerce** that align with **consumers'** preferences while being sustainable for **retailers, logistics operators** and **local authorities**. Additionally, the project is focused on providing clear, consumer-friendly communication and developing tools for local authorities to promote eco-friendly behaviour.

CodeZERO is articulated in four phases:

- An **ANALYSIS** phase which provides (1) an analysis of existing delivery and return options and an understanding of how they are shaped by the needs and constraints of all involved stakeholders; (2) an in-depth intersectional analysis of various groups of on-line consumers to understand what are the features of delivery and return options making them attractive, with the aim to identify mechanisms to incentivize behaviour changes; and (3) develops an assessment framework to measure the impacts in the environmental, economic and social domains of new solutions.
- A **DESIGN** phase, in which CodeZERO engages in a co-design process involving retailers, transport operators, consumers and local authorities in developing (1) guidelines for retailers to raise awareness among customers; (2) a set of zero-emission and sustainable delivery and return options for retailers and transport operators; and (3) a toolset for local authorities to accelerate the transition towards sustainable solutions in last mile consignments in e-commerce.
- A **TEST** phase running 4 pilots in 4 different European cities in Italy, Netherlands, Belgium, and Norway to test a set of sustainable solutions identified in the previous phase with the aim to prove their feasibility, to fine-tune their design and to assess their impacts from the perspective of all stakeholders.
- A **CONSOLIDATION** phase where (1) CodeZERO outcomes are fine-tuned based on the lessons learned from real life applications, (2) requirements for up-scaling of solutions at European level are discussed (3) recommendations are formulated and (4) directions for future research are outlined.

Engagement with consumers and retailers' associations, industry stakeholders, cities and researchers contributes to shaping project results.

Running from June 2024 to May 2027, CodeZERO is organized along eight WPs:

- WP1 Analysis of current delivery models
- WP2 Analysis of consumers' behaviour
- WP3 CodeZERO assessment framework
- WP4 Design of CodeZERO solutions
- WP5 Testing solutions: CodeZERO living labs
- WP6 Conclusions and recommendations
- WP7 Dissemination, communication and exploitation
- WP8 Project management.

1.2 Aim of this document

E-commerce last mile deliveries involve **various types of stakeholders**: **customers,** representing the demand side; **on-line retailers** and **transport operators,** representing the supply side; and **local authorities** representing the context where these deliveries take place.

The goals, needs and constraints of these stakeholders determine the way last-mile e-commerce deliveries are shaped along a wide array of features (or "**attributes**"). Based on these attributes, the perspectives of the various stakeholders on current delivery options can be mapped and used to classify and analyse them. Delivery options are defined as the possibilities that consumers have at their disposal when ordering goods online. These possibilities are shaped by different attributes from the demand and supply side.

Released within 'WP1 Analysis of current delivery models', this deliverable illustrates:

- the work performed in Task 1.1 on the identification of the most relevant attributes of delivery options,
- the analysis framework that will be used by CodeZERO to classify and analyse delivery options, both the existing ones (as part of Task 1.3), and those that will be developed by CodeZERO in Task 4.2.

The document is structured as follows:

- Chapter 2 provides a brief description of the methodology applied to develop the analysis framework,
- Chapter 3 illustrates the conceptual approach underpinning the framework,
- Chapter 4 provides the list of attributes of delivery and return options included in the framework,
- Chapter 5 discusses the relevance of these attributes in various situations
- Chapter 6 provides an overview of the interactions between attributes from different categories.

Annexes are provided to complement the deliverable by illustrating the key findings from desk and field research.

2 Methodology

The proposed analysis framework is aimed at providing a basis of concepts and relationships for the activities that will be carried out throughout CodeZERO regarding the analysis and assessment of current delivery options as well as the development of innovative options.

The analysis framework described in this deliverable builds on both desk and field research. In a first step, an in-depth review of existing literature investigating last mile urban logistics and its specific features - or 'attributes' - was conducted. Delivery attributes are basic elements featuring the process implemented to manage the delivery of the products purchased online to the customer.

The selection of literature was primarily based on a search for the most recent and relevant sources related to the e-commerce delivery. A variety of studies, articles, trade association reports and conference proceedings were selected, with a priority on post-pandemic literature.

The desk research was intended to identify and cluster:

- type of e-commerce retailers and type of products.
- delivery attributes relevant for
    - **customers** (e.g., date of delivery, times slots, cost of delivery, delivery speed, order tracking, punctuality etc.)
    - **retailers** (e.g., punctuality, delivery cost, delivery in right form, location/availability of warehouses, equipment of warehouses, etc.)
    - **transport operators** (e.g., organisation of the service, number of stops, vehicle type, delivery production costs, etc.)
    - **local authorities** (e.g., urban space occupancy, GHG and air pollution emissions, congestion, etc.).

Findings from desk research have been used to develop an initial version of the analysis framework. In a second step, this initial version was discussed and validated during a dedicated online workshop with various stakeholders representing consumers, e-commerce retailers, transport operators and local authorities (see Annex II). Results from the workshop have been used to finetune and finalize the analysis framework described in this document.

3 Approach

The desk research identified several attributes of delivery options, which can be clustered into different groups.

Some attributes clearly belong to the **demand side** – i.e. are defined looking at the delivery options with **customers' eyes** – while others belong to the **supply side** – i.e. are defined considering the delivery options from the perspective of **retailers and logistics operators**.

The approach adopted in this framework assumes that **demand-side attributes lead** while **supply-side attributes are**, in most cases, **consequences**. While both types of attributes are relevant to describe delivery options, the demand-side attributes are the initial ones as they provide a picture of how the delivery of goods purchased online would look like. The supply-side attributes, instead, describes how the organisation of deliveries should be adapted to fulfil needs implied by demand attributes. Given the future activities of the project aimed at assessing existing delivery options and defining innovative ones, the distinction between demand-side and supply-side looks useful as the former deals with consumers' preference (i.e. the **targets**) and the latter with how satisfying them in sustainable way (i.e. the **instruments**).

Another category of attributes identified from the desk research does not deal with demand or supply but with **impacts**. Basically, two categories of impacts can be defined.

- The first category can be defined as **"private" impacts** i.e., those mainly affecting one category of stakeholders (**logistics operators** or **own account transporting retailers**). As an example, if the type of vehicle used or the drop location or the delivery time slot can be defined by the operators, the average load factor of delivery vehicles, or the distance they travel, are to a lower extent the result of the operator's choices and cannot be planned. For this reason, in the analytical framework they are kept separated.
- The second category of impacts is that of **"social" impacts** i.e., those affecting the society as a whole. Environmental effects (e.g., GHG emissions, polluting emissions) as well as transport impacts (e.g., congestion) and working conditions for drivers and workers in the logistics sector belong to this category.

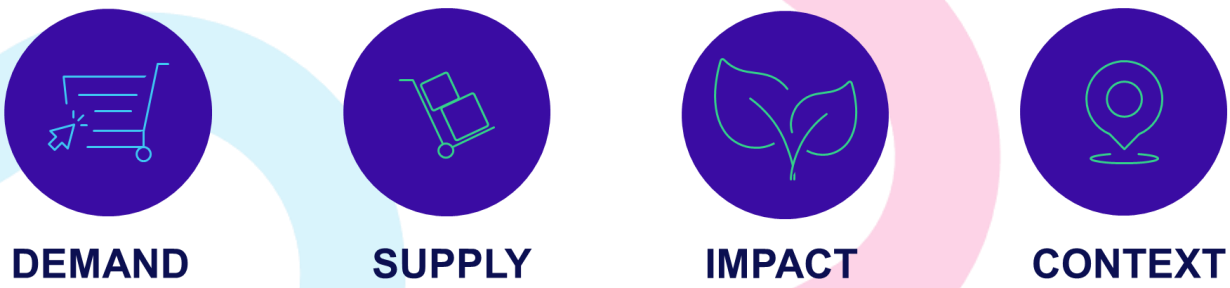
It is worth mentioning that cost is a special attribute. Indeed, although on the one hand delivery cost is clearly a major attribute for customers, and therefore can be considered a target, on the other hand it is also an impact, as it is largely a consequence of the other attributes. Furthermore, on the supply perspective, cost is eventually the key factor making a delivery option preferable to another one.

Therefore, in the proposed framework, the cost of delivery is defined twice. On the one hand, it is included within the demand-side attributes in terms of "delivery price" i.e., the amount of money asked to the customer to cover, entirely or partially, the delivery costs. On the other hand, the delivery cost – meant as production cost – is included among the "private" impacts for operators.

It should be considered that the analytical framework is developed as part of the methodology for studying delivery options and models rather than single deliveries. For single deliveries, price can even be zero if some promotional option is made available by online retailers to customers (e.g. free deliveries for certain amounts of products purchased). However, the delivery costs must be covered in one form or another in any case. Although, from the perspective of the analysis it is irrelevant whether this cost is explicitly charged or is invisibly spread on items prices, the transparency of delivery cost can be recommended for increasing customers awareness and providing more elements to choose among alternatives. However, this aspect lies beyond the scope of the analytical framework.

Another category of attributes found in the desk research concerns aspects that are neither targets nor instruments. They are not directly relevant to the customers but, at the same time, they are not under the control of the operators nor a consequence of their organisation. These attributes refer to the physical context as well as to **conditions set by the local authorities**, e.g. the establishment of vehicle-limited areas such as pedestrian zones and environmental zones, or the provision of parking lots reserved for delivering vehicles. This category of attributes has been labelled as **"context attributes"** and considered separately in the framework.

Figure 1: Categories of attributes



A final aspect considered in the analytical framework is that **some attributes can be more relevant in difference circumstances and less relevant in other ones**. In general, it is likely that for a specific customer, only a subset of demand-side attributes is significant as it is strongly shaped by his/her habits and needs (e.g. the possibility to choose time windows for deliveries) or type of products (e.g. groceries). Therefore, it is hard or even impossible to assign an objective and absolute measure of relevance to each single attribute. Notwithstanding, it is reasonable to assume that some attributes are particularly relevant for a given category of customers and type of products while other ones are likely less important for some types of consumers or products.

4 Attributes of delivery and return options

4.1 Analytical framework items

Given the approach described above, the analytical framework consists of the following items:

- A specification of each individual attribute, which is needed as in several cases the same broad denomination (e.g. delivery time) is applied in the desk research to describe different specific attributes (e.g. delivery date, delivery time slot, etc.).
- A categorisation of the specific attributes according to four classes: **demand, supply, context, impact**. The four classes are discussed in paragraphs 4.2 to 4.5 below.
- A classification of the **relevance of demand-side attributes by product type, customer type and spatial context**. The classification of relevance is discussed in paragraph 5.1.
- A classification of the r**elevance of supply-side and context attributes by product type, retailer type and spatial context.** The classification of relevance is discussed in paragraph 5.2.
- A matrix where the **interaction between demand-side and supply-side attributes** is identified is provided in Table *6-1*. The matrix shows which demand-side attributes affect a supply-side attribute and the interaction is discussed in paragraph 6.1.
- A matrix where the **interaction between demand-side attributes and context attributes** is identified is provided in Table *6-2* . This matrix identifies which context attributes affect demand-side attributes, and the interaction is discussed in paragraph 6.2.
- A matrix showing the **interaction between supply-side attributes and context attributes** is provided in Table *6-3*. This matrix identifies which context attributes affect supply-side attributes. The interaction is discussed in paragraph 6.3.
- A matrix where the **interaction between demand-side attributes and impacts** is identified is shown in Table *6-4*. This matrix identifies which demand-side attributes affect an impact and the interaction is discussed in paragraph 6.4.
- A matrix identifying the interaction **between supply-side, context attributes and impacts** is provided in Table *6-5*. This matrix shows which supply-side and context attributes affect an impact. The interaction is discussed in paragraph 6.5.

4.2 Demand-side attributes

The list of demand-side attributes includes 18 items, belonging to six different types (**Table 4-1**)**.** The first type is **Cost**. This type consists of just one element, which is the ***price of the delivery***. As mentioned, this price might not be explicitly charged on a single shipment but in some form is present in each delivery option. Clearly, from customer side, price is a relevant attribute, especially for cheapest products purchased, on which it can represent a non-negligible share of the overall delivery cost.

The second type of demand-side attributes is related to **delivery time**. One attribute of this type is the ***time*** required to finalise the delivery from when the order is placed online. In many cases, customers would like to receive the purchased products as soon as possible. Fast delivery is one of the most frequent options currently available for online orders. Another attribute of this type is the ***punctuality*** of delivery day announced when the purchase is made. Clearly, the respect of the announced day is expected by customers, both from a psychological perspective and for organisational reasons (e.g. being present at home in that day). Third attribute of this type is the ***time slot*** within the day in which the product is delivered, which might be more or less convenient. Strictly linked to this, is the attribute of ***punctuality of the time slot***, i.e. that the delivery is actually made within the announced slot. Of course, if this does not happen, the

benefits of being informed on when the delivery is supposed to take place and/or choosing the time slot disappears. The last attribute referred to delivery time is the ***delivery time optimisation***, i.e. possibility of receiving different items in one single delivery if this is more convenient. When products of different nature are purchased in a single order (e.g. books, cosmetics, household items, etc.) they usually come from different shops and can be delivered at different time. Therefore, they are often sent independently. However, if the customer does not need any product urgently, might prefer receiving everything together to avoid being available in different days and time slots.

The third type of demand attributes is related to the **method of delivery**. One attribute of this type is the ***point of delivery***. Typically, the products are delivered at home, but other out of home (ooh) solutions can be available and more convenient for the client like the workplace, or a picking point located in some public space (e.g., a train station or a post office). Furthermore, delivery at home can have different specific point of delivery; rather than at door, packages might be dropped at the road front in some conditions, which might be less convenient for the client. Another aspect regarding the method of delivery is the ***vehicle type*** used. From the customer perspective, this element is generally uninfluential for the delivery itself but can become relevant when the customer believes that a delivery made with a specific vehicle type is more sustainable or it is the only option allowed by local conditions (e.g. deliveries by zero-emission vehicles if the customer lives in a zero-emission environmental zone (ZEZ).

Another type of attributes of delivery options is that of **information**. Within this type, the ***tracking*** of the shipment is a relevant one. In principle, if the delivery date is respected, the customer should not worry about the status of the shipment but, at least currently, the possibility of tracking the position of the expected package along the process is helpful. Another attribute is receiving one or more ***delivery remind*** messages reminding the delivery (e.g. the day before, in the morning for a delivery scheduled in that day) to help ensuring the reception. A third attribute related to the information is knowing some key facts about ***impact of the delivery***. This kind of information is relevant especially considering the choice between alternative options, within e-commerce or even comparing e-commerce with traditional shopping in physical stores. Knowing about e.g. the emissions or the working conditions of drivers and knowing that different options exist can affect the choice of customers.

A further type of demand-side attributes is related to the **reliability** of the delivery. From one perspective, reliability refers to receive the purchased products in perfect conditions, without missing elements or damages to the items or even just to the original package (***product safety***). This type of attribute is not an option (incomplete or damaged products are clearly unacceptable) but, out of large numbers, a share of inconveniences may always occur, and different levels of tolerance exist regarding these events. A different dimension of reliability refers to fake delivery attempts (***actual delivery***). Receiving a message that the delivery was attempted but nobody was available, while one was actually at home at the referred time, is an annoying experience that customers would like to avoid.

Finally, four other attributes of delivery options form the demand perspective have to do with **flexibility**. Basically, flexibility concerns with the possibility of choosing among alternatives for many of the elements mentioned above. Namely, one specific attribute refers to the availability of the option for ***choosing the delivery date.*** This kind of flexibility can be especially important to shorten the waiting time (e.g. delivery in 24 hours). However, even if one customer is not interested in receiving the products as soon as possible, it might want to choose the day. Similarly, another important aspect of flexibility is the option of ***choosing the time slot*** when products are delivered so that the customer can arrange the daily agenda. Third, the availability of the choice about receiving all items together in one single delivery (i.e. the ***choice of time optimisation***) is another aspect of flexibility. Being able to ***choose*** among different ***points of delivery*** (not only at home or elsewhere but also at door or at road front) is another flexibility attribute. Last, even if currently probably not available, the possibility of ***choosing the vehicle type*** (e.g. a traditional van or an electric vehicle or a cargo bike) can also be desirable for customers.

Table 4-1: Specification and categorisation of delivery options demand-side attributes

Attribute type	Attribute	Definition	Category
Cost	Delivery price	Charge applied to cover shipment costs	Demand
Delivery time	Delivery date	Time needed to receive the ordered products	Demand
	Delivery date punctuality	The product is delivered in the day announced at the purchase	Demand
	Delivery time slot	The period of the day when the product is delivered to customer	Demand
	Delivery time slot punctuality	The product is delivered in the time slot chosen/announced	Demand
	Delivery time optimisation	All purchased items delivered in a single delivery on request	Demand
Delivery method	Point of delivery	The exact place where products are dropped (e.g. door, road front, picking point, lockers, etc,)	Demand
	Vehicle type	The vehicle type used for the delivery	Demand
Information	Tracking of shipment	Access to tracking interface to follow the status of the delivery	Demand
	Delivery reminder	Message sent in advance to remind of the delivery	Demand
	Impact of purchase	Detail on social impacts of purchase (e.g., emissions, drivers wage, etc.)	Demand
Reliability	Product safety	Products and original packages are not damaged	Demand
	Actual delivery	Procedures to avoid unfounded communications of failed delivery attempts	Demand
Flexibility	Choice of delivery date	The option for the customer to choose the delivery date	Demand
	Choice of delivery time slot	The option for the customer to choose the time slot	Demand
	Choice of time optimisation	The option for the customer to choose if receiving all items in a single delivery	Demand
	Choice of point of delivery	The option for the customer to choose the point of delivery	Demand
	Choice of vehicle type	The option for the customer to choose the type of vehicle used for the delivery	Demand

4.3 Supply-side attributes

The framework includes 15 supply-side attributes of delivery options classified according to five different types[1] (**Table** *4-2*). –

The first type contains the attributes related to **service organisation.** One of these attributes is the ***stock level***, which is the availability of products that are present in the online shop and can be ordered by customers. This attribute is relevant for retailers and refers to the level of stock of products they need to maintain to ensure that products are delivered within a reasonable time to customers. Sometimes it happens that some products are visible in the online shop but cannot be ordered because the stock is exhausted.

Another attribute of this type, again relevant for retailers, is the ***shops' coordination system***. In some cases, the online shop managed by the retailer is a marketplace where customers can visualise, and order products sold by different shops rather than directly by the retailer. When someone orders items sold by different parties, an organisation is needed to ensure that the delivery of all items is correctly and timely arranged to the customer.

The third attribute related to service organisation – the ***delivery optimisation system*** – is instead relevant for the logistics operator. Logistics operators serve multiple clients (retailers) to deliver products to a number of customers located in a certain geographical area. Obviously, they cannot manage each delivery separately as this would be at least inefficient or even just unfeasible. Therefore, they need to use some kind of organisation and rules to arrange deliveries in an efficient manner.

Last attribute of this type is the ***product handling protocol***, which is the list of rules and procedures that must be followed along the whole delivery process from when the products are made available by the retailers to ensure that items are delivered to customers without damages or missing elements. This attribute is especially relevant for some kinds of product while is of limited importance for others.

The second type of supply-side attributes is those related to the **size and composition of the vehicle fleet used for the deliveries**. All these attributes are relevant for the logistics operator. The first one is the ***type of vehicles used***. Most of deliveries are made by motorised road vehicles, yet alternatives have emerged like bikes, cargo-bikes or, even if for the time being mainly as experiments, automated bots or drones. The ***delivery vehicle technology*** is the second attribute in this group. Battery electric vehicles or hybrid vehicles or fuel cells vehicles can be used for the deliveries. The third attribute is the size of the fleet available for the deliveries. Since the analysis is focused on delivery options and not on the single deliveries, the ***number of vehicles (for each type and technology)*** is influential.

A third group of supply-side attributes includes those related to **distribution network arrangement**. Again, all these attributes are relevant for the logistics operator. First attribute in this group is the ***number of warehouses*** (in some cases, they might be shops) from which the last-mile deliveries start (this can be on a national or regional level). Depending on this number the organisation of the delivery is different (e.g., it can include multiple transshipment points with smaller hubs closer to the final customer). A pick-up point is also a facility that is part of a distribution network. A second attribute is the ***size of the warehouses***. This attribute is logically linked to the first one: a delivery option might be based on a limited number of large warehouses or on a wider number of smaller warehouses, again

[1] Supply-side attributes are relevant for the definition of the delivery models – i.e. all the related transport and logistics activities to fulfil a delivery option and to physically transport a product from a retailer to the customer (or a pick-up point). Delivery models are elaborated more in depth in Deliverable D1.2.

affecting the organisation of the process. More recently we also see combinations of different types of warehouses for last mile logistics. A linkage exists also with the third attribute of this type, which is the ***location of the warehouses***. They can be in peripheral area (e.g. close to highways and/or to rail terminals or ports) or closer to urban areas, or both. Large warehouses are more easily located outside cities, while urban platforms are likely smaller and can play a different role in the logistic chains. It should be noted that this attribute involves local authorities (i.e. it is somewhat in between supply-side and context) as the location of warehouses is affected by land planning and permits managed by the public decision makers. Finally, another attribute of the warehouse arrangement is the ***equipment available in the warehouses***., including automation or robotisation for the operations inside the warehouse, storage facilities, etc. Depending on this equipment, different operations can be managed within the warehouse. For instance, some warehouses can be equipped with facilities allowing freight transfers from HDV to micro-electric vehicles or cargo bikes, so that they can be considered as a sort of "micro hubs".

Still significant for the retailer or logistics operator, another type of supply-side attribute is the **workforce**. On the one hand, a certain ***number of drivers*** are necessary to manage a certain delivery option, also given the size of the vehicle fleet and the type of vehicles used. For some products, such as furniture or washing machines, two employees are required on a single vehicle. On the other hand, ***workers*** are needed ***in the warehouses*** to manage all operations required to arrange the single packages to be delivered. Depending on the available equipment (e.g. level of automation for handling items, uploading vehicles, etc.) and on internal organisation, a different number of workers can be needed to adopt a certain delivery option.

The last type of supply-side attribute is a sort of support function, which is not strictly required to implement a delivery option but is required to understand how a certain option works and compare alternatives. This support function is an **impact monitoring system** to measure some metrics related to aspects like load factors, number of kilometres driven, energy use, emissions and others. These elements are especially linked to the activity of the logistic operator. However, an impact monitoring system can be relevant for retailers too, especially if they manage deliveries in-house or purchase services from different logistics operators and need to compare their activity. Also, within retailers monitoring system, information related to the choices of customers can be collected and processed.

Table 4-2: Specification and categorisation of delivery options supply-side attributes

Attribute type	Attribute	Definition	Category
Service organisation	Stock level	The organisation used to minimise the time between order and products availability	Supply (Retailer)
	Shops coordination system	The organisation used to assemble deliveries with products available in different shops	Supply (Retailer)
	Deliveries optimisation system	The procedure used to optimise the use of vehicles, the work of drivers, the delivery tours, etc.	Supply (logistics operator)
	Product handling protocol	The procedure established to handle products to ensure their integrity at destination	Supply (logistics operator)

Attribute type	Attribute	Definition	Category
Size and composition of the vehicle fleet	Delivery vehicles type	The type of vehicles used for delivering (trucks, vans, cargo-bikes, drones, etc.)	Supply (logistics operator)
	Delivery vehicles technology	The energy source of vehicles used for delivering (fossil fuels, electricity, human activity, etc.)	Supply (logistics operator)
	Number of vehicles by type	The size and composition of the fleet available for deliveries	Supply (logistics operator)
Distribution network	Number or warehouses	Number of warehouses used for delivery services	Supply (logistics operator)
	Size of warehouses	Surface of warehouses used for delivery services	Supply (logistics operator)
	Warehouses' location	Position of warehouses used for delivery services	Supply (logistics operator)
	Warehouses equipment	Operations that can be managed by facilities available at warehouses	Supply (logistics operator)
Workforce arrangement	Number of drivers	Number of drivers available for deliveries	Supply (logistics operator)
	Number of warehouses workers	Number of workers at warehouses	Supply (logistics operator)
Impact monitoring system	Retailer Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)	Supply (Retailer)
	Logistics operator Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)	Supply (logistics operator)

4.4 Context attributes

The context attributes are those related to aspects which are neither under the direct control of the retailer or of the logistics operator nor are referred to customers' needs and preferences. In many cases, these attributes are affected by decisions of the local authorities which not only regulate land use but can facilitate desirable situations through the adoption of certain policies. These attributes are related to the **spatial context** in which delivery options are operated (**Table** *5-3*).

As mentioned under the supply-side attributes, local authorities affect the spatial context by regulating land use, which has implication on the ***areas where warehouses can be located*** (and therefore on their size).

One attribute is the ***accessibility of streets***. Accessibility can depend on a wide array of physical and infrastructural elements (e.g. street width) but the most significant aspect affecting this attribute is regulation. Pedestrian areas, low emission zones and other similar regulations can restrict the accessibility of some areas for all vehicles or for some of them.

Another attribute is the ***availability of parking lots*** (or unloading zones) dedicated to vehicles used to deliver goods. The number and the location of these lots, as well as the enforcement applied to prevent their misuse, affect the context in which delivery options are developed.

Even if currently the use of automated bots for delivering goods is essentially limited to some experiments, this option can potentially become more relevant in the future. Especially in an initial phase – when the problems potentially arising from the interaction with other vehicles (and with pedestrians) are not sufficiently known – it might be that automated vehicles are not admitted wherever in urban areas but confined to predefined paths *(**CCAM available paths**).* The decisions about imposing this type of limitations would affect the extent to which some technologies can be used and, therefore, some delivery options can be implemented.

Similarly, another technological option experimented for delivering products are drones. As for automated vehicles, restrictions to where and when drones can fly (***drones flight permits***) would be likely introduced and would affect their use.

Finally, authorities define the context for delivery options by ***monitoring and enforcing*** regulations regarding local elements (like road accessibility or parking) as well as broader aspects like emission levels of vehicles or driving time and working conditions.

Table 4-3: Specification and categorisation of delivery options context attributes

Attribute type	Attribute	Definition	Category
Spatial arrangement	Land use planning	Definition in urban plan documents of areas open to location of industrial buildings and, more specifically, warehouses	Context
	Streets accessibility	Vehicle types admitted in each street of a given area (e.g., pedestrian areas, low emissions zones, time windows)	Context
	Parking lots	Number and location of lots available for parking commercial vehicles during delivery tours	Context
	CCAM available paths	Where driverless vehicles used for delivery can be operated (streets, platforms, etc.)	Context
	Drones flight permits	Where remote-controlled drones can fly in a given area (banned areas, corridors, minimum altitude, etc.)	Context
Enforcement	Rules enforcement	Activity to ensure that regulations affecting some aspects of delivery options are respected	Context

4.5 Impacts attributes

The last category of attributes of the delivery options includes impacts stemming from the application of such options. As mentioned in section 3, two broad categories of impacts can be identified: ***private impacts*** **(Table** *4-4***)** ***and social impacts*** **(Table** *4-5***)**.

4.5.1 Private impacts

The first type of impacts attributes refers to private impacts, i.e. those mainly affecting on logistics operators, namely **service efficiency** One attribute of this type is the (average) ***load factor*** of the vehicles used for the delivery. This element is considered an impact because operators can define the load of a vehicle, but this load will change case by case under the requirements emerging in specific circumstances (number of clients and their location, nature and size of products, delivery time to be respected, accessibility of the areas where customers live, and so on). Different delivery options can result in different average load factors (for different vehicle types).

The second attribute is the ***distance travelled***. As for load factor, specific delivery tours can be planned but they will change case by case and different delivery options may lead to different distances travelled by different vehicle types.

The third attribute related to service efficiency is the ***consolidation of shipments***, i.e. using the same vehicle/tour to deliver different types of products to one client or the same type of product to several clients and so on. Once again, this kind of optimisation is a matter of organisation for specific cases, but the extent to which it can be applied, considering the whole activity, is an impact depending on requirements and constraints.

Last, but definitely not least, an attribute of this type is the ***delivery cost***. This cost is a function of all supply-side elements and can therefore be different for each delivery option.

Table 4-4: Specification and categorisation of delivery options private impact attributes

Attribute type	Attribute	Definition	Category
Service efficiency	Vehicle load factor	Loaded tonnes per vehicle	Impact (private)
	Distance travelled	Distance travelled for delivering products	Impact (private)
	Shipments consolidation	Use of the same vehicle/delivery tour to serve more clients	Impact (private)
	Delivery production cost	Costs of all supply-side elements	Impact (private)

4.5.2 Social impacts

Moving to social impacts, a first type of attributes is related to **transport impacts**. One attribute of this type is the contribution of vehicles used for delivery to ***congestion***. The other attribute of this type is ***irregular parking***. They are two separate attributes even if irregular parking is a source of congestion. Basically, the attribute related to congestion refers to the number of vehicles circulating in a certain period (e.g., peak hours of an average working day), to their type (e.g. cargo-bikes contribute to

congestion differently from vans) and to the number of km they travel. The attribute related to irregular parking deals specifically to vehicles parked where they should not (on platform, in second row, etc.).

A second type of social impact attributes include **environmental impacts**. The first one is the level of greenhouse gases ***(GHG) emissions***. This attribute is a consequence of the combination of other attributes, especially the vehicle technology and the distance travelled. The second attribute concerns ***pollutant emissions***. Rather than referring to emissions of elements contributing to global warming, it refers to the emissions of substances harmful for human health (e.g. particulate matters, nitrogen dioxides). Another environmental impact is ***noise***, which again depend mainly on the vehicle types used and their technology.

Last type of attributes concerning social impacts is the one related to **labour impacts**. Different delivery options have different implications on the effort required to the workers involved in the process. On the one hand, ***labour conditions for drivers***, in terms of wage, working hours per day and week, number of deliveries to be completed but also reliable working schedules allowing the organisation of personal life. Similar elements define the working conditions for those operating in other phases of the delivery chain (***logistic chains labour conditions***).

Table 4-5: Specification and categorisation of delivery options social impact attributes

Attribute type	Attribute	Definition	Category
Transport impacts	Congestion	Commercial vehicles contributing to traffic jam	Impact (social)
	Irregular parking	Commercial vehicles parked irregularly	Impact (social)
Environmental impacts	GHG emissions	Emissions of GHG gases	Impact (social)
	Pollutant emissions	Emissions of air pollutants	Impact (social)
	Noise	Noise emissions	Impact (social)
Labour impacts	Drivers labour conditions	Wage, working hours, anticipated working schedule, required deliveries per day etc.	Impact (social)
	Logistic chain labour conditions	Wage, working hours, anticipated working schedule, required packages per day etc.	Impact (social)

Figure 2: Summary of attributes of delivery and return options

DEMAND

Demand attributes

Attributes defined looking at the delivery options with customers' eyes

Cost	Delivery time	Delivery method	Information	Reliability	Flexibility
• Delivery price	• Delivery date • Delivery date punctuality • Delivery time slot • Delivery time slot punctuality • Delivery time optimisation	• Point of delivery • Vehicle type	• Tracking of shipment • Delivery reminder • Impact of purchase	• Products safety • Actual delivery	• Choice of delivery date • Choice of delivery time slot • Choice of time optimisation • Choice of delivery point • Choice of vehicle type

SUPPLY

Supply attributes

Attributes defined considering the delivery options from the perspective of retailers and logistics operators

Service organisation	Size and composition of the vehicle fleet	Distribution network	Workforce arrangement	Monitoring system
• Stock level • Shops coordination system • Deliveries optimisation system • Product handling protocol	• Delivery vehicles' type • Delivery vehicles' technology • Number of vehicles by type	• Number or warehouses • Size of warehouses • Warehouses' location • Warehouses equipment	• Number of drivers • Number of warehouses' workers	• Retailer measurement process • Logistics operator measurement process

CONTEXT

Context attributes

Attributes refer to conditions set by the local authorities

Spatial arrangement	Enforcement
• Land use planning • Streets accessibility • Parking lots • CCAM available paths • Drones flight permits	• Rules enforcement

IMPACT

Impact attributes

Refer to the effects or consequences of certain decisions or actions taken in logistics and retail logistics processes

Private Impact

Social Impact

Service efficiency	Transport impacts	Environmental impacts	Labour impacts
• Vehicle load factor • Distance travelled • Shipments consolidation • Delivery production cost	• Congestion • Irregular parking	• GHG emissions • Pollutant emissions • Noise	• Drivers working conditions • Logistic chain workers conditions

5 Relevance of attributes in different situations

The previous sections provide an overview of the attributes associated with delivery options from different perspectives. This general list of attributes includes elements which are very relevant in some situations and less relevant, or even not relevant at all, in other situations. The term “situation” is used to describe the combination of different elements like the type of product, the segment of customers and the type of location where the delivery is made.

Even if producing a list of relevant attributes for any specific circumstance is unfeasible, it is useful to highlight which attributes are particularly significant in each case and which ones are less or not important. This exercise is discussed, separately for demand-side and supply-side attributes, in the following.

5.1 Relevance of demand-side attributes

An overview of the relevance of demand-side attributes for a specific **group of products**, **group of customers**, **spatial context** is presented respectively in Table *5-1*, Table *5-2*, Table *5-3*. Tables show when the relevance of an attribute can be considered higher or lower than the average.

5.1.1 Relevance by product type

While the price of delivery can be considered an attribute which demand is sensitive to, when the price of the purchased product is already significant, the delivery price is often comparably small, and its relevance is therefore minor. This is the case for electronic products and furniture. Vice-versa, for other product types, like books or food, whose price is generally limited, the delivery price is influential. The point of delivery is more significant when the items purchased are difficult to handle because of volume, shape or weight. Electronic products and household items are products type for which this can happen more frequently than for, e.g. clothes or cosmetics. Even if food is generally easy to handle, ordering food is generally an alternative chosen to remain at home. Therefore, the point of delivery is also relevant because food ordered should be delivered at door.

For food products several demand-side attributes are more relevant than on average. In addition to price and point of delivery, the time slot and the flexibility regarding such a slot are also influential. At the same time, for food products, aspects like the flexibility on delivery date or receiving messages reminding that a delivery is in progress are usually not important. There are no reasons to believe that the flexibility about the vehicle type used for the delivery is especially important for some product type; instead, it is likely that for furniture, whose products can be voluminous, this flexibility is less relevant, because e.g. cargo-bikes are not a feasible option (see Table *5-1*). The ratings in the table are a generalisation per product type and can vary depending on the circumstances.

5.1.2 Relevance by customer type

Considering customer types, it can be expected that tighter daily personal agendas make individuals more sensitive to several attributes, especially those making easier the organisation of their own time. Therefore, employed singles, and even more employed singles with children, but also those living in couples with children are likely very interested in the delivery time slot, in the punctuality regarding both the delivery date and the time slot and in the possibility of choosing both these elements. On the other hand, elderly individuals have generally more available time and less constraints. Therefore, they are probably not so interested in those same attributes. However, elderly individuals can be more sensitive to price and, given that their mobility might be somewhat reduced (especially if carrying some load) they can be more affected than the average by the point of delivery. Young individuals are often more

sensitive about environmental issues; therefore, the flexibility about the vehicle type used for the delivery can have a higher relevance for this group (see Table *5-2*).

5.1.3 Relevance by spatial context

As far as the spatial context is concerned, it seems likely that its role is relevant especially regarding the delivery method, namely the point of delivery (and delivery area) and the vehicle type (and, consequently, the flexibility regarding the choice of the vehicle type). The point of delivery is likely quite relevant when the customer lives in a vehicle-restricted area such as a pedestrian area or low emission zone, which is less accessible. The possibility of choosing the vehicle type can allow who lives in these areas to decide about receiving the products at home. For different reasons, also in rural areas the point of delivery is relevant as alternatives to receiving products at the door are probably much less convenient than in urban areas, where lockers or pick-up points can be quite close to customers' home. Instead, in rural areas the vehicle type is probably not very relevant as congestion or pollution are usually much less problematic (see Table *5-3*).

Table 5-1: Relevance of demand-side attributes of delivery options by product type

Demand side attributes of delivery options			Product type									
Attribute category	*Attribute*	*Attribute definition*	*Books & Media*	*Clothes & Shoes*	*Cosmetics & Beauty*	*Health & Wellness*	*Electronics*	*Household items*	*Furniture & Furnishings*	*Pet care*	*Food & Beverage*	*Product mix*
Cost	**Delivery price**	Charge applied to cover shipment costs	**HIGHER**		**HIGHER**	**HIGHER**	**LOWER**		**LOWER**	**HIGHER**	**HIGHER**	
Delivery time	**Delivery date**	Time needed to receive the ordered products				**HIGHER**					**HIGHER**	
	Delivery time slot	The period of the day when the product is delivered to customer									**HIGHER**	
	Delivery date punctuality	The product is delivered in the day announced at the purchase										
	Delivery time slot punctuality	The product is delivered in the time slot chosen/announced										
	Delivery time optimisation	All purchased items delivered together on request									**HIGHER**	**HIGHER**
Delivery method	**Point of delivery**	The exact place where products are dropped (e.g. door, road front, picking point, lockers, etc,)					**HIGHER**	**HIGHER**	**HIGHER**		**HIGHER**	
	Vehicle type	The vehicle type used for the delivery										
Information	**Tracking of shipment**	Access to tracking interface to follow the status of the delivery				**HIGHER**					**HIGHER**	
	Delivery reminder	Message sent in advance to remind of the delivery									**LOWER**	
	Impact of delivery	Detail on social impacts of delivery (e.g., emissions, drivers wage, etc.)										
Reliability	**Products safety**	Products and original packages are not damaged										
	Actual delivery	Procedures to avoid unfounded communications of failed delivery attempts									**LOWER**	
Flexibility	**Choice of delivery date**	The option for the customer to choose the delivery date									**LOWER**	
	Choice of delivery time slot	The option for the customer to choose the time slot							**HIGHER**		**HIGHER**	
	Choice of time optimisation	The option for the customer to choose if receiving all items in a single delivery									**LOWER**	
	Choice of point of delivery	The option for the customer to choose the point of delivery					**HIGHER**	**HIGHER**	**HIGHER**		**HIGHER**	
	Choice of vehicle type	The option for the customer to choose the type of vehicle used for the delivery							**LOWER**			

Table 5-2: Relevance of demand-side attributes of delivery options by customer type

Demand side attributes of delivery options			Customer type										
Attribute category	*Attribute*	*Attribute definition*	*Single*	*Single + children*	*Couple*	*Couple + Children*	*Young*	*Adult*	*Elderly*	*Employed*	*Not employed*	*Female*	*Male*
Cost	**Delivery price**	Charge applied to cover shipment costs							HIGHER				
Delivery time	**Delivery date**	Time needed to receive the ordered products											
	Delivery time slot	The period of the day when the product is delivered to customer	HIGHER	HIGHER		HIGHER			LOWER	HIGHER			
	Delivery date punctuality	The product is delivered in the day announced at the purchase	HIGHER	HIGHER		HIGHER			LOWER	HIGHER			
	Delivery time slot punctuality	The product is delivered in the time slot chosen/announced	HIGHER	HIGHER		HIGHER			LOWER	HIGHER			
	Delivery time optimisation	All purchased items delivered together on request							LOWER				
Delivery method	**Point of delivery**	The exact place where products are dropped (e.g. door, road front, picking point, lockers, etc,)		HIGHER		HIGHER			HIGHER				
	Vehicle type	The vehicle type used for the delivery											
Information	**Tracking of shipment**	Access to tracking interface to follow the status of the delivery											
	Delivery reminder	Message sent in advance to remind of the delivery											
	Impact of delivery	Detail on social impacts of delivery (e.g., emissions, drivers wage, etc.)											
Reliability	**Products safety**	Products and original packages are not damaged											
	Actual delivery	Procedures to avoid unfounded communications of failed delivery attempts	HIGHER	HIGHER		HIGHER			HIGHER	HIGHER			
Flexibility	**Choice of delivery date**	The option for the customer to choose the delivery date		HIGHER		HIGHER			LOWER	HIGHER			
	Choice of delivery time slot	The option for the customer to choose the time slot		HIGHER		HIGHER			LOWER	HIGHER			
	Choice of time optimisation	The option for the customer to choose if receiving all items in a single delivery		HIGHER		HIGHER			LOWER	HIGHER			
	Choice of point of delivery	The option for the customer to choose the point of delivery		HIGHER		HIGHER			HIGHER	HIGHER			
	Choice of vehicle type	The option for the customer to choose the type of vehicle used for the delivery					HIGHER						

Table 5-3: Relevance of demand-side attributes of delivery options by spatial context

Demand side attributes of delivery options			Spatial context				
Attribute category	*Attribute*	*Attribute definition*	*Urban*	*Rural*	*Low Emission Zone*	*Vehicle restricted area*	*Suburbs*
Cost	**Delivery price**	Charge applied to cover shipment costs					
Delivery time	**Delivery date**	Time needed to receive the ordered products					
	Delivery time slot	The period of the day when the product is delivered to customer					
	Delivery date punctuality	The product is delivered in the day announced at the purchase					
	Delivery time slot punctuality	The product is delivered in the time slot chosen/announced					
	Delivery time optimisation	All purchased items delivered together on request					
Delivery method	**Point of delivery**	The exact place where products are dropped (e.g. door, road front, picking point, lockers, etc,)		**HIGHER**	**HIGHER**	**HIGHER**	
	Vehicle type	The vehicle type used for the delivery		**LOWER**	**HIGHER**	**HIGHER**	
Information	**Tracking of shipment**	Access to tracking interface to follow the status of the delivery					
	Delivery reminder	Message sent in advance to remind of the delivery					
	Impact of delivery	Detail on social impacts of delivery (e.g., emissions, drivers wage, etc.)					
Reliability	**Products safety**	Products and original packages are not damaged					
	Actual delivery	Procedures to avoid unfounded communications of failed delivery attempts		**HIGHER**			
Flexibility	**Choice of delivery date**	The option for the customer to choose the delivery date					
	Choice of delivery time slot	The option for the customer to choose the time slot					
	Choice of time optimisation	The option for the customer to choose if receiving all items in a single delivery					
	Choice of point of delivery	The option for the customer to choose the point of delivery					
	Choice of vehicle type	The option for the customer to choose the type of vehicle used for the delivery	**HIGHER**		**HIGHER**	**HIGHER**	

5.2 Relevance of supply-side and context attributes

An overview of the relevance of supply-side attributes for a specific **group of products**, **retailer types** or **spatial context** is presented respectively in Table *5-4*, Table *5-5* and Table *5-6*. Tables show when the relevance of an attribute can be considered higher or lower than the average.

5.2.1 Relevance by product type

As per the product type, it can be expected that the stock level is more relevant when customers likely wish receiving the purchased items quickly, as they might need them in specific circumstances. This can apply to clothes and shoes purchased to attend a specific event, to drugs required to tackle a disease or food (e.g. a bottle of wine for a planned dinner).

The coordination between different shops can be more important when several versions of a certain product exist and not all versions are necessarily available in a single shop. For instance, versions of smartphones of original colours might be not very popular; so, they might not be available in any shop. Also, books are sometimes reprinted in new editions and older ones (which some customer might want) might remain available only in some shops.

The vehicle type can be particularly relevant when products are large in size or weight. Some kinds of furniture or some appliances like washing machines cannot be transported by cargo-bikes. A similar reasoning applies to streets accessibility and parking lots, as larger or heavier items need adequate space and need more time to complete the delivery.

It has to be noted that specific requirements in terms of warehouse equipment can exist to handle food, to ensure hygiene as well as a correct storing to ensure that the features of the product are preserved (see Table *5-4*).

5.2.2 Relevance by retailer type

Online retailers can be classified into different types according to their business model, size, geographic reach, and type of services offered to consumers. Five main types of retailers can be identified: marketplaces, single-brand e-stores, multi-brand e-stores, multichannel/omnichannel retailers, and boutique e-tailers.

An **online marketplace** is a digital platform where multiple third-party sellers can offer products or services to buyers. Ebay but also Takeaway.com are examples. Unlike a traditional online store, which is owned and managed by a single company, a marketplace acts as an intermediary, connecting buyers and sellers, while occasionally serving as a seller itself. Sellers on a marketplace can be both individuals and companies. Rather than owning the entire inventory, the marketplace provides a virtual space where various vendors can display and sell their items. Typically, the marketplace manages aspects such as payment processing, listings, customer support, and sometimes even logistics services.

A **single-brand e-store** is a retailer that sells only its own products online (e.g., a fashion brand or an online supermarket), whereas a **multi-brand e-store** exclusively offers a catalogue featuring multiple brands online.

It is increasingly common for retailers to combine physical shops with an online store, creating what is known as a **multichannel or omnichannel retailer**. The distinction depends on the degree of integration between the in-store and online experience. For instance, in some cases, customers can order online and pick up in-store, or they may buy items online, receive home delivery, and return them to a physical location. Goods can be shipped from both warehouses as well as physical stores (e.g. IKEA, MediaMarkt, Decathlon).

The last category includes **boutique e-tailers**, which focus on niche markets or high-value product catalogues. These e-tailers typically offer a personalised and exclusive shopping experience, They

typically offer a high level of item customization and a 'white glove delivery' service as part of the purchase experience (e.g. luxury furniture stores, luxury watch stores).

The type of retailer influences the relevance of delivery attributes to a different extent. For marketplaces and multi-brand e-stores the relevance of “stock level” is higher emphasizing the importance of inventory management and coordination. On the other hand, these attributes are of lower relevance for Boutique e-tailers, reflecting less reliance on extensive stock and coordination. Multichannel/omnichannel retailer must coordinate the operation both in physical stores, that could operate as micro hubs, and e-commerce delivery. Thus the “shops coordination system” attribute is especially relevant for them.

In the case of logistics operators, retailer types like multi-channel retailers put more pressure on delivery optimisation systems, highlighting the need for efficient routing and scheduling. On the other hand, boutique e-tailers have simpler logistics requirements; therefore, are less dependent on delivery optimisation systems. Warehouse resources — including the number, size, equipment, and workforce of warehouses — is especially important for marketplaces and multi-brand e-stores, underlining the importance of warehousing for larger retail models.

Finally, for Local Authorities and Logistics Operators, warehouse location has a high impact for marketplaces, as strategic placement supports faster deliveries, while it has a lower impact for single-brand e-stores, which might rely on more centralised logistics networks (see Table *5-5*).

5.2.3 Relevance by spatial context

The spatial context plays a role whenever it implies some limitations or adaptations of the delivery option. The urban context is more demanding, as space is more limited. At the same time stop density might be quite high. Pedestrian areas or low emission zones add further constraints, which apply especially to vehicle types and technologies. Vice-versa, in rural areas there are fewer limitations, especially regarding accessibility, parking and vehicles technology (see Table *5-6*).

Table 5-4: Relevance of supply side and context attributes of delivery options by product type

Supply side and context attributes of delivery options			Product type									
Stakeholder	*Attribute*	*Attribute definition*	*Books & Media*	*Clothes & Shoes*	*Cosmetics & Beauty*	*Health & Wellness*	*Electronics*	*Household items*	*Furniture & Furnishings*	*Pet care*	*Food & Beverage*	*Product mix*
Retailer	**Stock level**	The organisation used to minimise the time between order and products availability		**HIGHER**	**HIGHER**	**HIGHER**					**HIGHER**	
	Shops coordination system	The organisation used to assemble deliveries with products available in different shops	**HIGHER**				**HIGHER**	**HIGHER**				
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)										
Logistics operator	**Delivery vehicles type**	The type of vehicles used for delivering (trucks, vans, cargo-bikes, drones, etc.)						**HIGHER**	**HIGHER**			
	Delivery vehicles technology	The energy source of vehicles used for delivering (fossil fuels, electricity, human activity, etc.)										
	Number of vehicles by type	The size and composition of the fleet available for deliveries										
	Number of drivers	Number of drivers available for deliveries										
	Number or warehouses	Number of warehouses used for delivery services										
	Size of warehouses	Surface of warehouses used for delivery services										
	Warehouses equipment	Operations that can be managed by facilities available at warehouses									**HIGHER**	
	Number of warehouses workers	Number of workers at warehouses										
	Delivery optimisation system	The procedure used to optimise the use of vehicles, the work of drivers, the delivery tours, etc.										
	Products handling protocols	The procedure established to handle products to ensure their integrity at destination					**HIGHER**	**HIGHER**	**HIGHER**			
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)										
Logistics operator / Local authority	**Warehouses' location**	Position of warehouses used for delivery services										

Supply side and context attributes of delivery options			Product type									
Stakeholder	*Attribute*	*Attribute definition*	*Books & Media*	*Clothes & Shoes*	*Cosmetics & Beauty*	*Health & Wellness*	*Electronics*	*Household items*	*Furniture & Furnishings*	*Pet care*	*Food & Beverage*	*Product mix*
Local authority	**Land use planning**	Definition in urban plan documents of areas open to location of industrial buildings and, more specifically, warehouses										
	Streets accessibility	Vehicle types admitted in each street of a given area (e.g., pedestrian areas, low emissions zones, time windows)						HIGHER	HIGHER		HIGHER	
	Parking lots	Number and location of lots available for parking commercial vehicles during delivery tours						HIGHER	HIGHER		HIGHER	
	CCAM available paths	Where driverless vehicles used for delivery can be operated (streets, platforms, etc.)					LOWER	LOWER	LOWER			
	Drones flight permits	Where remote-controlled drones can fly in a given area (banned areas, corridors, minimum altitude, etc.)					LOWER	LOWER	LOWER			
	Rules enforcement	Activity to ensure that regulations affecting some aspects of delivery options are respected										

Table 5-5: Relevance of supply side and context attributes of delivery options by retailer type

Supply side and context attributes of delivery options			Retailer type				
Stakeholder	*Attribute*	*Attribute definition*	*Marketplace*	*Single-brand e-store*	*Multi-brand e-store*	*Multichannel/ Omnichannel retailer*	*Boutique e-tailers*
Retailer	**Stock level**	The organisation used to minimise the time between order and products availability	**HIGHER**		**HIGHER**		**LOWER**
	Shops coordination system	The organisation used to assemble deliveries with products available in different shops				**HIGHER**	
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)					
Logistics operator	**Delivery vehicles type**	The type of vehicles used for delivering (trucks, vans, cargo-bikes, drones, etc.)					
	Delivery vehicles technology	The energy source of vehicles used for delivering (fossil fuels, electricity, human activity, etc.)					
	Number of vehicles by type	The size and composition of the fleet available for deliveries				**HIGHER**	
	Number of drivers	Number of drivers available for deliveries				**HIGHER**	
	Number or warehouses	Number of warehouses used for delivery services	**HIGHER**		**LOWER**		
	Size of warehouses	Surface of warehouses used for delivery services	**HIGHER**		**HIGHER**		
	Warehouses equipment	Operations that can be managed by facilities available at warehouses			**HIGHER**		
	Number of warehouses workers	Number of workers at warehouses	**HIGHER**				
	Delivery optimisation system	The procedure used to optimise the use of vehicles, the work of drivers, the delivery tours, etc.				**HIGHER**	**LOWER**
	Products handling protocols	The procedure established to handle products to ensure their integrity at destination					**HIGHER**
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)					
Logistics operator / Local authority	**Warehouses' location**	Position of warehouses used for delivery services	**HIGHER**	**LOWER**			
Local authority	**Land use planning**	Definition in urban plan documents of areas open to location of industrial buildings and, more specifically, warehouses					
	Streets accessibility	Vehicle types admitted in each street of a given area (e.g., pedestrian areas, low emissions zones, time windows)					
	Parking lots	Number and location of lots available for parking commercial vehicles during delivery tours					
	CCAM available paths	Where driverless vehicles used for delivery can be operated (streets, platforms, etc.)					

Supply side and context attributes of delivery options			Retailer type				
Stakeholder	*Attribute*	*Attribute definition*	*Marketplace*	*Single-brand e-store*	*Multi-brand e-store*	*Multichannel/ Omnichannel retailer*	*Boutique e-tailers*
	Drones flight permits	Where remote-controlled drones can fly in a given area (banned areas, corridors, minimum altitude, etc.)					
	Rules enforcement	Activity to ensure that regulations affecting some aspects of delivery options are respected					

Table 5-6: Relevance of supply side and context attributes of delivery options by spatial context

Supply side and context attributes of delivery options			Spatial context				
Stakeholder	*Attribute*	*Attribute definition*	*Urban*	*Rural*	*Low Emission Zone*	*Vehicle restricted area*	*Suburbs*
Retailer	**Stock level**	The organisation used to minimise the time between order and products availability					
	Shops coordination system	The organisation used to assemble deliveries with products available in different shops					
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)					
Logistics operator	**Delivery vehicles type**	The type of vehicles used for delivering (trucks, vans, cargo-bikes, drones, etc.)	**HIGHER**		**HIGHER**	**HIGHER**	
	Delivery vehicles technology	The energy source of vehicles used for delivering (fossil fuels, electricity, human activity, etc.)		**LOWER**	**HIGHER**		
	Number of vehicles by type	The size and composition of the fleet available for deliveries	**HIGHER**		**HIGHER**		
	Number of drivers	Number of drivers available for deliveries		**HIGHER**			
	Number or warehouses	Number of warehouses used for delivery services	**HIGHER**				
	Size of warehouses	Surface of warehouses used for delivery services	**HIGHER**				
	Warehouses equipment	Operations that can be managed by facilities available at warehouses					
	Number of warehouses workers	Number of workers at warehouses					
	Delivery optimisation system	The procedure used to optimise the use of vehicles, the work of drivers, the delivery tours, etc.					
	Products handling protocols	The procedure established to handle products to ensure their integrity at destination					
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)					
Logistics operator / Local authority	**Warehouses' location**	Position of warehouses used for delivery services	**HIGHER**				
Local authority	**Land use planning**	Definition in urban plan documents of areas open to location of industrial buildings and, more specifically, warehouses	**HIGHER**	**HIGHER**			**HIGHER**
	Streets accessibility	Vehicle types admitted in each street of a given area (e.g., pedestrian areas, low emissions zones)	**HIGHER**	**LOWER**			
	Parking lots	Number and location of lots available for parking commercial vehicles during delivery tours	**HIGHER**	**LOWER**			
	CCAM available paths	Where driverless vehicles used for delivery can be operated (streets, platforms, etc.)	**HIGHER**	**LOWER**			
	Drones flight permits	Where remote-controlled drones can fly in a given area (banned areas, corridors, minimum altitude, etc.)	**HIGHER**	**LOWER**			

Supply side and context attributes of delivery options			Spatial context				
Stakeholder	*Attribute*	*Attribute definition*	*Urban*	*Rural*	*Low Emission Zone*	*Vehicle restricted area*	*Suburbs*
	Rules enforcement	Activity to ensure that regulations affecting some aspects of delivery options are respected.	**HIGHER**		**HIGHER**	**HIGHER**	

6 Interaction between attributes of different categories

The classification of attributes in different categories discussed above helps to identify their nature and role. Yet, attributes belonging to different categories are not only present at the same time but affect each other.

The analysis of the **interactions between attributes of different categories** (demand-side, supply-side and so on) is informative especially considering that some attributes refer to organizational aspects (i.e. instruments in the hands of logistics operators, retailers and local authorities) and others to consumers' requirements (i.e. objectives to be pursued for customers' satisfaction). Therefore, analysing the interaction between demand-side and supply-side attributes it is possible to identify which ones in the latter group should be involved when alternative options are designed aiming at objectives related to the demand-side attribute. For instance, it can emerge that ensuring the possibility of choosing the vehicle type used for the delivery has implications for the size and composition of the fleet of vehicles as well as on the number and location of warehouses. Then, the interaction between supply-side attributes and private impacts can shed light on the potential consequences of the alternative options for retailers and logistics operators. In a nutshell, considering the interactions between different attribute types, one can have an initial idea of how complex pursuing a certain objective can be in terms of the leverages available.

More specifically, the interaction between **demand-side and supply-side** attributes shows that delivery options aimed at different objectives in terms of customer satisfaction require a different number of supply-side aspects to be organised. The same applies if impacts are considered rather than demand-side attributes.

The interaction between **demand-side and impact attributes** provides some indications on how wishes of consumers are consistent with operators' objectives and social goals. For instance, ensuring the punctuality of deliveries affects basically every impact attribute, from load factors and distance travelled to emissions, congestion and labour conditions.

It is worth noting that several interactions imply a contradiction between consumers' preferences and operators' objectives and social goals rather than a synergy. As an example, reducing the time needed for delivery and respecting the agreed slot can easily require more frequent transport of parcels in partially loaded vehicles resulting into increased congestion and, potentially, more emissions. More pressure is most likely put on drivers and logistics chain workers as well.

The interactions presented below can therefore help for the analysis of existing delivery options and, even more, in the design of novel options in the next activities of this project.

6.1 Interaction between demand-side and supply-side attributes

An overview of the interactions between **demand-side and supply-side attributes** is presented in Table *6-1*.

As previously mentioned, demand-side attributes define requirements for the delivery options, while supply-side attributes mainly refer to instruments for meeting the requirements. From this perspective, it is logical to address the interaction between the two categories in terms of which supply-side attributes may need to be adapted when aiming to a certain level of a demand-side attribute. For instance, delivery time is affected by several supply-side attributes like the stock level (the larger the stock, the more likely that the product is immediately available), the number of vehicles (the more vehicles, the more likely that the package can quickly leave the warehouse towards its final destination), the number and size of warehouses (the more warehouses are available, and the larger they are, the more likely that products

are handled quickly), the workforce available (the more drivers and logistics workers are available, the more likely is that the various operations along the delivery chain are completed quickly).

The attribute “point of delivery” depends on supply elements like the number of vehicles available: for a given number of products purchased, the more vehicles are available, the lower the number of clients they have to visit and the higher the time they have to complete a delivery. Eventually, for a given number of products purchased, the more vehicles are available the easier is to receive products at home) and their types (the more zero-emissions vehicles are available, the more likely that the delivery occur at home even in restricted areas).

Some supply-side elements are more significant as they play a role for several demand-side attributes. Namely, the most relevant supply-side attributes are number of vehicles, the number of drivers and the system used to optimise deliveries. These three attributes play a role in more than half of all demand-side attributes. Other important supply-side attributes are the system applied to coordinate different shops selling products that customers can purchase online on the same platform, the type of vehicles used for the delivery, the number, size, location of the warehouses and the size of the staff working in those.

From another perspective, some demand-side attributes depend on a specific supply-side attribute or on a few of them, while others are affected by several aspects of supply. Basically, all supply-side attributes affect the delivery price. Instead, the delivery time slot is function basically “only” of the delivery optimisation system (but punctuality in terms of respecting the slot chosen/announced depends also on other supply-side attributes: number of vehicles and number of drivers). The demand-side attributes affected by several supply-side elements are the delivery price, the delivery date, the delivery date punctuality but also the optimisation of delivery (the option of receiving all items in a single delivery). Demand-side attributes related to information or reliability are “simpler” in the sense that they depend on just a few supply-side attributes (which, however, are not necessarily easy to adjust, however).

Table 6-1: Interaction between demand-side and supply-side attributes of delivery options

Demand side attributes of delivery options			Retailer			Logistics operator										Logistics operator / Local authority
Attribute category	*Attribute*	*Attribute definition*	*Stock level*	*Shops coordination system*	*Impact measurement process*	*Delivery vehicles type*	*Delivery vehicles technology*	*Number of vehicles by type*	*Number of drivers*	*Number or warehouses*	*Size of warehouses*	*Warehouses equipment*	*Number of warehouses workers*	*Delivery optimisation system*	*Products handling protocols*	*Impact measurement process*	*Warehouses' location*
Cost	**Delivery price**	Charge applied to cover shipment costs	●	●		●	●	●	●	●	●	●	●	●	●		●
Delivery time	**Delivery date**	Time needed to receive the ordered products	●	●				●	●	●	●	●	●	●			●
	Delivery time slot	The period of the day when the product is delivered to customer												●			
	Delivery date punctuality	The product is delivered in the day announced at the purchase		●				●	●	●	●	●	●	●			●
	Delivery time slot punctuality	The product is delivered in the time slot chosen/announced						●	●					●			
	Delivery time optimisation	All purchased items delivered together on request	●	●		●		●	●	●	●	●	●	●	●		●
Delivery method	**Point of delivery**	The exact place where products are dropped (e.g. door, road front, picking point, lockers, etc,)				●	●	●	●					●			
	Vehicle type	The vehicle type used for the delivery				●	●	●									
Information	**Tracking of shipment**	Access to tracking interface to follow the status of the delivery		●													
	Delivery reminder	Message sent in advance to remind of the delivery															
	Impact of delivery	Detail on social impacts of delivery (e.g., emissions, drivers wage, etc.)			●											●	
Reliability	**Products safety**	Products and original packages are not damaged													●		
	Actual delivery	Procedures to avoid unfounded communications of failed delivery attempts			●				●								
Flexibility	**Choice of delivery date**	The option for the customer to choose the delivery date		●				●	●	●	●		●	●			●
	Choice of delivery time slot	The option for the customer to choose the time slot						●	●					●			
	Choice of time optimisation	The option for the customer to choose if receiving all items in a single delivery		●		●		●	●	●	●		●	●	●		●
	Choice of point of delivery	The option for the customer to choose the point of delivery				●	●	●	●					●			
	Choice of vehicle type	The option for the customer to choose the type of vehicle used for the delivery				●	●	●	●	●		●					●

6.2 Interaction between demand-side and context attributes

An overview of the interactions Interaction between demand-side and context attributes is presented in Table *6-2*.

Context attributes play a limited role on several demand-side attributes. Namely, the level of reliability and flexibility of a delivery option is basically unaffected by the accessibility of roads or by the number of parking lots. There can be some indirect linkages (e.g., if parking lots are unavailable in one area, the logistic operators might be forced to schedule deliveries in that area only off-peak), but there is not a strong interaction. Also, the time required for delivery is basically independent on the context, which plays a role especially as regard of the point of delivery, the vehicle type used and, more indirectly, on the delivery time slot (e.g., if some streets are closed in some hours).

Table 6-2: Interaction between demand-side and context attributes of delivery options

Demand side attributes of delivery options			Local authority					
Attribute category	*Attribute*	*Attribute definition*	*Land use planning*	*Streets accessibility*	*Parking lots*	*CCAM available paths*	*Drones flight permits*	*Rules enforcement*
Cost	**Delivery price**	Charge applied to cover shipment costs		●	●	●	●	●
Delivery time	**Delivery date**	Time needed to receive the ordered products						
	Delivery time slot	The period of the day when the product is delivered to customer		●	●	●	●	●
	Delivery date punctuality	The product is delivered in the day announced at the purchase						
	Delivery time slot punctuality	The product is delivered in the time slot chosen/announced						
	Delivery time optimisation	All purchased items delivered together on request		●	●			
Delivery method	**Point of delivery**	The exact place where products are dropped (e.g. door, road front, picking point, lockers, etc,)	●	●	●	●	●	●
	Vehicle type	The vehicle type used for the delivery		●	●	●	●	●
Information	**Tracking of shipment**	Access to tracking interface to follow the status of the delivery						
	Delivery reminder	Message sent in advance to remind of the delivery						
	Impact of delivery	Detail on social impacts of delivery (e.g., emissions, drivers wage, etc.)						
Reliability	**Products safety**	Products and original packages are not damaged						
	Actual delivery	Procedures to avoid unfounded communications of failed delivery attempts						
Flexibility	**Choice of delivery date**	The option for the customer to choose the delivery date						
	Choice of delivery time slot	The option for the customer to choose the time slot						
	Choice of time optimisation	The option for the customer to choose if receiving all items in a single delivery		●	●			
	Choice of point of delivery	The option for the customer to choose the point of delivery		●	●			
	Choice of vehicle type	The option for the customer to choose the type of vehicle used for the delivery		●	●			

6.3 Interaction between supply-side and context attributes

An overview of the interactions Interaction between supply-side and context attributes is presented in Table *6-3*.

Context attributes interact with supply-side attributes related to the logistic operator. The attributes relevant for the retailer are not dependent on the spatial context as they concern virtual elements or a physical element – the stock of products – which is however spatially distributed and generally not in the same places where last mile deliveries are arranged.

The most influential context attribute for supply is the accessibility of roads. This element affects the organisation of delivery in terms of both vehicles (number, type, technology) and warehouses (location, size and number). It can be noted that the location of warehouses is often influenced by territorial plans, which are issued by the same authorities regulating roads accessibility. Therefore, road accessibility and (potential) locations of warehouses should be defined in a consistent way.

Of course, the regulation about if, where and when innovative transport vehicles, like automated bots or drones, can operate would (will) strongly affect the diffusion of these vehicle types and, consequently, also the arrangement of warehouses, including their equipment.

The availability of parking lots can have a “tactic” influence on the vehicles used. In general terms, the context attributes, which are mainly under control of local authorities can be considered as potential drivers for the arrangement of warehouses and fleets.

Table 6-3: Interaction between context and supply-side attributes of delivery options

Context attributes of delivery options			Retailer			Logistics operator										Logistics operator / Local authority
Attribute category	*Attribute*	*Attribute definition*	*Stock level*	*Shops coordination system*	*Impact measurement process*	*Delivery vehicles type*	*Delivery vehicles technology*	*Number of vehicles by type*	*Number of drivers*	*Number or warehouses*	*Size of warehouses*	*Warehouses equipment*	*Number of warehouses workers*	*Delivery optimisation system*	*Products handling protocols*	*Impact measurement process*	*Warehouses' location*
Spatial arrangement	**Land use planning**	Definition in urban plan documents of areas open to location of industrial buildings and, more specifically, warehouses								●	●	●					●
	Streets accessibility	Vehicle types admitted in each street of a given area (e.g., pedestrian areas, low emissions zones)				●	●	●		●	●	●		●			●
	Parking lots	Number and location of lots available for parking commercial vehicles during delivery tours				●		●									
	CCAM available paths	Where driverless vehicles used for delivery can be operated (streets, platforms, etc.)				●	●	●	●			●		●			●
	Drones flight permits	Where remote-controlled drones can fly in a given area (banned areas, corridors, minimum altitude, etc.)				●	●	●	●			●		●			●
Enforcement	**Rules enforcement**	Activity to ensure that regulations affecting some aspects of delivery options are respected.				●	●	●	●				●		●		●

6.4 Interaction between demand-side and impacts attributes

An overview of the interactions Interaction between demand-side and impact attributes is presented in Table *6-4*.

The interaction between these types of attributes can be easily summarised: most of demand-side attributes affect basically any impact. Since impact attributes identify some key consequences of a given delivery option, it is not surprising that they are influenced, in a mode or another, by all or most of demand-side attributes. The level of a given demand-side attribute depends on one or more supply-side elements, as discussed above. In turn, supply-side elements are direct drivers of effects for the operators and direct or indirect effects for the society. For instance, punctuality in respecting the delivery date depends on how many vehicles are available and used and how they are used. If the target is respecting punctuality, the optimisation of loads or tours can be difficult to achieve for a certain volume of online purchases in a given area. Therefore, punctuality will eventually affect impacts like load factors and the distance travelled. The same mechanism applies to most of the demand-side attributes.

Exceptions are the demand-side attributes related to information, which is entirely managed in a virtual space, and it affects basically only delivery production costs, without significant social effects. Otherwise, not all demand-side attributes affect all impact attributes but for most of both groups some kind of dependency can be identified.

Table 6-4: Interaction between demand side and impact attributes of delivery options

Demand side attributes of delivery options			Logistic operators				Society						
Attribute category	*Attribute*	*Attribute definition*	*Vehicles load factor*	*Distance travelled*	*Shipments consolidation*	*Delivery production cost*	*GHG emissions*	*Pollutant emissions*	*Noise*	*Congestion*	*Irregular parking*	*Drivers labour conditions*	*Logistic chains labour conditions*
Cost	**Delivery price**	Charge applied to cover shipment costs				●							
Delivery time	**Delivery date**	Time needed to receive the ordered products	●	●	●	●	●	●	●	●		●	●
	Delivery time slot	The period of the day when the product is delivered to customer	●	●	●		●	●	●	●	●	●	●
	Delivery date punctuality	The product is delivered in the day announced at the purchase	●	●	●	●	●	●	●	●	●	●	●
	Delivery time slot punctuality	The product is delivered in the time slot chosen/announced	●	●	●	●	●	●	●	●	●	●	●
	Delivery time optimisation	All purchased items delivered together on request	●	●	●	●	●	●	●	●	●	●	●
Delivery method	**Point of delivery**	The exact place where products are dropped (e.g. door, road front, picking point, lockers, etc,)		●		●	●	●	●	●	●	●	
	Vehicle type	The vehicle type used for the delivery	●	●		●	●	●	●	●	●	●	
Information	**Tracking of shipment**	Access to tracking interface to follow the status of the delivery				●							●
	Delivery reminder	Message sent in advance to remind of the delivery											
	Impact of delivery	Detail on social impacts of delivery (e.g., emissions, drivers wage, etc.)											
Reliability	**Products safety**	Products and original packages are not damaged	●		●	●	●	●	●	●		●	●
	Actual delivery	Procedures to avoid unfounded communications of failed delivery attempts				●					●	●	●
Flexibility	**Choice of delivery date**	The option for the customer to choose the delivery date	●	●	●	●	●	●	●	●	●	●	●
	Choice of delivery time slot	The option for the customer to choose the time slot	●	●	●	●	●	●	●	●	●	●	●
	Choice of time optimisation	The option for the customer to choose if receiving all items in a single delivery	●	●	●	●	●	●	●	●	●	●	●
	Choice of point of delivery	The option for the customer to choose the point of delivery	●	●	●	●	●	●	●	●	●	●	●
	Choice of vehicle type	The option for the customer to choose the type of vehicle used for the delivery	●	●	●	●	●	●	●	●	●	●	●

6.5 Interaction between supply-side, context and impact attributes

An overview of the interactions between supply-side, context and impact attributes is presented in Table *6-5*.

What noted regarding the interaction between demand and impact attributes holds for this case: most of the supply-side or context attributes affect many, if not all, the impact attributes. This is an obvious consequence of the role of supply-side attributes to create the conditions incorporated in the demand-side attributes. If the latter are widely linked to impacts, the former necessarily are.

Some supply-side attributes are less influential for many impacts. For example, the level of stock is relevant for some private impacts but does not play any role on social impacts, i.e. does not affect emissions or congestion or other potential consequences of delivery options. Also, the number of drivers affects delivery production costs (any attribute affects delivery production costs) and is influential for the working conditions of drivers themselves but is basically neutral for any other impact.

Table 6-5: Interaction between supply-side, context and impact attributes of delivery options

Supply side and context attributes of delivery options			Logistic operators				Society						
Stakeholder	*Attribute*	*Attribute definition*	*Vehicles load factor*	*Distance travelled*	*Shipments consolidation*	*Delivery production cost*	*GHG emissions*	*Pollutant emissions*	*Noise*	*Congestion*	*Irregular parking*	*Drivers labour conditions*	*Logistic chains labour conditions*
Retailer	**Stock level**	The organisation used to minimise the time between order and products availability			●	●							
	Shops coordination system	The organisation used to assemble deliveries with products available in different shops		●	●	●	●	●	●	●			●
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)				●	●	●	●	●		●	●
Logistics operator	**Delivery vehicles type**	The type of vehicles used for delivering (trucks, vans, cargo-bikes, drones, etc.)	●		●	●	●	●	●	●	●	●	●
	Delivery vehicles technology	The energy source of vehicles used for delivering (fossil fuels, electricity, human activity, etc.)	●	●		●	●	●	●	●			
	Number of vehicles by type	The size and composition of the fleet available for deliveries	●	●	●	●	●	●	●	●			
	Number of drivers	Number of drivers available for deliveries				●						●	
	Number or warehouses	Number of warehouses used for delivery services		●		●	●	●	●	●		●	●
	Size of warehouses	Surface of warehouses used for delivery services		●		●							●
	Warehouses equipment	Operations that can be managed by facilities available at warehouses			●	●							●
	Number of warehouses workers	Number of workers at warehouses				●							●
	Delivery optimisation system	The procedure used to optimise the use of vehicles, the work of drivers, the delivery tours, etc.	●	●	●	●	●	●	●	●	●	●	●
	Products handling protocols	The procedure established to handle products to ensure their integrity at destination	●		●	●	●	●	●	●		●	●
	Impact measurement process	Internal data collection and elaboration system to measure indicators for customers (e.g. on emissions per delivery)				●	●	●	●	●		●	●
Logistics operator / Local authority	**Warehouses' location**	Position of warehouses used for delivery services		●	●	●	●	●	●	●		●	●

Supply side and context attributes of delivery options			Logistic operators				Society						
Stakeholder	*Attribute*	*Attribute definition*	*Vehicles load factor*	*Distance travelled*	*Shipments consolidation*	*Delivery production cost*	*GHG emissions*	*Pollutant emissions*	*Noise*	*Congestion*	*Irregular parking*	*Drivers labour conditions*	*Logistic chains labour conditions*
Local authority	**Land use planning**	Definition in urban plan documents of areas open to location of industrial buildings and, more specifically, warehouses		●		●	●	●	●	●	●		
	Streets accessibility	Vehicle types admitted in each street of a given area (e.g., pedestrian areas, low emissions zones)	●	●	●	●	●	●	●	●	●	●	
	Parking lots	Number and location of lots available for parking commercial vehicles during delivery tours	●	●	●	●	●	●	●	●	●	●	
	CCAM available paths	Where driverless vehicles used for delivery can be operated (streets, platforms, etc.)		●		●	●	●	●	●	●		
	Drones flight permits	Where remote-controlled drones can fly in a given area (banned areas, corridors, minimum altitude, etc.)		●		●	●	●	●	●	●		
	Rules enforcement	Activity to ensure that regulations affecting some aspects of delivery options are respected.	●	●		●	●	●	●	●	●	●	●

Annex I – List of reviewed literature

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Annex II – CodeZERO workshop "What really matters in e-commerce deliveries?"

An on-line workshop entitled "What really matters in e-commerce deliveries?" was held on October 9, 2024. The workshop was attended by 52 participants, representing logistic operators, local authorities, e-tailers, consumers, and research institutes.

The objective of the workshop was to collect feedback from various types of stakeholders on the most important features that e-commerce deliveries should have from their point of view.

Preliminary documentation explaining the objectives of the workshop and its structure was sent to all registered participants ahead of the event to enable an informed discussion.

The workshop was organised along two main sessions:

- Session 1: E-commerce delivery attributes
- Session 2: Interactions between categories.

Contents and results from each session are here presented.

Session 1 - E-commerce delivery attributes

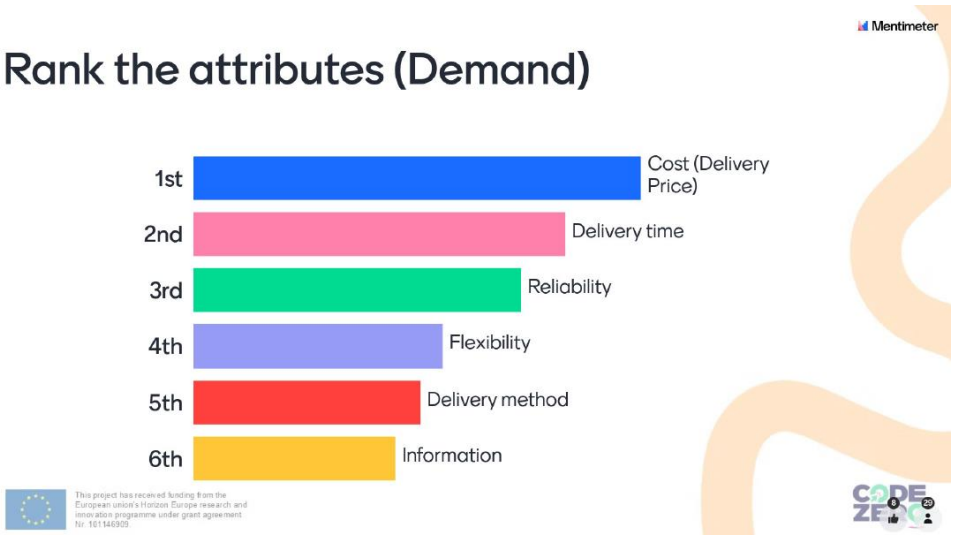
The first part of this session was dedicated to present the approach adopted for building the analysis framework as well as the attributes identified from the desk research and their clarification as per Chapter 4.

Participants were then engaged in two interactive surveys intended to collect their feedback on a) the relevance of the various attributes categories by ranking them and b) any potential gaps in the attributes list.

The first survey, entitled “Rank the attributes”, was conducted for every attribute category: demand-side, supply-side, context and impacts.

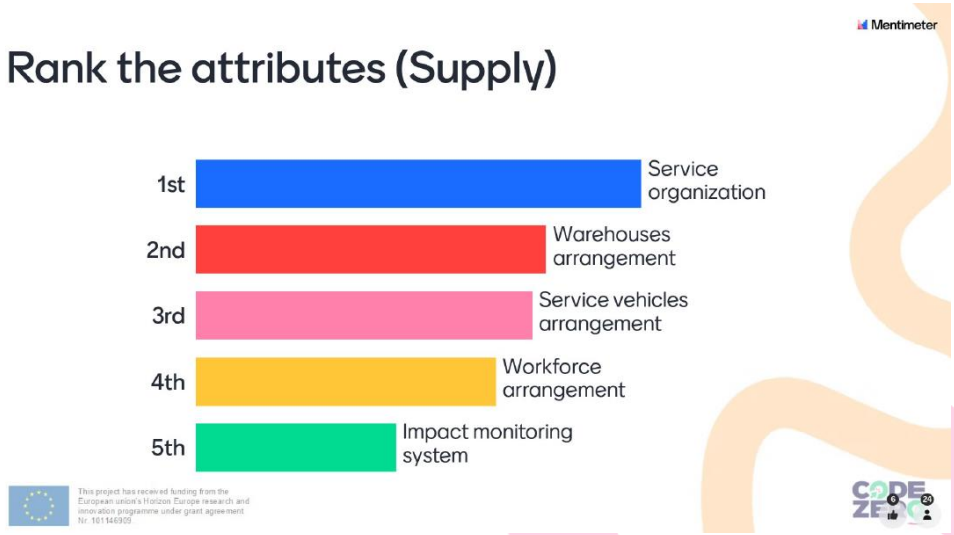
When looking at **demand-side** delivery attributes, respondents to the survey share the opinion that **delivery cost** is the one that consumers value the most followed by **delivery time** and **reliability**. **Flexibility, delivery methods,** and **information** are ranked as less important to consumers (Figure 3).

Figure 3: Ranking of demand-side attributes



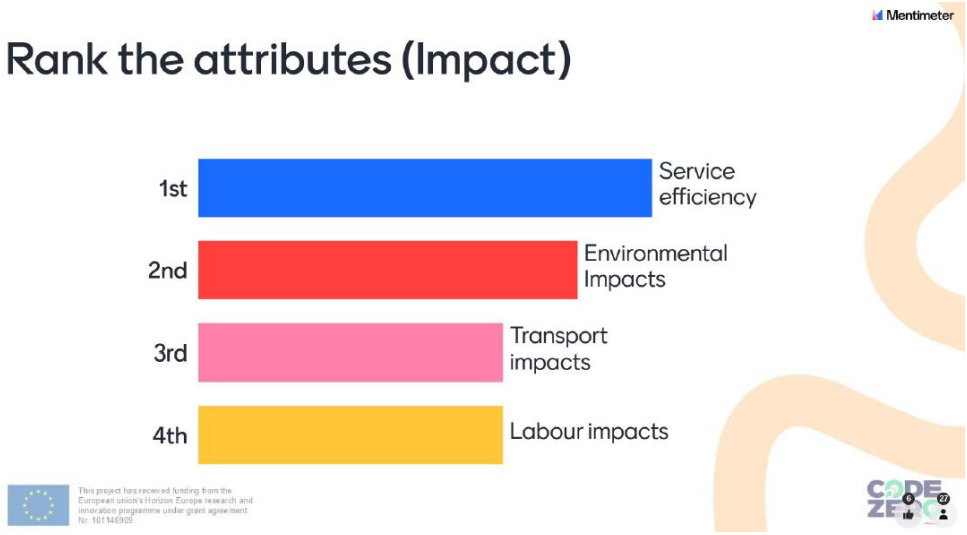
As per supply-side attributes, ***service organization*** was ranked as the most important attribute. ***Warehouses arrangement*** is considered the second most important, followed by ***service vehicles arrangement***, ***workforce arrangement***, and finally ***impact monitoring system*** (Figure *4*).

Figure 4: Ranking of supply-side attributes



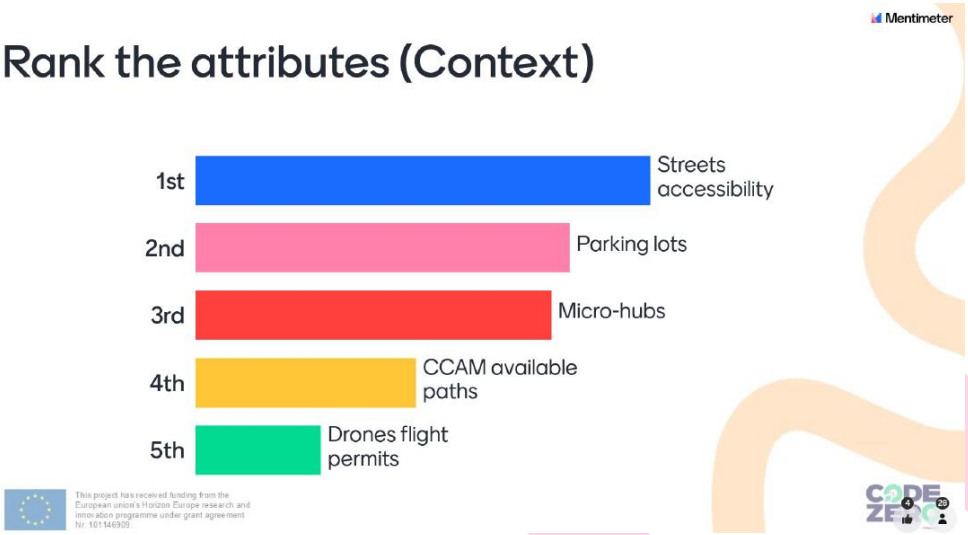
As per the impacts, participants considered ***service efficiency*** the most important attribute in the category, followed by ***environmental impacts***, ***transport impacts***, and ***labour impacts*** which received equal preference (Figure *5*).

Figure 5: Ranking of impact attributes



The last ranking survey concerned the Context category. ***Street accessibility*** was ranked as the most important for this category attribute. ***Parking lots*** availability is considered the second most important, followed by ***micro-hubs*** availability. Not surprisingly, the availability of ***CCAM paths***, and finally ***Drones flight permits*** are ranked as less relevant due to their highly innovative nature.

Figure 6: Ranking of context attributes



With the aim of filling any potential gaps in the identification of attributes, stakeholders were also asked to suggest other attributes they considered important in the context of e-commerce delivery that are not included in the framework. Most of the attributes suggested by stakeholders were specifications of context attributes. The two attributes mostly quoted were “Zero Emission Zones” and “Cycle Path Quality”, that can be considered a specification of the attribute ***street accessibility*** which is already part of the framework.

Session 2 - Interactions between categories

During the session some key interactions among delivery attributes reported in section 6 were presented to participants. Following the presentation, participants were engaged into an open discussion on the most significant relationships between attributes in different categories.

Local context specificities emerged as an important attribute impacting on logistics operations in many ways.

Other considerations regarded the possibility for e-tailers offering customers only sustainable deliveries; the need to consider the mode used by customers to reach pick-up points or lockers, as it highly influences the overall sustainability of these solutions; the need for closer collaboration between e-tailers and logistics operators in consolidating the shipments and increasing vehicles' load factor.