D.T.1.2.1 SULPITER SOFTWARE TOOL DEVELOPMENT FOR UNDERSTANDING FREIGHT BEHAVIOURS AND IMPACTS IN FUAS

HANDBOOK FOR USERS

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1 Scope of the handbook

This handbook or user manual aims to provide guidance on the tool that the SULPiTER project developed to estimate the freight demand generated by the economic activities in the Functional Urban Areas (FUA) identified by the project partners.

The handbook was created to allow each partner to follow a structured and clear method to be applied in different FUAs of Central Europe on which the project SULPiTER is tailored. The tool could also be applied to other geographical areas.

The user manual will take the reader through the steps necessary to gain a clear understanding of the urban freight distribution in each FUA. All the steps are explained in details to be replicated by technical experts and policymakers that wish base their decisions on a robust and solid tool. The handbook also includes a modelling system to feed the evaluation through performance indicators (in this case the Logistics Sustainability Index -LSI), an application example, and references.

The LSI represents the final step of the procedure of the tool proposed by SULPITER, having the aim to assess the performance of smart urban logistics solutions, policies and measures. The tool is then able to portray the complexity of Urban Freight Transport (UFT) systems in terms of divergent stakeholders' interests.

The Annexes complement the handbook with all the survey templates, explanation of the suggested weighting methodologies and of the normalization methodology.

2 Overview of the SULPiTER tool

2.1 Background

SULPiTER designed and developed a tool aimed at estimating the freight demand generated by the economic activities in the Functional Urban Areas (FUA) individuated by the project partners.

SULPiTER tackles urban freight in the perspective of FUAs, taking into consideration the functional transport and economic relations between inner urban centres (the usual and limited territorial target of public regulations) and the surrounding urban territories, as well as the functional transport and economic relations within FUAs not affecting downtowns.

OECD introduced FUAs to overcome limitations for international comparability of densely populated areas linked to administrative boundaries. FUAs are used for highly densely populated municipalities (urban cores) as well as any adjacent municipalities with high degree of economic integration with the urban cores, measured by travel-to-work flows.

2.2 General description of the tool

The SULPiTER tool is to be intended as a decision support system for policy makers to facilitate the process of elaboration of alternative city logistics scenarios.

The tool provides a clear understanding of the urban freight distribution in each FUA and includes a modelling system to feed the evaluation through performance indicators, in this case the Logistics Sustainability Index (LSI).

As depicted in Figure 1, the tool consists of a three steps procedure.

Figure 1 Conceptual process of the SULPiTER tool.

The first step concerns the definition of the FUA and the data collection to characterize the FUA and collect all the information to represent the urban freight distribution system. The characterisation of the FUA is to be done by means of investigation (surveys, traffic counts), and gives a dimension to the demand for urban freight transport services, and to the supply (services, operators, infrastructures …).

The second step involves specific transport models able to assess the freight demand through O/D matrices (origin/destination of freight movements), providing quantities of goods (volumes), number and type of vehicles, and giving the basis for performance analysis of the system. The third step consists of the ex-ante assessment of Urban Freight Transport scenarios and involves the calculation of the Logistics Sustainability Index to provide an aggregate performance index of the overall freight related activities present in the FUA, according to the measurements and elaborations made through the procedure of the tool. The performance measured by the LSI involves seven impact areas; economy and energy, environment, transport and mobility and society; policy and measure maturity, social acceptance and user uptake.

Figure 2 represents a flow diagram of the tool showing the different activities the three steps procedure above involves. In addition, the diagram shows the iterative process that can be put in place to evaluate different scenarios in order to meet the targets (objectives) of the area and of the distribution system.

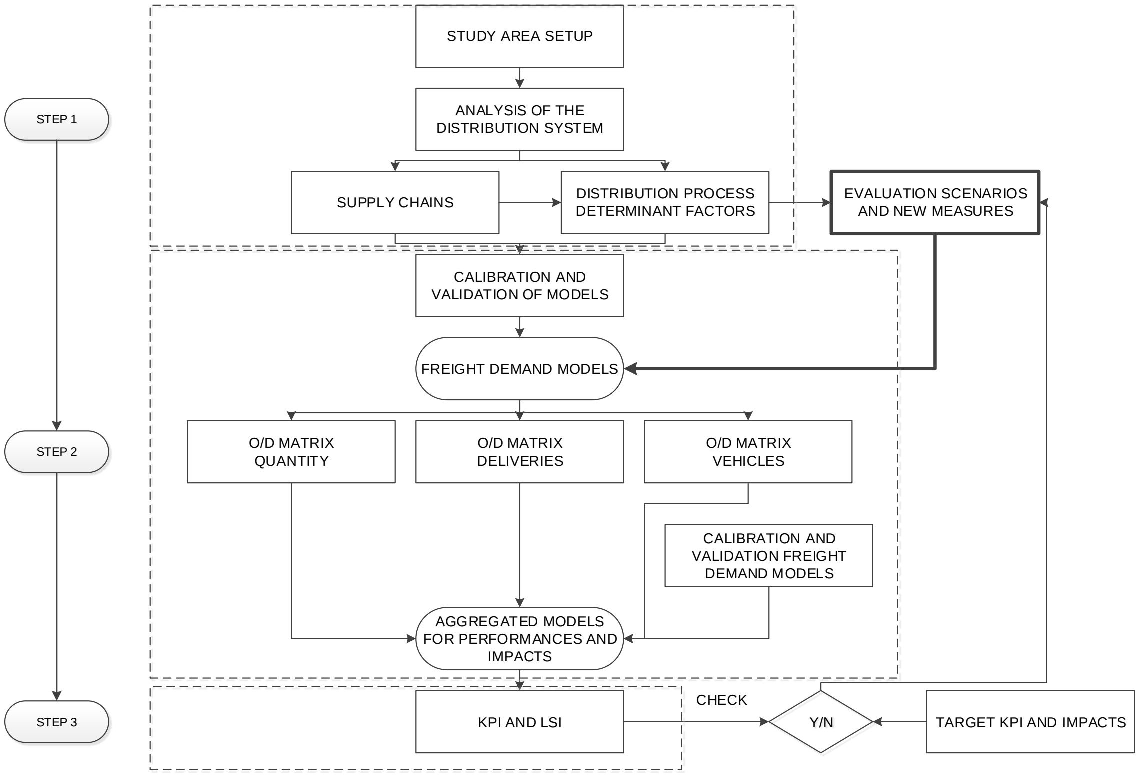

Figure 2 Flow diagram of the procedure of the SULPITER tool.

Sections 3, 4 and 5 will be describing in detail the three steps of the tool.

3 Characterisation of the FUA and data collection

3.1 Overview

The first step of the SULPiTER tool concerns the definition of the FUA and the data collection to characterize the FUA and collect all the information to represent the urban freight distribution system. The characterisation of the FUA is to be done by means of investigation (surveys, traffic counts), and gives a dimension to the demand for urban freight transport services, and to the supply (services, operators, infrastructures …).

3.2 Identification and characterisation of the FUA

The activity requires first to define borders and zones of the Functional Urban Area on which investigation for understanding freight distribution is to be done. The definition should be done according to the specific local context (e.g. city, metropolitan area) taking into consideration all the requirements of the different stakeholders, public and private, for what concerns the mobility of goods. It is, in fact, fundamental to recognize the objectives of the different stakeholders, which may have been included in already existing plans (e.g. SUMP, SULP,…) or should be collected through surveys or other approaches (e.g. Freight Quality Partnerhips). Geographic and administrative borders of the FUA have to be considered at the same time, in order to contemplate the issues related to the actual possibility to collect data and to implement measures.

Once the borders of the FUA have been established, the area is to be divided into homogeneous traffic zones, in order to achieve a coherent representation of the mobility of the area (movements of goods) in terms of freight O/D matrices. These zones will be also used to conduct surveys, as described below. For this reason, it is recommended to conduct the zoning according to the borders of the census areas. Resulting zones will be consequently groups of census areas.

The characterisation of the FUA requires the collection of information on the territorial, social and economic characteristics that influence freight demand, such as: residents, commercial activities (e.g. shops, bar, restaurants,…) and employees, logistics operators (e.g. carriers) retailers and wholesalers, etc. In addition, the main features of the road network have to be collected (capacity, service levels, transit time and costs), along with current regulation, logistics nodes, technology (e.g. cameras, traffic counting systems).

To do this, it is needed to collect data through surveys on:

- Economic activities present in the area and selected according to specific NACE codes from official databases (National Statistical office, Chamber of Commerce). See Figure 3 to have an example of classification of activities pertaining to urban freight distribution.
- Transport and logistics operators, who offer distribution services in the area.
- Counting the vehicular traffic in and out from the area.

Detail
- G WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
- 47 Retail trade, except of motor vehicles and motorcycles
+ 47.1 Retail sale in non-specialised stores
+ 47.2 Retail sale of food, beverages and tobacco in specialised stores
+ 47.3 Retail sale of automotive fuel in specialised stores
+ 47.4 Retail sale of information and communication equipment in specialised stores
+ 47.5 Retail sale of other household equipment in specialised stores
+ 47.6 Retail sale of cultural and recreation goods in specialised stores
+ 47.7 Retail sale of other goods in specialised stores
+ 47.8 Retail sale via stalls and markets
+ 47.9 Retail trade not in stores, stalls or markets

Figure 3 Example of NACE classification.

Because the FUA may include both urban and peripheral areas, it is fundamental to conduct different surveys, since the nature of freight traffic flows is different. In the case of peripheral areas, due to the presence of factories or warehouse for primary distribution, freight traffic flows are typically to move products outside the area (not for last-mile distribution), or to move intermediate goods among factories. The type of vehicles adopted (large trucks) and the unitisation of the cargo (pallet based), and probably the adoption of FTL transport practices, suggest to investigate this type of traffic flow separately from what concerns the last-mile distribution of finished goods to urban areas, typically for stock replenishment to shops, deliveries to retailers' shop, e-commerce deliveries. In this case, vehicles are smaller, unitisation is less-than-pallet based and groupage is the predominant practice for delivery, along with the important growing presence of express couriers.

In the following sections, therefore, we introduce guidance on how to conduct a survey on distribution flows (last-mile urban deliveries), a survey on industrial flows, a survey on transport operators, and traffic counts.

3.3 Survey on distribution flows

3.3.1 Introduction

In order to investigate distribution flows, it is fundamental to adopt a supply chain approach. Supply chains are defined on the basis of the «operating formal procedure for the service and management of goods». This procedure changes depending not only on the type of goods, but also on the structure of their distribution, which includes the distribution channel (retail chain and brands sector, independent retail sector) and the physical distribution. This perspective seems to be the most appropriate in order to obtain a state-of-the-art of the mechanisms behind the distribution flows.

The survey involves different steps. The first consists in a census of activities representing the sources of demand for urban freight transport in a specific urban area, and in their categorisation. Since retail is a complex system, composed of differently organized sectors, which have to be differently treated to be understood, observed retail activities have to be split in independent retail activities and outlets belonging to retail chains or brands.

Regarding the former type of activities, the method considers the following steps:

- sampling;
- web-based establishment and commodity flow survey;
- database collection;
- analysis and statistical inference process.

Since retail chains and brands control their distribution processes, the procedure requires to define a sample of firms having some outlets in the study area, and to capture data about their distribution organisational structure and their deliveries.

3.3.2 Basic data to be collected

In order to identify the operating supply chains in a specific urban area, the first step consists of a census of the so-called “freight demand generators” located in the area. This operation can be limited to retail activities or it can be extended to every activity which usually orders/receives/ships goods.

Retail services encompass a wide variety of forms, formats (from small shops to hypermarkets), products, legal structures (independent stores, franchises, integrated groups, etc.). While the major retail groups are important players for distributing goods to their stores in urban areas, small independent retailers often do not control deliveries, with wholesalers or suppliers being responsible for the transport of goods (using their own account or third party carriers). In addition, small retailers do not pay for the transport directly and have no contact with the carrier except for the proof of delivery.

Because of that, the supplying process and the «operating formal procedure for the service and management of goods» used by retail groups are different from those used in the independent retail sector. Therefore, retail chain stores and independent retail outlets have to be separately recorded during the census.

3.3.3 Survey technique used in the independent retail sector

In order to identify and characterize the operating supply chains of the independent retail sector, the method involves an establishment and commodity flow survey conducted on a statistically significant sample size of shopkeepers located in a specific urban area. Participants have to be asked of a series of questions about the supplying process of each type/class of goods they merchandise.

In this case, every supplying process represents an “observation unit”, that is the entity on which information is received and statistics are compiled when collecting statistical data. Every participant, instead, represents a “reporting unit”, that is the means to obtain information about the observation units.

For each type of goods supplied, the following topics have to be collected:

1. type of suppliers (manufacturers, wholesalers, etc.)
2. type of agreement for delivery/collection from supplier
3. who organizes delivery/collection of goods
4. who resolves delivery/collection problems
5. type of delivery/collection operator (own account, logistics company, carrier, express courier, etc.)

6. vehicle types/sizes
7. no. of deliveries/collections
8. size/type of delivery/collection
9. type of delivery packaging used
10. quantity of goods delivered/collected
11. frequency of delivery/collection of goods
12. time of day
13. variation by day of week
14. variation during year
15. who sets delivery/collection time
16. time taken to carry out deliveries
17. whether staff from establishment need to be present
18. whether signature is required
19. whether goods have to be checked by receiver

In addition, participants have to be asked also to provide a series of information about their establishments located in the specific urban area. Specifically:

20. type of establishment
21. size of establishment
22. employees at establishment
23. size of warehousing space at establishment
24. other warehousing space out of establishment
25. no. of deliveries/collections (considering all types of goods as a whole)
26. delivery/collection frequency (considering all types of goods as a whole)
27. size/type of delivery/collection (considering all types of goods as a whole)
28. time of day
29. variation by day of week
30. variation during year
31. whether vehicles based at establishment
32. vehicle types/sizes
33. deliveries/home deliveries made by vehicles at the establishment

Data collected on topics from 20 to 33 improve the knowledge of the urban economic composition. In this additional survey, observation units and reporting units coincide. The survey does not address the activities performed on the retailer side during the delivery of goods.

3.3.4 Survey techniques used in the retail chains and brands sector

Since retail chains and brands control their distribution processes, the procedure involves their Head Offices directly, to capture data about deliveries to their stores located in the study area. It consists of a survey used to gather data about:

- Distribution organisational structure
- Type of delivery operator (own account, logistics company, carrier, express courier, etc.)
- Goods flows to establishments in the urban area
- Trip details and patterns of goods vehicles in the urban area
- Loading/unloading activities of goods vehicles in the urban area
- Movement of goods between vehicles and establishments in the urban area.

3.3.5 Methods for data analysis and data elaboration

Data collected as described above allow drawing conclusions about population by means of a statistical inference process. It is necessary to remark that, regarding the independent retail sector, the main scope of the establishment and commodity flow survey is to know supply characteristics and procedures for each type/class of goods delivered in the specific urban area.

As described above, in this survey "observation units" and "reporting units" are not coincident. Observation units are those entities on which information is received and statistics are compiled, while a reporting unit is a unit that supplies the data for a given survey instance. In our case shopkeepers are "reporting units", while data to be collected (e.g. deliveries, type of suppliers, etc.) are "observation units". This happens because a statistically significant sample of shopkeepers can be determined, given that the population of shops located in the study area can be easily known. Instead, the universe of supplying processes related to each kind of goods is a priori unknowable.

Consequently, this methodology could provide not statistically significant quantitative results about supply chains characteristics. In this case, only a qualitative characterisation can be provided. If quantitative results were required to assess city logistics measures, the realised establishment and commodity flow survey would represent a pilot survey and the main survey would be carried out afterwards only on selected supplying processes. In any case, even if this limitation is present, the proposed method provides more in depth information on the mechanisms governing the demand for urban freight transport, on the needs of retailers and commercial entities if compared with the simplifications introduced by urban freight models.

3.3.6 Structure of the questionnaire

The survey can be conducted by means of a structured questionnaire to collect several information useful to understand freight movements, distribution processes, commercial processes and understand also criticalities, within each of the considered supply chains.

The questionnaire results to be complex due to the need to collect detailed information on each of the category of goods the respondent operates, in terms of type of shipper, delivery conditions, logistics governance, characteristics of shipments, type of carriers and vehicles adopted, and so on.

Figure 4 illustrates the four main categories into which different questions have been divided.

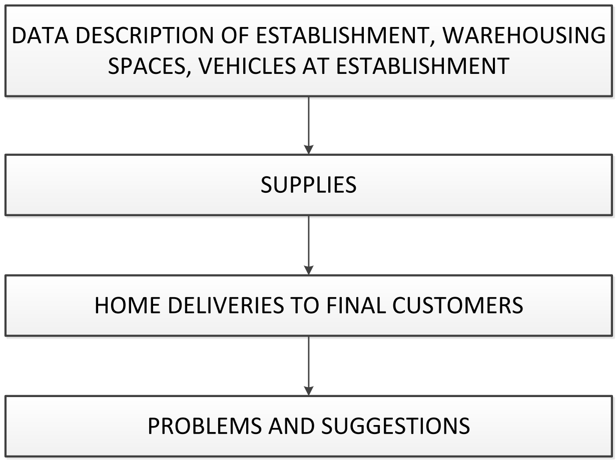

Figure 4 Logical process of the questionnaire of the survey on distribution flows.

With regards to Figure 4, it is to be noted that:

- The first argument (Data description of establishment…) includes all the features of the local establishment and of the other establishments the shop-owners may have in the surroundings on in other area, and of the vehicles used for deliveries.
- “Supplies” concern the most complex section of the questionnaire, since goods can be supplied in different modalities to the same shop, and the same supplying process may happen in different phases.
- The third argument regards deliveries to final customers (at home) from the shops in the area.
- “Problems and suggestions” is oriented to acquire free answers.

In order to understand all the relationships within the supply chain, the questionnaire could not be a linear sequence of questions, but it resulted to be a highly structured interview including differentiated patterns and possibilities on the basis of the respondent and the possible alternative answers. Figure 5 illustrates in detail the structure of the questionnaire related to the “Supplies” part of the process described above.

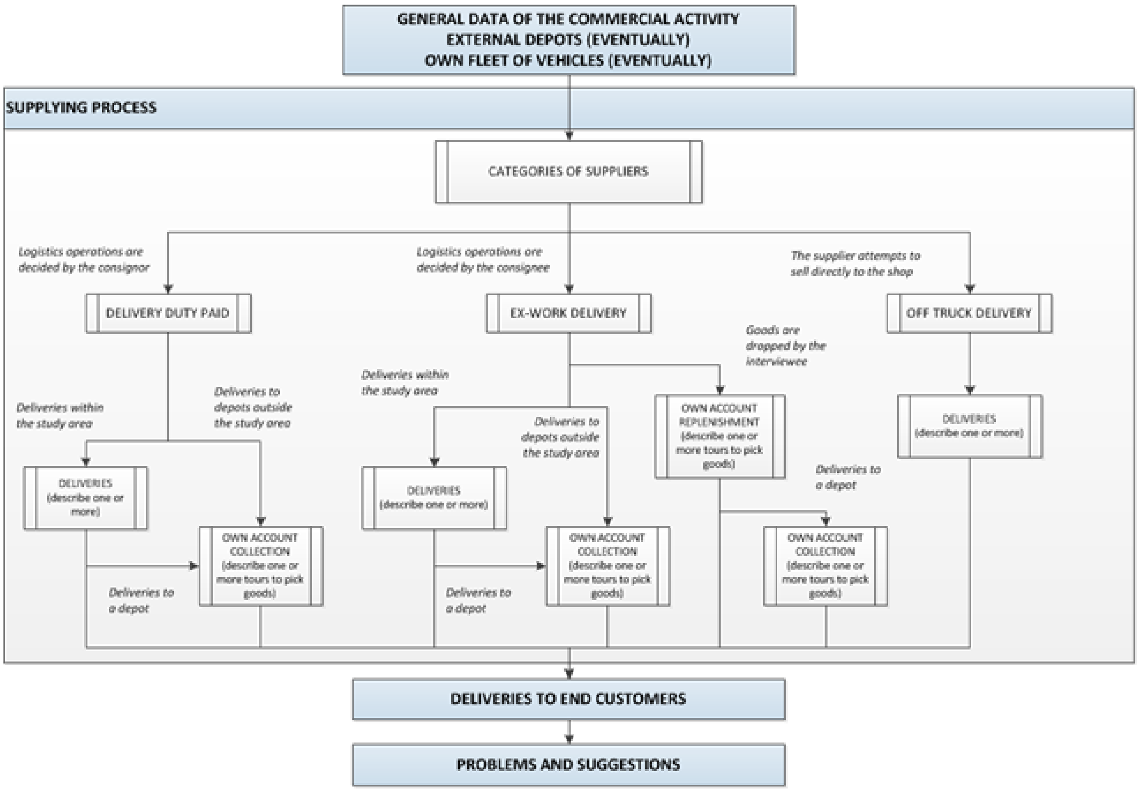

Figure 5 Detail of the "Supplies" process of the questionnaire.

The questionnaire needs to be implemented through a software application due to the different conditions it involves. In Annex A the list of questions and related conditions are reported.

3.4 Survey on industrial flows

Industrial flows are those for supplying factories and manufacturing activities, and also flows between transport and logistics nodes within the primary legs of the supply chain. They may appear in the FUA and should be revealed through a survey to be conducted by means of a dedicated questionnaire.

The survey should collect inbound or outbound quantities of goods for each economic activity, classified according to NACE categories. A selection of activities and a sampling for statistically significant survey have to be done.

Elements of the freight movements to be collected are, by example:

- Destination/Origin (inside or outside the study area)
- Type of flows: directed to destination or to other industrial activities
- Type of load unit
- Transport mode
- Level of Service attributes (travel time and costs)
- Average shipment quantity
- Type of vehicle used according to type of destination (e.g. center)

Figure 6 presents the overall structure of the questionnaire to be used to conduct the survey on industrial flows. An example of the questionnaire can be found in Annex B.

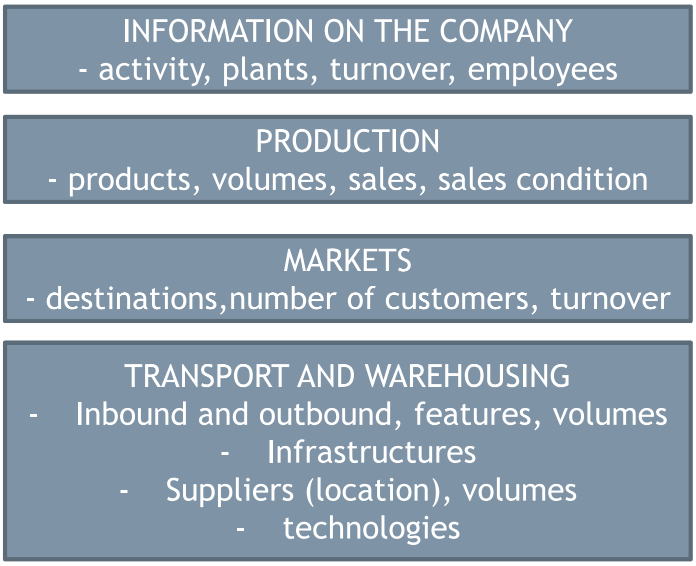

Figure 6 Structure of the questionnaire for the survey on industrial flows.

3.5 Survey on transport operators

This type of survey allows analysts to build a comprehensive database to help decision-makers in the field of city logistics in the inner area, quantifying the consistence of urban mobility from or to the study area and supporting the development of modelling framework able to support ex-ante assessment of future scenarios. Further, they permit to identify the homogeneous goods types on the basis of current classifications used by international, national or local institutes of statistics. Then, according to specific study objectives, it is possible to have further classifications obtained aggregating classes from other classifications (e.g. for foodstuffs: fresh foodstuffs, frozen foodstuffs, etc.).

The survey consists of interviews with transport operators (e.g. truck drivers) to investigate their freight distribution trips; the drivers to be interviewed could be randomly stopped at border sections or randomly selected from the list of permits issued by the local administration.

The interviews permit to define supply of freight transport, the used facilities and the quantities moved. They should be integrated, as described in the next section, with traffic counts both for private and commercial vehicles. The data to collect mainly consists of:

- personal data; e.g. status and localization of interviewee’s firm;
- characteristics of transport modality; e.g. technical characteristics of vehicle used (e.g. brand, types, fuel, weight, environmental standards);
- characteristics of transport; e.g. scope of trips (e.g. loading, unloading), vehicle owner, on behalf of who is carried out and with what frequency;
- info on trip; e.g. origin, type of sender and receiver (producer, warehouse, depot, etc), destinations of trip chains (sequence of stops within the study area), time spent for delivery tours and at each stop (destination);

- type of parking; e.g. type, use of delivery on-street bays, problems in using delivery bays;
- suggestions for improving goods transport in the study area.

3.6 Traffic counts

Manual or automatic traffic counts in the relevant roads, which allow access to the study area and in some relevant sections within the study area, provide to investigate the vehicle flows that interest the study area. Figure 7 reports an example of count sections implemented in the inner area of Rome, while Figure 8 gives an example of form for collecting traffic counts. The revealed vehicles should be classified, for example:

Motorcycle and moped;

Cars;

Buses;

Commercial vehicles for delivering (which could be disaggregated also according to service type: courier or carrier),

gross laden weight less than 1.5 tons,

gross laden weight between 1.5 and 3.5 tons,

gross laden weight between 3.5 and 8.5 tons,

other type of vehicles;

heavy vehicles used for urban waste.

This survey could be integrated with further activities finalised to the evaluation of crossing or exchange mobility through the analysis of a sample of vehicles along the border of study area (screen line).

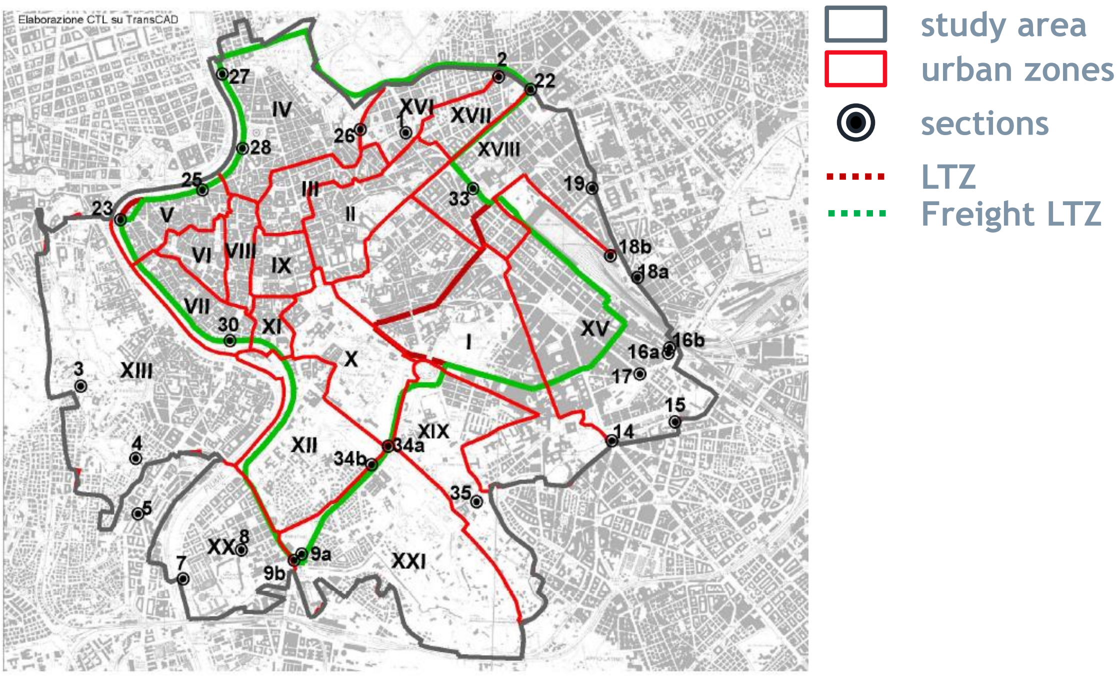

Figure 7 Example of sections for traffic counts.

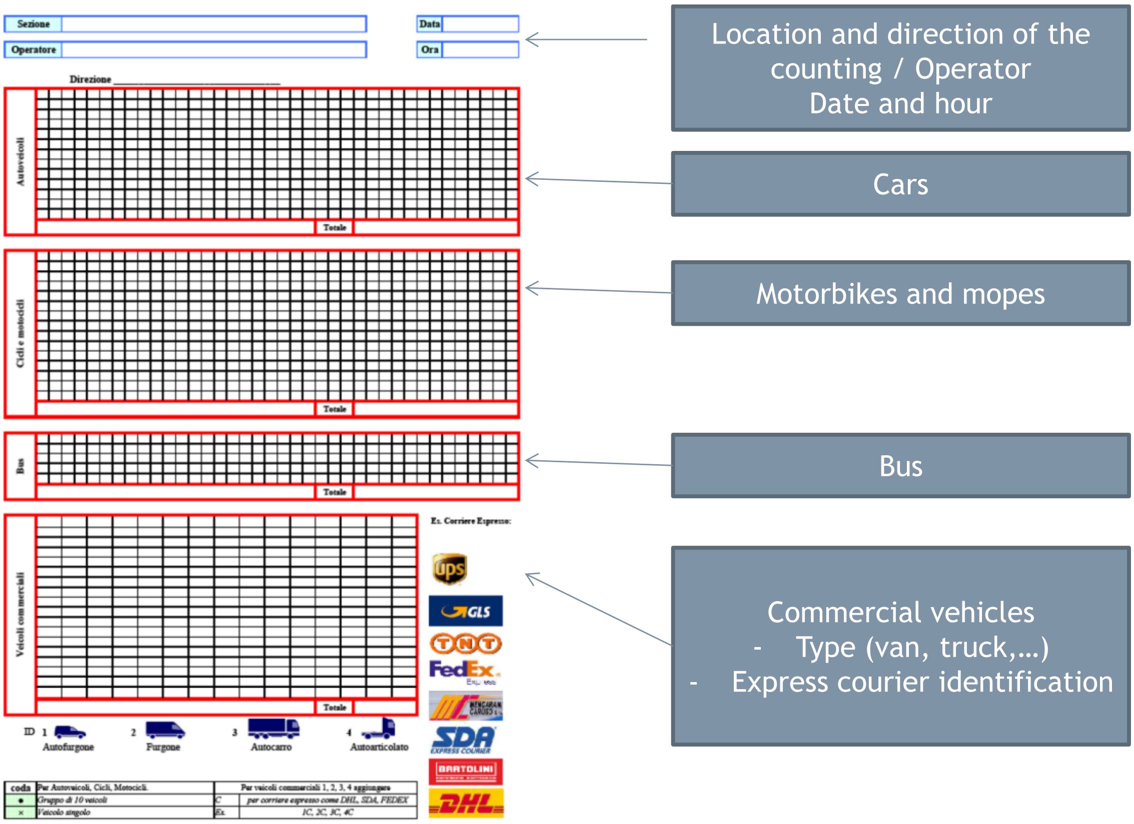

Figure 8 Example of form to record traffic counts.

4 Freight demand and supply modelling

4.1 Overview

The section presents a modelling approach that tries to point out the relations existing among city logistics measures, actors and choice dimensions. It comprises three model sub-systems to estimate the quantity O-D matrices by transport service type (e.g. retailer on own account or wholesaler on own account or by carrier), the delivery O-D matrices, and the vehicle O-D matrices according to delivery tour departure time and vehicle type.

The presented modelling system is hence a multi-stage model and considers a discrete choice approach for each decisional level. Models are specified within the quantity/delivery/vehicle mixed modelling approach. Quantity is used since it enables the mechanisms underlying freight transport demand to be well captured. Delivery allows us to improve the definition of delivery tours, while vehicle is required by assignment model for the estimation of road link performances.

This modelling system allowed us to take into account the influence of: the economic characteristics of a traffic zone on attracted freight traffic, the localization of freight centres (e.g. distribution centres, warehouses) on freight traffic generated for each zone, the characteristics of shops with related depots and the shipment size on the choice of service type (retailer on own account, wholesaler on own account, carrier) and vehicle type. This system of models could be also easily extended to consider the pattern of delivery tours according to freight type, origin and destination zone accessibility, vehicle type, shipment size and capacity of the zone attraction.

In order to simplify the understanding model, in addition to this text, has been draw up “Freight Origin-Destination Forecast Handbook” – Guidelines and example of application for distribution flows”, which indicates the detailed methodology of the process.

4.2 The freight demand

The demand for freight transportation is closely connected to the production and distribution of goods, that is, to the study area’s economic system and its interactions with the external economic system.

A system of freight demand models can be formally expressed as:

$$d_{od}\left[K_1, K_2, \ldots\right] = d\left(\mathbf{SE}, \mathbf{T}, \mathbf{\beta}\right) \quad (1)$$

The relevant characteristics, K_1, K_2, …, are normally associated with *commodity type* (raw materials, semi-finished products, finished products, ...), with *sectors of economic activity*, with characteristics of firms (e.g., firm size, logistics organization), *transportation characteristics* (e.g., shipping frequency, size, and value) as well as with *transportation mode*. The ***SE*** variables reflect the economics of production (value of production by sector, number, and size of production units, ...) and consumption (household consumption, imports, ...). The transportation system variables ***T*** are related to the attributes of the different transportation modes and services (times, costs, service reliability, ...). Vector $\boldsymbol{\beta}$ denotes the model parameters.

These considerations suggest that the mechanisms underlying the formation of freight transportation demand and its fulfilment by transportation services are considerably complex and interrelated. There is no single decision-maker for freight, but rather a complex and connected set of decision-makers responsible for production, logistics (storage and shipping), distribution, and marketing. Decision makers (that influences the level and composition of freight transportation demand) can be, by example, transport and logistics operators (retailers, wholesalers and carriers).

Freight models can be *disaggregate* or *aggregate* depending on whether their variables refer to disaggregate units such as individual companies or individual shipments, or to aggregate units such as all the companies of a given category. Furthermore, freight demand models can be behavioural or descriptive depending on whether they are based on explicit assumptions regarding the behaviour of market agents, or on empirical relationships between freight transportation demand and causal variables corresponding to the economic and/or transportation system.

The freight flows result from the aggregation of single trips (shipments or consignments) made in the study area during the reference period. The spatial characterization of trips is made by grouping them by place (zone or centroid) of origin and destination, and demand flows can be arranged in tables, called origin–destination matrices (O-D matrices), whose rows and columns correspond to the different origin and destination zones, respectively (Figure 9). Matrix entry d_{od} gives the number of trips made in the reference period from origin zone *o* to destination zone *d* (the O-D flow).

Trips can be characterized by whether their endpoints are located within or outside of the study area. For internal (*I-I*) trips, the origin and the destination are both within the study area. For exchange (*I-E* or *E-I*) trips, the origin is within the study area and the destination outside, or vice versa. Finally, crossing (*E-E*) trips have both their origin and their destination external to the study area, but cross the study area, that is, use the transportation system under study (Figure 9).

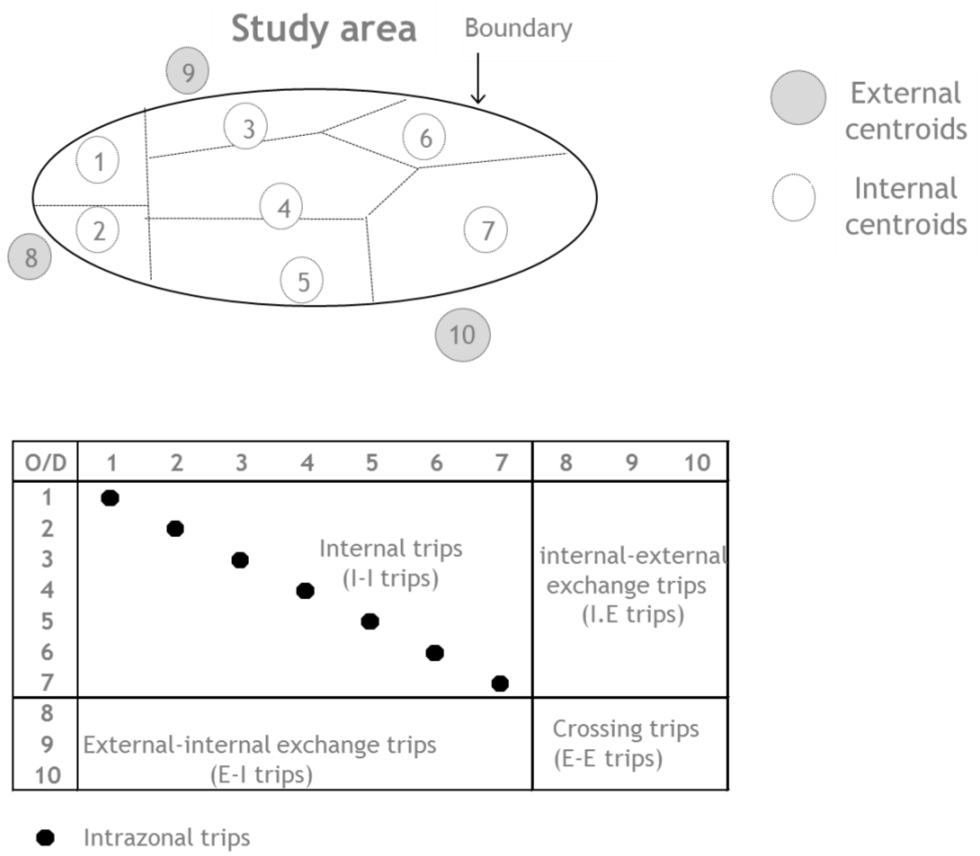

Figure 9 Example of study area and origin/destination matrix.

4.3 Evaluation of the freight demand

Given a study area, the estimation of freight demand depends on its characteristics. In principle, a study area can be interested by industrial or distribution flows. As depicted in Figure 10 the industrial freight flows are those allowing firms to be supplied or to move freight among distribution centres within their supply chain. The distribution freight flows are devoted to restock retail activities. According to this classification, in what follows it is first introduced the method to evaluate origin-destination flows for distribution, and then the method to evaluate industrial flows.

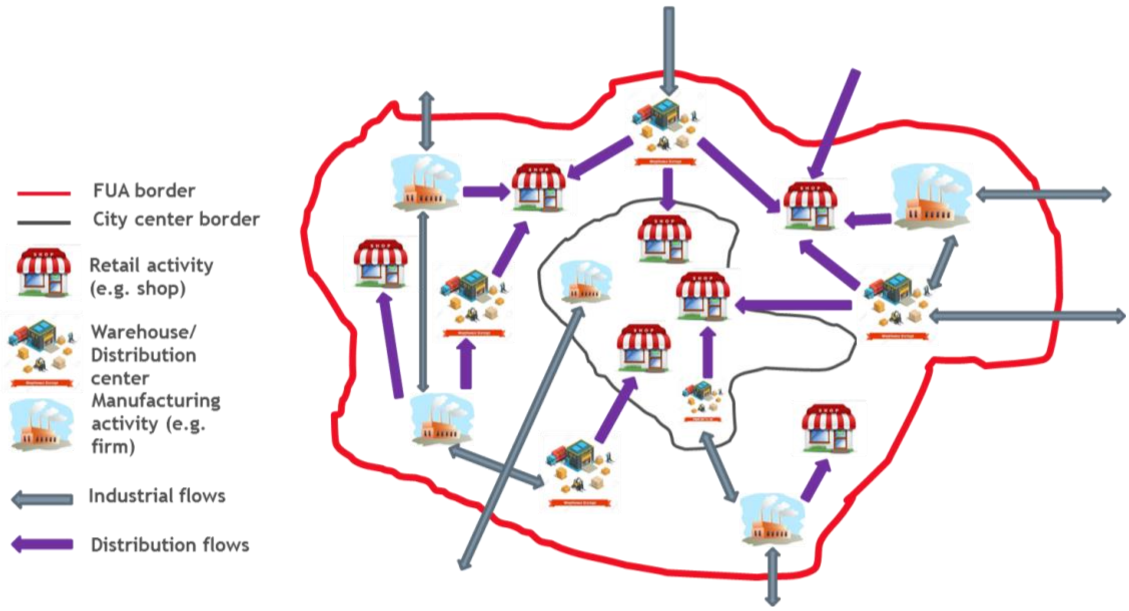

Figure 10 Schematization of industrial and distribution freight flows.

4.3.1 Distribution flows

In urban and metropolitan areas freight transport is mainly related to the distribution of final products from producers, wholesalers and distribution centres to the businesses in the area (e.g. shops, food-and-drink outlets, offices). For example, in Rome it represents more than 80% of total daily freight movements.

In general, the concept of urban distribution can be depicted through the functional scheme of Figure 11.

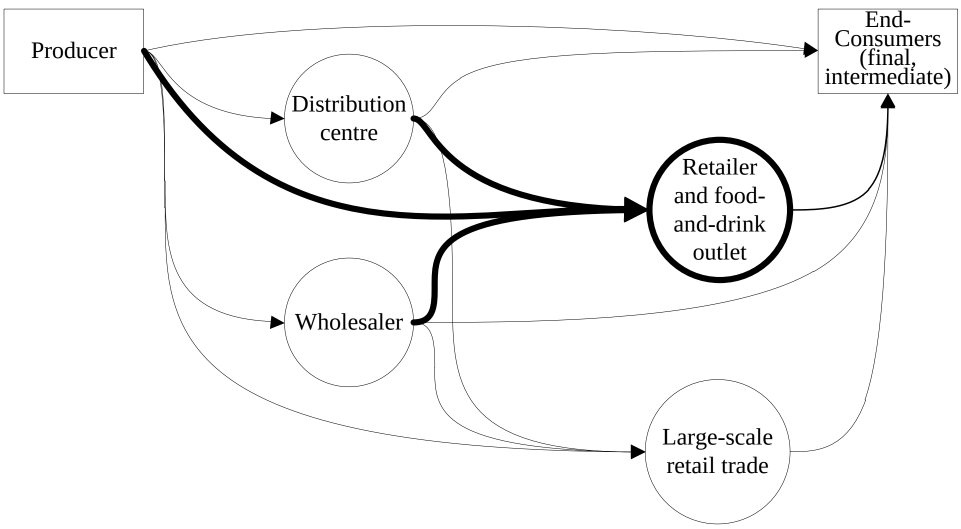

Figure 11 Distribution process (distributive logistics).

The modelling approach for distribution flows comprises three model sub-systems to estimate (see Figure 12):

- the quantity O-D matrices for freight types (e.g. foodstuffs, clothing, home accessories),
- the delivery O-D matrices by transport service type (e.g. retailer on own account or wholesaler on own account or by carrier),
- the vehicle O-D matrices according to delivery time period and vehicle type.

This modelling system is a multi-stage model and considers a discrete choice approach for each decisional level.

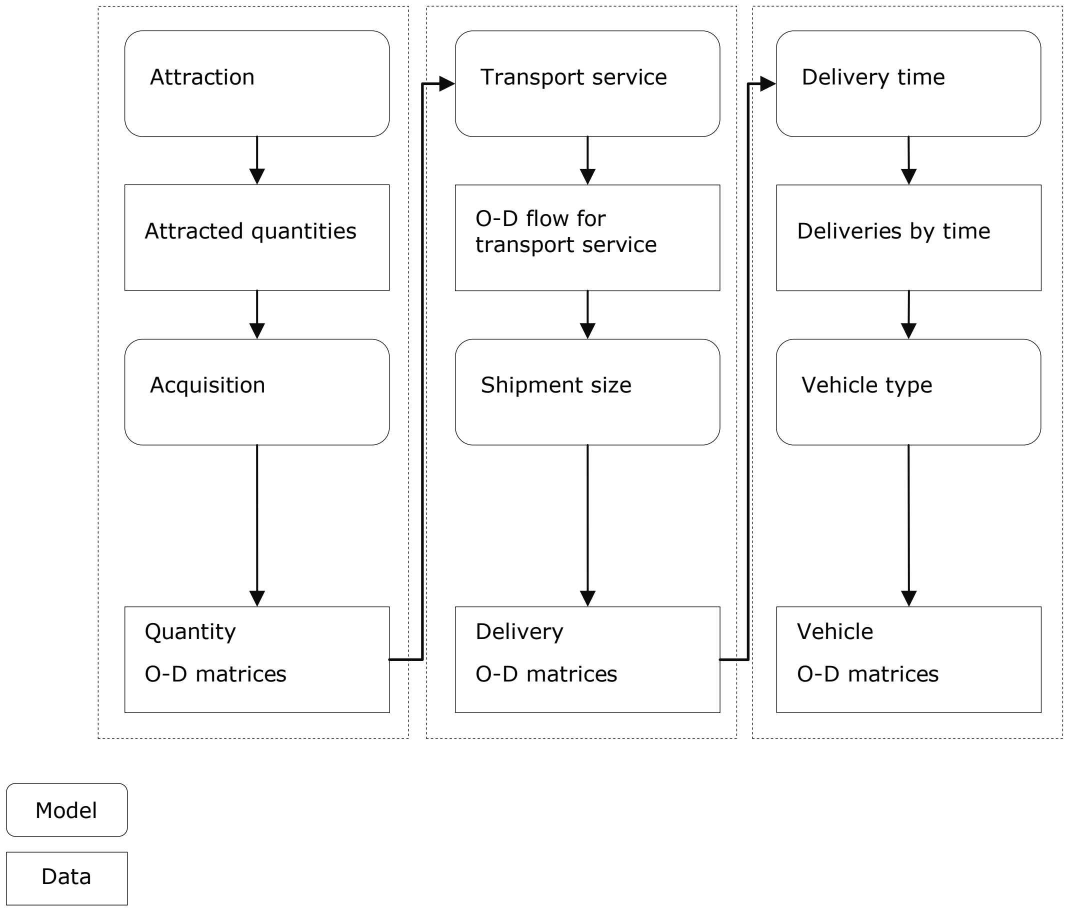

Figure 12 Modelling framework for distribution O-D flows.

In the next sections, the three sub-models are introduced. For each model, it is also provided an example of calibration based on data collected in Rome. The study area is the inner area of Rome, it is a mixed land-use area (CBD, residential, commercial, tourist) which is mainly affected by attraction freight flows, while the origins of freight flows take place mainly in the peripheral areas of Municipality. The analysis highlighted freight movements in the study area amounting to about 15,000 tons per day and more than 66% is destined to shops or food-and-drink outlets. In terms of freight segmentation, 36% consists of foodstuffs (about 16% is dispatched to restaurants and cafe, and 20% to retailers), 61% consists of other end-consumer products (e.g. household and health products), and the remaining 3% are goods related to services. To analyse the system, the area of the municipality of Rome was divided into 99 traffic zones with a level of detail which increases as the inner area was approached. The inner area, the portion of territory where the freight flows are destined, consisted of 7 traffic zones.

For further information, refer to Nuzzolo and Comi (2015), Nuzzolo et al. (2016).

4.3.1.1 Origin-destination matrices in quantity

The quantity model sub-system allows estimating the quantity O-D matrices characterized by freight type *s* (or in general by the identified supply chain as revealed by survey).

Let Q_{od}^{sh} be the average *quantity* flow of freight type *s* attracted between zone *o* and come from zone *d* in a time period *h* (e.g. day). For simplicity of notation, the class index *s* (freight type) and *h* (time period) will be taken as understood unless otherwise stated. Thus, the average quantity flow, Q_{od}, can be estimated as follows:

$$Q_{od} = Q_{.d} \cdot p\left[o/d\right] \quad (2)$$

where

- Q_{od} is the average quantity flow of freight attracted by zone *d* and coming from zone *o*;
- $Q_{.d}$ is the average freight quantity attracted by zone *d* obtained by an *attraction model*;
- $p\left[o/d\right]$ is the probability that freight attracted by zone *d* comes from zone *o* (e.g. warehouse location zone); it represents the acquisition share obtained, for example, by a discrete choice *acquisition model*.

As an example, referring to the model developed for Rome and for two freight types (or supply chains; foodstuffs and household products), the attraction models which allows us to obtain the average flow of freight that arrives in each zone of the study area (seven for the case of Rome) in order to satisfy end-consumer demand. In general, each end consumer can purchase the goods required in different shops or, in the case of some freight types, he/she can buy or consume them in commercial concerns such as cafés and restaurants. The attraction model is a regressive model in which the average daily quantity of freight attracted by zone *d*, $Q_{.d}$, is estimated as follows:

$$Q_{.d} = ßAD \cdot AD_d + ßASA \cdot ASA_d \text{ [t/day]} \quad (3)$$

Where:

- AD_d is the total number of retail employees in zone *d*;
- ASA_d is a dummy variable equal to *1* if the proportion of retail employees to inhabitants in the zone *d* is higher than *35*%;
- Q.d is the average freight quantity attracted by zone d obtained by an attraction model;
- ßAD and ßASA are model parameters that depend on characteristics data of every FUA.

The reported models were calibrated employing the Generalised Least Squares (GLS) method as explained in the following sections.

In order to simulate the origin of freight for each attraction zone within the study area, the *acquisition model* was set up. It, as said, simulates the choice of an origin among possible alternatives to get the freight to be sold. Random utility models in a gravitational form were specified and calibrated. The share of freight attracted by zone *d* coming from zone *o* (e.g. places where production places/firms, distribution centres, warehouses are located) is obtained as follows:

$$p\left[\frac{o}{d}\right] = \frac{(AI_o)^{\beta 1} \cdot C_{od}^{\beta 2}}{\sum_{o'} (AI_{o'})^{\beta 1} \cdot C_{o'd}^{\beta 2}} \quad (4)$$

where

- $p[o/d]$ is the probability that the freight attracted by zone d comes from zone o;
- AI_o is the number of warehouse employees of zone o;
- C_{od} is the travel distance between o and d;
- $\beta 1$ and $\beta 2$ are model parameters.

On the basis of traffic counts and truck-driver interviews, the quantity O-D flows ($\hat{Q}_{od}$) were obtained and the calibration was performed using the GLS method as explained in the following sections.

4.3.1.2 Origin-destination matrices in delivery

The delivery model sub-system allows us to estimate the delivery O-D matrices characterized by transport service of type *r*.

The possible transport service types are (Figure 13):

- retailer on own account;
- retailer by third party (i.e. transport company or courier that offers small size shipment);
- wholesaler on own account;
- wholesaler by third party.

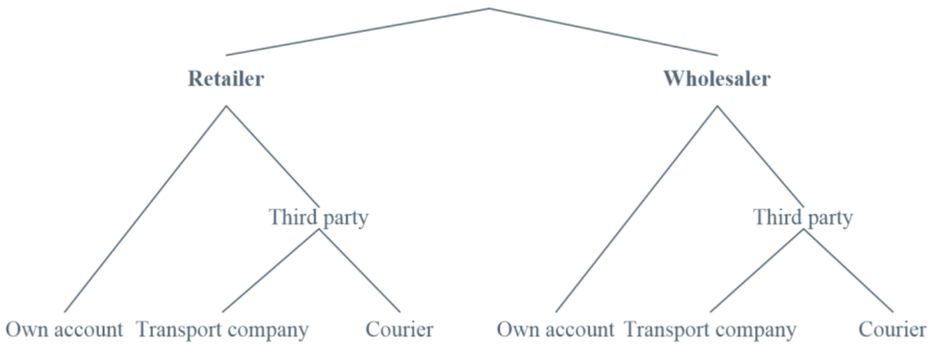

Figure 13. Transport service type: structure of choice dimensions.

The average delivery O-D flow carried out by transport service type r on pair od, $ND_{od}[r]$, can be determined as follows:

$$ND_{od}[r] = \frac{Q_{od}[r]}{q[r]} = \frac{Q_{od} \cdot p[r/od]}{q[r]} \quad (5)$$

where

- $ND_{od}[r]$ is the number of deliveries performed by transport service type r on pair od;
- $q[r]$ is the average freight quantity delivered with transport service type r (average *shipment size*);

- $p[r/od]$ is the probability to use the service r to move the freight from origin o to destination d.

The average delivered quantity (shipment size) but also the transport service type used, are obtained from survey data.

4.3.1.3 Origin-destination matrices in vehicle

Movements of deliveries can happen by using different types of vehicles (e.g., Light Goods Vehicles, Heavy Goods Vehicles).

The number of vehicles of type v moving freight on the od pair in time period τ (e.g. peak hour in the morning, off-peak hour) with service transport type r, can be expressed as:

$$VC_{od}\left[\tau rv\right] = \frac{ND_{od}\left[\tau rv\right]}{nd_d\left[\tau rv\right]} = \frac{ND_{od}\left[r\right] \cdot p\left[\tau / od\right] \cdot p\left[v / \tau od\right]}{nd_d\left[\tau rv\right]} \qquad (6)$$

where

- $ND_{od}\,[\tau rv]$ is delivery flow on the od pair for service transport type r and vehicle type v in delivery time period τ evaluable as:

$$ND_{od}\left[\tau rv\right] \cdot = ND_{od}\left[r\right] \cdot p\left[\tau / od\right] \cdot p\left[v / \tau od\right] \qquad (7)$$

  with
  - $ND_{od}[r]$ the average number of deliveries performed by service transport type r departing from origin zone o;
  - $p[\tau/od]$ the probability that the deliveries from o to d are performed in time interval τ;
  - $p[v/\tau od]$ the probability that deliveries from o to d in time interval τ are performed by vehicle type v;
- $nd_d[\tau rv]$ is the number of stops (deliveries) per trip undertaken service transport type r using vehicle type v in delivery time period τ.

Referring to data collected in Rome, below the revealed shares and some developed models are reported. In many city centres around the world, as confirmed by our test cases and by the literature (Quak and de Koster, 2008; Sathaye et al., 2010), time is constrained by governance regulations: the public authorities define one or two time-windows (e.g. one in the morning between 8:00 and 10:00 am and one in the afternoon). For this reason, our delivery time period model is usually statistic-descriptive (Table 1). In Rome for many freight types, the retailers prefer to be restocked in the morning before opening time (about 60% of interviewees). In fact, purchases of some non-durable goods mainly occur in the morning, whereas durable goods are generally purchased in the afternoon. Thus, retailers prefer to receive freight in the morning in order to reduce interference with customers. Focusing on the departure time from the warehouse, in Rome 74.4% of tours depart from warehouses in the early morning (7 am – 10 am). A small share was found in the afternoon with the peak-hour in the early afternoon. Afternoon delivery is mainly related to just-in-time movements that allow shops to be restocked with small quantities (i.e. only those required in the short term) before the customer arrives.

Table 1 Time distribution: revealed shares.

	before 9am	9am-11am	11am - 1pm	1pm-4pm	after 4pm
Foodstuffs	30%	40%	24%	6%	0%
Home Accessories	30%	37%	17%	13%	3%
Stationery	34%	50%	9%	7%	1%
Clothing	23%	51%	15%	11%	1%
Building Materials	38%	42%	10%	4%	5%
Household and personal hygiene	47%	32%	19%	2%	0%
Other	27%	31%	21%	20%	0%
Total (average)	**34%**	**40%**	**16%**	**9%**	**1%**

The delivery O-D matrices can be hence characterised by vehicle type using a *vehicle type model*. A statistic-descriptive model has been set up from truck driver interviews. It allows us to obtain the vehicle type share independently form transport service type *r*, as reported in Table 2.

Table 2 Vehicle types: revealed shares.

	Light Goods Vehicle [less than 1.5 tons]	Medium Goods Vehicle [1.5 to 3.5 tons]
Foodstuffs	70%	30%
Home Accessories	51%	49%
Stationery	62%	38%
Clothing	65%	35%
Building Materials	35%	65%
Household and personal hygiene	95%	5%
Other	51%	49%
Total (average)	**61%**	**39%**

Table 3 reports the average number of deliveries according to the survey data.

Table 3 Number of deliveries per trips.

Foodstuffs	2,6
Home Accessories	2,2
Stationery	2,0
Clothing	2,0
Building Materials	1,8
Household and personal hygiene	2,2
Other	2,6
Total (average)	**2,1**

4.3.2 Industrial flows

This section presents a system of models for the estimation of industrial freight flows through a partial share approach. It allows us to simulate attraction, production, distribution and modal split for the estimation of origin-destination matrices in quantities and in vehicles.

The proposed modelling system is based on the partial share approaches aiming at characterising freight flows as:

- origin *o* and destination *d*;
- activity type *g* (e.g. producers, warehouses);
- freight type *s* (e.g. foodstuffs, clothing);
- vehicle type *v* (e.g. light, medium or heavy goods vehicle).

The proposed system of models allows to simulate the average flow of goods (*Q*) and vehicles (*VC*) by road using production (for outcoming flows), attraction (for inbound flows), distribution, type of activity and vehicle loading models. These models allow us to carry out freight flows both in quantities and vehicles by considering:

- a commodity level, in which the freight O/D matrices in quantity are estimated from socio-economic data or other census data (Figure 14);
- a vehicle level, in which quantity flows are converted in order to obtain O/D matrices in vehicles (e.g. trucks or lorries; Figure 15).

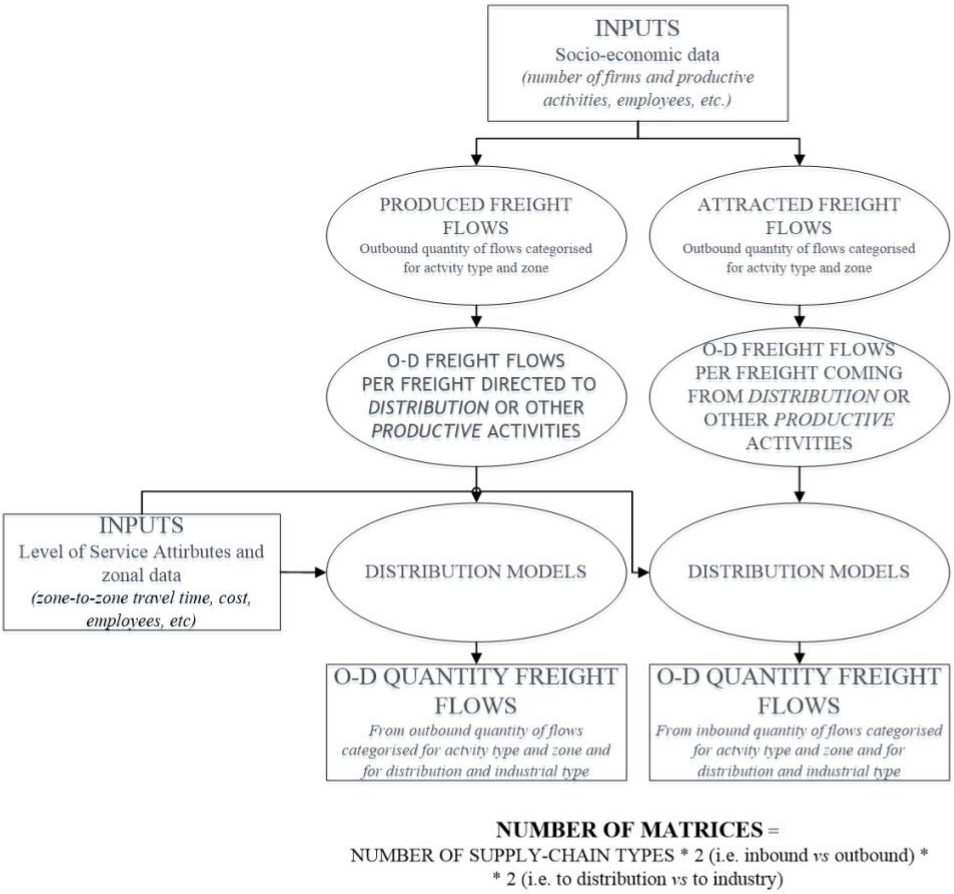

Figure 14 The system of models for industrial quantity flow estimation.

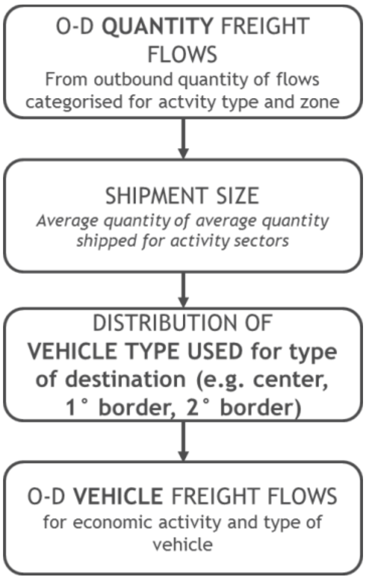

Figure 15 The system of models for industrial vehicle flow estimation.

4.3.2.1 Origin-destination matrices in quantity

Attraction and production

Attraction and production models are specified within the commodity level; they allow us to estimate the freight attracted (incoming) and produced/generated (outcoming) by each traffic zone from (incoming) and to (outcoming) each other.

For what concerns the attraction model, the average flow of freight quantity of type *s* attracted by zone *d* in time period *h* (e.g. year or week or day; which, for simplicity, will be omitted in the following), $Q_{.d}^{sh,in}$, can be estimated by a descriptive model belonging to the category regression class, for which $Q_{.d}^{s,in}$ can be expressed as a function, typically linear, of variables X_{id}^{s} representative of freight type *s* and destination zone *d*, as:

$$Q_{.d}^{s,in} = \sum_i \beta_i^s X_{id}^s + \varepsilon^{s,in} \quad (8)$$

where β_i^s are the model coefficients to be estimated and $\varepsilon^{s,int}$ is the error component.

In order to estimate the outcoming flows, the production/generation model allows us to estimate the average flow of freight type *s* departing by road from zone *o* in time period *h* (for simplicity, will be omitted in the following), $Q_{o.}^{s,out}$, that can be expressed by a category regressive model, specified through variables representative of freight type *s* and origin zone *o*, as:

$$Q_{o.}^{s,out} = \sum_j \beta_j^s X_{jo}^s + \varepsilon^{sh,out}. \quad (9)$$

where β_j^s are the model coefficients to be estimated and $\varepsilon^{sh,out}$ is the error component.

Attributes X^s of eqns. (8) and (9) represent socio-economic variables (such as income or GDP) and level of service ones (such as zone accessibility or transportation costs).

Activity type

The activity type models allow us to characterise the incoming or outcoming flows if they come or are directed to industrial or distribution (e.g. warehouses) activities.

Therefore, although behaviour-probabilistic models can be used, traditionally descriptive ones are used. They provide the share of freight flows directed or coming from producers or distribution activities. Let $Q_{.d}^{s,in}[g]$ and $Q_{o.}^{s,out}[g]$ be the freight flows directed/coming to/from activity type *g*, they can be obtained through the *p[g]* share as follows:

$$Q_{.d}^{s,in}[g] = Q_{.d}^{s,in} \cdot p[g / ds, in]$$

$$Q_{o.}^{s,out}[g] = Q_{o.}^{s,out} \cdot p[g / os, out] \quad (10)$$

where *p[g/ds,in]* and *p[g/os,out]* are the share of flows directed of coming from activity of type *g*, obtained for example from survey.

Distribution

Distribution models are used to obtain the spatial share; they can be differently specified for incoming and outcoming freight flows.

Distribution models can be interpreted and specified following either a behavioural or a descriptive approach with various specifications and interpretations of the attributes. According to the behavioural interpretation, the distribution model simulates the choice of a destination among possible alternatives. It should be noted that typically the chosen alternative for carrying out an activity is not a traffic zone but one (or more) elementary alternatives (such as a firm, a general market, etc.) located within the zone. The traffic zone is therefore a compound alternative made of aggregation of elementary alternatives.

Variables considered into the distribution model can be divided into two groups: variables representing the activity system, which measure the generation/emission/production or attraction power of a given zone for freight type *s* (e.g. wholesale employees of freight type *s*), and variables representing cost or separation attributes, which measure the generalized travel cost for transporting goods of type *s* on the *od* pair.

Referring to incoming, the distribution model allows us to obtain from which zone *o* the freight arrives to zone *d* (destination constrained); in other words, it gives the probability $p\left[o / gds, in\right]$ that freight attracted by zone *d* arrives from zone *o*. Referring to a Multinomial Logit structure, this probability can be expressed as:

$$p\left[o / gds, in\right] = exp\left(V_o / \theta_o\right) \Big/ \sum_{o' \in I_d} exp\left(V_{o'} / \theta_o\right) \qquad (11)$$

where

- V_o is the systematic utility of zone *o*, that can be expressed as a linear combination of attributes;
- I_d is the set of possible origin zones within the study area from which freight can arrive to zone *d*;
- is the parameter of the Gumbel random variable.

For outcoming, the distribution model (origin constrained) allows us to carry out the probability $p\left[d / gos, out\right]$ that freight generated from zone *o* is destined to zone *d*. As described for incoming, referring to a Multinomial Logit structure, this probability can be expressed as:

$$p\left[d / gos, out\right] = exp\left(V_d / \theta_d\right) \Big/ \sum_{d' \in I_o} exp\left(V_{d'} / \theta_d\right) \qquad (12)$$

where I_o is the set of possible zones within the study area where freight can be destined from zone *o*.

Besides the specification of behavioural models, in many real applications descriptive distribution models are used. One of these models that allows to reduce this complexity and to eliminate the influence of the level of spatial disaggregation adopted is the simply constrained gravitational model. For example, in the case of incoming, the probability $p\left[o / gds,in\right]$ can be expressed by activity system (A_o^s) and cost of separation (C_{od}) variables, as:

$$p\left[o / gds,in\right] = \left(A_o^s\right)^{\beta_A^s} \left(C_{od}\right)^{\beta_C^s} \Big/ \sum_{o' \in I_d} \left[\left(A_{o'}^s\right)^{\beta_A^s} \left(C_{o'd}\right)^{\beta_C^s}\right] \tag{13}$$

where β_j^s are the model coefficients to be estimated.

The probability $p\left[d / gds,out\right]$ for the export can be expressed in the same way.

Finally, the average flow of freight type *s* between zones *o* and d characterised for serving activity type *g* can be obtained as follows:

$$\begin{aligned} Q_{od}^{s,in}\left[g\right] &= Q_{.d}^{s,in} \cdot p\left[g / d\,s,in\right] \cdot p\left[o / gd\,s,in\right] \\ Q_{od}^{s,out}\left[g\right] &= Q_{o.}^{s,out} \cdot p\left[g / o\,s,out\right] \cdot p\left[d / go\,s,out\right] \end{aligned} \tag{14}$$

where

- $Q_{od}^{s,in}\left[g\right]$ and $Q_{od}^{s,out}\left[g\right]$ are the average incoming and outcoming flows of freight type *s* between zone *o* and *d* for activity type *g*;
- $Q_{.d}^{s,in}$ and $Q_{o.}^{s,out}$ are the average incoming and outcoming flows estimated, respectively, by eqns. (13) and (14);
- *p[g/ds,in]* and *p[g/os,out]* are the probabilities estimated as previously explained;
- $p\left[o / gds,in\right]$ and $p\left[d / gos,out\right]$ are the probabilities estimated by eqns. (11) and (12).

4.3.2.2 Origin-destination matrices in vehicle

Freight transport is strictly related to the logistic system considering all operations from supplying to final distribution that allows freight to arrive from the supplier to the producer and, then, to consumer. In general, the logistic systems are composed by several Logistic Center (LC), where the same activities (e.g. groupage/degroupage, assembly, packing, storage, etc.) are carried out.

This aspect reflects on shipment size and vehicle type choice because choices of vehicle and transportation management are different if we consider the problem of feeding producers (both raw materials and intermediate products) from suppliers (supplying process), or if we consider the freight transport to the final distribution (distribution process).

The use of a particular supplying channel defines the average size of shipment and hence the type of vehicles to be used. In other words, the direct shipping of freight from the supplier to the producer implies an average shipping size of goods higher than that shipped to a logistic centre; this influences the type of vehicle to be used (in terms of capacity), and hence the estimation of the number of vehicles moving on the road network. This is a crucial point, for example, in capacity analysis studies.

Given commodity flows, it is possible to estimate road freight flows in vehicles by using a vehicle loading model. Vehicle loading models should consider:

- the capacity and the average transportable quantity by each type of vehicle;
- the nature of the consignment; the proportion of vehicle capacity required by each consignment and the aggregate volume of consignments by each shipper in a specific time period;
- the characteristics of the desired pick up and delivery vehicle patterns.

Given the O/D matrices in quantity, through eqn. (14), the number of vehicles that are necessary to transport the quantity $Q^{s}_{od}\left[g\right]\left(=Q^{s,in}_{od}+Q^{s,out}_{od}\right)$ by vehicle type *v* is given by:

$$VC^{s}_{od}\left[g,l,v\right]=\frac{Q^{s}_{od}\left[g\right]\cdot p\left[lv/g,od\right]}{q^{s}\left[glv\right]} \quad (15)$$

where

- $VC^{s}_{od}\left[g,l,v\right]$ is the number of vehicles of type *v* moving freight type *s* on the *O/D* pair *od*, which refers to average transported quantity $q^{s}[glv]$;
- $p\left[lv/g,od\right]$ is the vehicle type share obtained by a *vehicle type model*, which represents the share of vehicle type *v* used to move freight on *O/D* pair od according to the type of destination *d* (e.g. centre, the first or the second border).

In general, eqn. (15) can be specified both for incoming and outcoming. In fact, depending on the characteristics of freight demand it is possible to have different vehicle type models and then different average transported quantities by each type of vehicle. The vehicle type model can be also specified in the framework of the RUM (Random Utility Model) theory by using (for example) a Multinomial Logit model.

5 Ex-ante evaluation of UFT scenarios

5.1 Overview

The present section of the handbook has the aim to introduce the Logistics Sustainability Index (LSI), a Multi-stakeholders Multi Criteria Decision Analysis tool used to aggregate normalized values of indicators into a unique index. This index is able to assess the city logistics measure's impacts over a given impact area, and eventually to aggregate different indexes to assess the overall convenience of a measure.

The LSI is to be intended within the context of the *overall tool for understanding freight behaviours and impacts in the Functional Urban Areas of SULPITER*. As depicted in Figure 2, the calculation of the LSI represents the final step of the procedure of the tool proposed by SULPITER, having the aim to assess the performance of smart urban logistics solutions, policies and measures. The tool is then able to portray the complexity of Urban Freight Transport (UFT) systems in terms of divergent stakeholders' interests.

5.2 What is the LSI?

Sustainability is a prerequisite and an objective of any decisions made in the field of transport planning and management. Sustainability, along with the complex nature of decision-making, pose the need to create integrated evaluation tools, due to the difficulty to systematically take into account and manage all the information required to take effective decisions.

Multi-Criteria Decision Analysis (MCDA) tools have been developed to provide directions taking into account all the different components of sustainability, i.e. economy, environment, society, transport system. The formulation of an integrated tool, however, is becoming even more challenging when different types of stakeholders are involved in the decision making process. In that case, the MCDA is transformed into a multi-stakeholder MCDA able to include the different perspectives of the stakeholders in the evaluation process.

The Logistics Sustainability Index (LSI) represents in its formulation an integrated evaluation tool able to quantify the overall performance of a logistics system according to different criteria and different perspectives. For this reason, it can be a valid index to implement a multi-stakeholder MCDA in the specific sector addressed by SULPITER. The LSI is elaborated adopting a bottom-up approach which starts with the valorisation of basic performance indicators that will be aggregated into weighted composite indicators per impact area and finally into a unique synthetic index. The LSI may evaluate one or more impact areas jointly.

The LSI is useful when a comparison between the current status and a potential scenario is required, or when two potential scenarios have to be compared. In the following sections, the method to calculate the LSI will be explained in details along with an example of calculation, in order to make clear the statements above.

5.3 How to calculate the LSI?

The calculation process of the LSI is composed of six steps, as depicted in Figure 16:

- Step 1. Selection of the impact area. There are seven impact areas and the user selects at least one of these for which the assessment of the measure will be performed.

- Step 2. Selection of criteria. Criteria are linked to the selections operated in the previous step. Criteria and indicators have to be individuated considering the impact areas, along with the perspective of stakeholders, UFT measures and related lifecycle stages.
- Step 3. Selection and computation of indicators. In this step, the user selects the final indicators from a list, which is provided for each criterion (and impact areas), and attributes a value to each of them. These values may come from databases, elaborations, estimations, direct measurement.
- Step 4. Weighting process. The user incorporates his/her preferences and priorities, by assigning weights to impact areas, criteria and indicators, following a specific methodology. Weights incorporate the different stakeholders' perspective.
- Step 5. Values normalization. The impacts are translate into homogeneous values, through different methodologies according to the specific impact. All the values are then normalized, multiplied by their weights, and a final index is estimated per impact area.
- Step 6. Logistics Sustainability Index. Indices per measure and impact area are aggregated into a Logistics Sustainability Index (LSI) per measure that is used for the comparison of the sustainability performance between measures or for the evaluation of the same measure in different scenarios (before-after evaluation) as defined by the user.

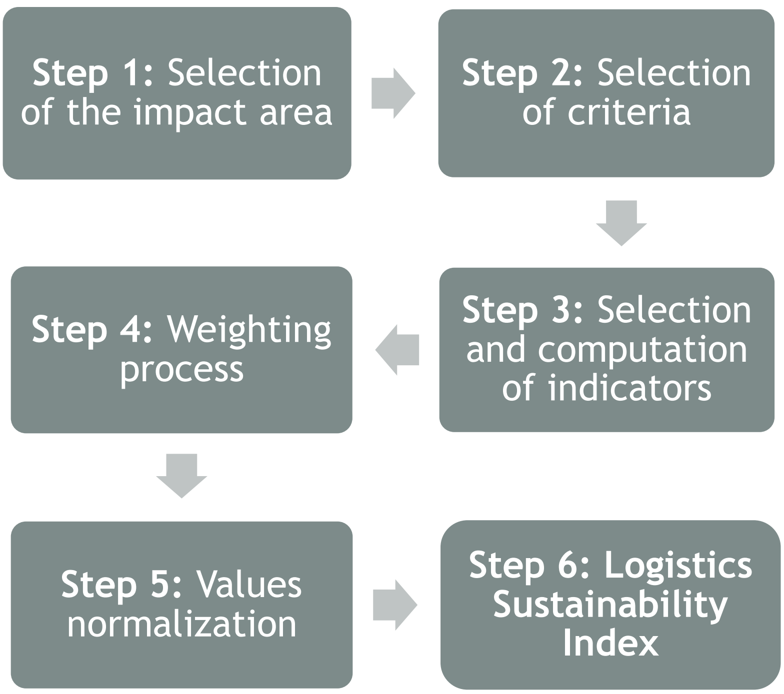

Figure 16 Steps of the calculation process.

The steps are detailed in the following sections.

5.3.1 Phase 1: Selection of the impact area

The choice of the impact area depends on primary and secondary objectives of the cities or the stakeholders. Such objectives have to be established in advance and will suggest the impact areas to be included in the evaluation of the LSI.

Seven impact areas have been individuated and contribute to the LSI:

- **Economy and energy**. Energy is a major field that is directly connected with economy in modern community; e.g. Energy availability, demand, price and actual consumption have short term and long term impacts on lifestyles. The creation of a sustainable economy requires partial utilization of energy and development within environmental limits. Continuous utilization of non-renewable energy sources results in depleted energy sources and increased energy pricing, therefore unsustainable communities.
- **Environment**. The environment refers to the preservation of natural resources and the limits within which activities should take place without depleting of non-renewable resources. The environmental impact of logistics is addressed through emissions, air quality and noise impacts on communities.
- **Transport and mobility**. Transport and mobility are two concepts that are becoming more and more popular at local, national and European level. The continuous pursuit of improving transport of goods and mobility of people is usually translated into terms of attractiveness, accessibility, level of service, safety as well as availability of infrastructure.
- **Society**. Society is defined as different groups of people that interact with other people in a community. Societal impacts of logistics can be described adequately with respect to sustainability, convenience and living standards of the community.
- **Policy and measure maturity**. The policy and measure maturity impact area expresses mainly the involvement of stakeholders into the implementation of a proposed UFT measure. More specifically, it is related to the awareness of stakeholders towards the measure, their managerial skills as well as their related knowledge, experience and willingness to adopt it.
- **Social acceptance**. The social acceptance impact area can be discerned into two levels; the social approval level, i.e. to what extend a measure is welcomed and respected by the society, and the regulations acceptance level, which has to do with regulations compliance and the way a measure is enforced.
- **User uptake**. This impact area checks the adaptability, flexibility, transferability and success of the implementation of a UFT measure, taking into consideration stakeholders' opinions, agreements and acceptance.

The LSI can consider 26 criteria and 137 indicators (see Annex A), which have been selected and defined to evaluate comprehensively the impacts on all areas. The seven impact areas with the respective number of criteria and indicators are presented in Table 4.

Table 4 Number of criteria and indicators per impact area.

Impact areas	Criteria	Indicators
Economy and energy	5	36
Environment	3	10
Transport & mobility	5	29
Society	3	20
Policy and measure maturity	3	24
Social acceptance	2	9
User uptake	5	9
Total	**26**	**137**

5.3.2 Phase 2: Selection of criteria

For every impact areas there will be several criteria and each criterion will involve several indicators. The criteria for the different impact areas are the following:

- Economy and energy: energy, development, benefits, costs, economic and financial risk.
- Environment: air quality, GHG emissions, noise pollution.
- Transport and mobility: level of service, safety and security, transport system, UFT vehicles, IT infrastructure and technology.
- Society: greening, convenience, living standards, socio-political dimensions, natural disaster and civil disturbances.
- Policy and measure maturity: awareness, managerial, background.
- Social acceptance: social approval, regulations acceptance.
- User uptake: flexibility, knowledge and experience transfer, consensus, success.

5.3.3 Phase 3: Selection and computation of indicators

To evaluate the performance of a measure, the user can select a series of indicators that are relevant to the stakeholder categories involved and the lifecycle stages of the measure.

The indicators (explained in detail in Annex A) can be divided into the following main categories:

- Impact Assessment Indicators (IAM). IAM are linked to the impact areas of “Environment” and “Transport and mobility” and are divided in seven criteria: air quality, greenhouse gas Emission, noise, level of service, safety and security, transport system and UFT vehicles.
- Social Cost Benefit Indicators (SCBI). SCBI are linked to the impact area of “Economy and Energy” and are divided in four criteria: energy, development, benefits and costs.
- Transferability and Adaptability Indicators (TAM) are linked to the impact areas of “Policy and measure maturity”, “Social acceptance”, “User uptake” and are divided in seven criteria: background, social approval, flexibility, adaptability, consensus, transferability and success.

5.3.4 Phase 4: Weighting process

Weighting is the process of comparing two or more elements according to decision maker's preference. There are several weighting methods, but everyone follows the same standard principle: the higher the weight, the more important the corresponding element is.

In literature, the five most prevalent methods in terms of simplicity and effectiveness are:

- Analytical Hierarchy Process (AHP) method,
- Pairwise Comparison method,
- Delphi method,
- Ratio Method and
- Rank Order Centroid method.

In our case we establish to use the Analytical Hierarchy Process (AHP) method. Only to provide a reference, we described the others in Annex B.

AHP is considered the most-widely used method for multi-criteria analysis within the transportation and urban logistics fields. The main strengths of the AHP method are:

- usable in a very wide spectrum of fields;
- easy to be understood;
- flexibility and easiness of use;
- interdependence of the different criteria;
- usable for both monetary and non-monetary scales.

The user is called to state the importance (or preference) of element 1 compared to element 2 by rating it according to a scale from 1 to 9, where:

- 1 = same;
- 3 = moderately,
- 5 = very;
- 7 = much more;
- 9 = exceptionally more.

All the intermediate integer ratings are possible. When element 1 is less important than 2, then the respective reciprocal value is attributed (e.g. 1/5).

The **A** matrix (**n x n**), called "comparison" or "reciprocal matrix", is filled in by the user, where **n** is the number of the compared elements. The cells under the unitary diagonal cells are filled in with the user's rating input values, while the others below are equal to the reciprocal value of the input value.

An example is the following matrix A (3x3)

$$A = \begin{matrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{matrix}$$

where $a_{21} = \frac{1}{a_{12}}\,, a_{12} \neq 0$

The required weight $\mathbf{W_i}$ of the element in row i, is calculated using the following equation (16).

$$W_i = \frac{\sum_j \frac{aij}{\sum i\, aij}}{n} \qquad (16)$$

The consistency of the weight is estimated through the consistency index (CI) using (17) and the consistency ratio (CR) using (18).

$$CI = \frac{\lambda_{max-n}}{n} - 1 \qquad (17)$$

$$CR = \frac{CI}{RI} \qquad (18)$$

In (18) the Random Consistency Index (RI) depends on the number of elements n to be compared, as illustrated in the following Table 5.

Table 5 The values of RI.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

Generally, a CR of up to 10% is considered a good consistency. However, higher values (e.g. up to 30%) may be also acceptable.

Impact areas are weighted each other and then the criteria are weighted each other within the respective impact area. All the weights of the elements belonging to the same component (Impact Area or Criterion), after the aggregation should sum up to one.

5.3.5 Phase 5: Values normalization

The use of indicators of different context, nature and value in a common assessment methodology, requires to establish a commensurate scale, thus making indicator values dimensionless. This can be achieved by means of the normalization of values of each criteria and indicator into the set of dimensionless real numbers.

Data normalization consists of the rescaling of the values of the data into a single specified range, such as from 0 to 1 or from 0 to 100.

There are several normalization methods available in literature: normalization by comparison with the best alternative, classic normalization, max and min normalization, vector normalization, statistical z score (this last is described in detail in Annex C).

A summary of other normalization methods applied in different occasions can be found in OECD (2008). Also, research on the methodology for choosing the best normalization method based on a set of criteria and on the proper matching of type of normalization in accordance with preferences of the decision-maker is scarce. (19) presents the most used normalization method, where r_{ij} denotes the transformed and normalised value of I_{ij} for alternative i and indicator j.

In this case, the normalization by comparison with the best alternative is used: all the indicators values are divided (inside the same criterion) by the maximum value.

$$\bar{r}_{ij} = \frac{I_{ij}}{max_j I_{ij}} \qquad (19)$$

Where:

$\bar{r}_{ij} = normalised\ value$

$I_{ij} = indicator\ value\ for\ alternative\ i\ and\ indicator\ j$

$max_j I_{ij} = maximum\ value$

5.3.6 Phase 6: Logistics Sustainability Index

The final step of the LSI procedure involves data interpretation and calculation. Evaluation incorporates a multiple weighting scheme, and elimination and ranking techniques and models, for the facilitation of “shared” decision-making, taking into account the participation, viewpoint and contribution of all involved stakeholders to the conformation of the final decision made on the measures.

The complexity of a decision-making process lies in the difficulty of taking into account all the aspects and the areas being affected by the decision (i.e. economy, environment, society, transport system, etc.) and the multiple stakeholder categories participating in the process.

Decision-making is the task of identifying and choosing alternatives based on values and preferences that are in agreement with the goals, objectives and desires of each plan.

For a problem with multiple alternatives and a single choice criterion, the decision-maker has to determine the best alternative by comparing each alternative based on the value of the criterion (problem optimization). The techniques able to solve this kind of problem are: Bayesian decision making, Entropy technique, Expected value method, Goals achievement method, Utility function based methods (Multi attribute utility theory (MAUT), Simple Multi Attribute Rated Technique (SMART), Analytical hierarchy process (AHP), Weighted Sum model (WSM), Weighted Product model (WPM), Outranking methods (ELECTRE, PROMETHEE I and II, REGIME analysis).

WSM is the method used in this methodology. This is the earliest and most common used method. The assumption that governs this model is the additive utility assumption. The WSM can be applied in problems with different alternatives and one indicator, where the units that describe the indicator are the same for all alternatives. Addition among indicator with different units is performed only after the different measurement units are normalized into a dimensionless scale.

The utility V_i for each alternative is estimated by (20).

$$V_i = \sum_{j=1}^{m} w_j r_{ij} \tag{20}$$

Where r_{ij} is the normalized value of indicator j for alternative i.

WSM is used to aggregate normalized values of indicators into a unique index able to assess the city logistics measure’s impacts over a given impact area, and eventually to aggregate all these indexes in a unique Logistic Sustainability Index assessing the overall convenience of measure’s implementation.

Aggregation of indicators results in a single index that reveals the sustainability lifecycle ranking of a measure relative to another measure. The performance of each Impact area has been computed as:

$$LSI_i = \sum_{m=1}^{M} I_m w_m \tag{21}$$

Where:

$LSI_i = logistics\ sustainability\ index\ assessing\ the\ performance\ of\ impact\ area\ i$

$I_m = normalized\ value\ of\ indicator\ m\ with\ a\ minus\ or\ plus\ sign, according\ to\ its\ contribution$

$w_m = weight\ of\ indicator\ m$

The total Logistic Sustainability Index, is calculated as the weighted sum of the LSI_i:

$$LSI = \sum_i LSI_i w_i \qquad (22)$$

Where w_i are the weights of the impact area.

6 Example of application

6.1 Introduction

The methodology depicted above has been applied to a specific case study, thanks to a wide set of data provided by the Centre for Transport and Logistics - Sapienza University in Rome and derived from the city logistics experience named LOGeco which took place in Rome in 2011-2012. LOGeco has been a program funded by Unindustria Lazio and the Chamber of Commerce of Rome. The project aimed at assessing how much the implementation of a city logistics measure (such as introducing a Transit Point served by electrical vehicles, for instance) represents a business opportunity for the actors involved in the process. The study area considered was the Tridente zone in the center of Rome (Figure 17, between Piazza del Popolo and Via di Ripetta, Via del Corso and Via del Babbuino), that has already been turned into a pedestrian zone in 2014.

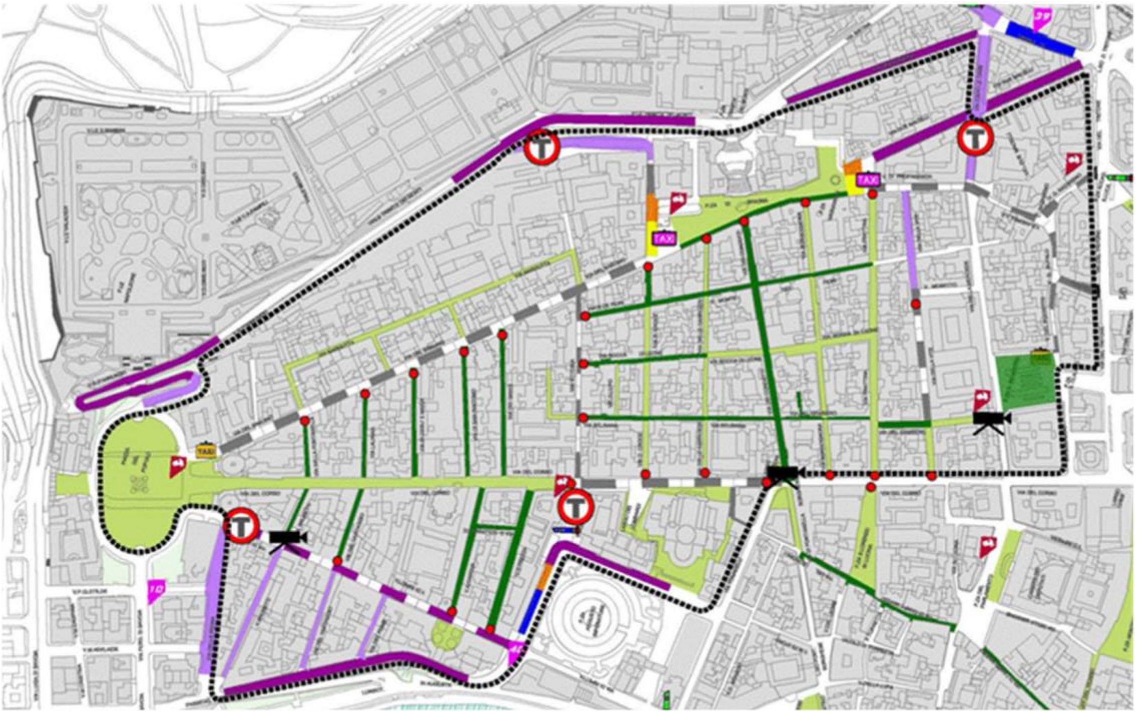

Figure 17 Pedestrianization of Tridente Mediceo in Rome, 2014 (Roma Capitale)

LOGeco conducted an in depth analysis of freight distribution system in the Tridente zone and the experimentation of a Transit Point served by electric vehicles. The logistics solutions experimented gained data and useful information to define business opportunities. The experimentation has been specifically aimed to:

- Prove the actual effectiveness of using electric vehicles serving a Transit Point in urban area for freight distribution operations;
- Detect a set of mobility data through and ICT system able to measure energetic consumptions and also make an estimation of the reduction of environmental impacts.

6.2. Data Collection

The experiment conducted has been based on data collection, consisting of traffic counts and census conducted over the commercial activities of the area, in order to assess the distribution scenario, both from the demand and supply points of views.

A number of 1,100 commercial activities has been identified in the study area and classified according to the specific supply chain.

Traffic counts have been performed and revealed the study area to be daily crossed by almost 45.000 vehicles, 4% of which is made of commercial vehicles. Results of the traffic counts are reported on Table 6.

Table 6 Results of traffic counts. LOGeco experience (Rome 2011).

Motor car	Motorcycle	Bus	Commercial Vehicle	Total
31.415	10.562	840	1.755	44.572

The second macro-activity of the project has been the experimentation of a Transit Point served by electric vehicles performing the last-mile freight distribution. It has been possible to gain information from the electric vehicles fleet through a Fleet Management System (FMS) able to provide data related to vehicles energetic environmental behaviour, as well.

The results stated that:

- Electric vehicles turn out to be reliable and appropriate and they allow meaningful savings of CO_2 emissions, with respect to gasoline vehicles;
- The cost/km is almost 5 times less than a gasoline vehicle;
- The traffic flow of the study area is composed of only a 4% of commercial vehicles. However, their environmental impact (in terms of emissions, noise and vibration, congestion) is outstanding, because of the typology of vehicles performing the deliveries (generally diesel vehicles) and the delivery procedures (double parking, frequent stops, braking aimed at looking for parking spaces, stops in no-parking areas, unloading times, etc.).

LOGeco evalutated also the hypothesis of a Urban Distribution Centre (as a logistics measure) served by electric vehicles, mainly reserved to the Tridente area, which is already a pedestrian area, forbidden to tradition vehicles, has been supposed. The main hypothesis made were that:

- only commercial vehicle with emission characteristics similar to the UDC vehicles fleet can access to the zone;
- the UDC must provide, in addition to the distribution system, warehousing and micro-logistics services, as well.

Once the solution has been identified, it has been verified if it could represent a business opportunity for some stakeholders categories and under which conditions.

The followed procedure can be schematized in some steps:

- Assess for which supply-chains it could be appropriate and realistic to use a distribution system realized by a UDC served by electric vehicles, and compute their respective demands. Seven supply-chains have been identified (Table 7): non-food wholesalers, bakery packaged products, beverage, coffee, other non-food, gadget, gadget-jewelry accessories and books. These kind of supply-chains is related to non-perishable foods or grocery with no need of cold chain. In the area covered by these supply-chains, the possible clients of the UDC are goods 'senders (if they use own-account transport system) or transport operators. In the Tridente zone more or less 180.000 annual deliveries have been estimated, 20.000 of which are related to the above-mentioned supply-chains. Considering 283 working days during the years, the daily number of deliveries in the study area is approximately 71.

Table 7 Supply –chains served by the UDC.

Supply chain	**Macro-sector**
Non-food wholesalers	Ho.Re.Ca.
Bakery packaged products	Ho.Re.Ca.
Beverage	Ho.Re.Ca.
Coffee	Ho.Re.Ca.
Other non-food	Ho.Re.Ca.
Gadget, jewelry accessories	Gadget, Gadget-jewelry accessories
Books	Books

- Some basic assumptions (made by considering market indications) have been formulated:
  - Localization of the UDC: 4 km from Tridente;
  - Average length of delivery tour: 12 km;
  - Max number of tour/vehicle: 4;
  - Dimension of the UDC: 500 m^2;
  - Annual working days: 283.

  Moreover, the tariff plans for the distribution system, the warehousing services and micro-logistics services have been stated.
- Then, three scenarios have been identified, based on the number of deliveries performed by the structure and the handled quantities. Each one of these alternatives is related to its Forecast Income Statement. This analysis aims at assessing if the UDC activity reaches the break-even point in the short term.
- The assessed results showed that, for scenario 1 (corresponding to the lowest demand and thus to the fewer number of deliveries performed by the UDC), the incomes cannot cover the total costs of the activity. In scenario 2 the break-even point is reached during the second year of activity, but the optimal alternative is scenario 3, in which there is a (small) profit margin already during the first year of activity.

All these analysis have provided a large dataset, exploited to apply the methodology depicted in the previous chapter to the specific case study of the Tridente in Rome, in order to make an evaluation of the UDC served by electric vehicles 'measure, from different points of view, the economic, environment, societal and transportation ones. The description of the procedure followed is reported in the next paragraphs.

6.3. Assessment of the “before” and “after” scenarios

The two scenarios analyzed (“before” and “after” situations) have been settled.

In the “before” context, all the supply-chains of Tridente area are daily served by 1.755 commercial vehicles. They are assumed to be diesel vehicles in order to simplify the computations of the emissions. In the “after” scenario, the seven supply-chains of this area, reported in Table 7, are served by the two electric vehicles (bimodal vehicles with 2500 kg. capacity) of the introduced UDC. The remaining supply-chains have been supposed to be served by all diesel vehicles, each one with total laden weight < 3,5 t.

A summary of the two scenarios is reported in Table 8.

Table 8 Summary of the two scenarios supposed.

Features	Scenario Before	Scenario After	
	All the supply chains	Supply chains served by UDC	Remaining supply chains
Annual deliveries	180.000	20.000	160.000
Annual quantities (q)	249.804	27.756	222.048
Daily deliveries	634	71	563
Daily quantities (q)	878	98	781
Number of vehicles	1.755 diesel vehicles	2 bimodal vehicles with 25 q capacity	1.560 diesel vehicles with total lades weight < 35 q

Then, a set of indicators has been computed for both the situations (Table 12).

Table 9 Indicators of the two scenarios supposed.

Impact area	Criterion	Indicator
Economy and energy	Development	Business development
	Benefits	Income generated, strength and diversification of a local economy
	Costs	Installation, structure, employees, equipments, software, tools, accidents, fleet and driver, on-board unit and communication, ZTL permits, other
Environment	Air quality	Gas concentration (CO, NMVOC, NOx, PM, N2O, NH3)
	GHG emissions	CO2, SO2
	Noise	Noise level
Transport and mobility	Level of service	Customer satisfaction, supply chain visibility
	Safety and security	Accidents, fatalities, injuries
	IT infrastructure and technology	Network barriers
Society	Greening	Green reputation, Green concern

Impact area	Criterion	Indicator
	Convenience	Perceived visual and audio nuisance, diffusion of information
	Living standards	Perceived alternative mobility, quality of life, lack of awareness of UFT impacts, bad habits of UFT users, protest interference of nearby residents
Policy and measure maturity	Awareness	Awareness level
	Managerial risk	Information flows problems, time planning misjudgement, lack of knowledge about stakeholders requirements
Social acceptance	Social approval	Public acceptance, social consciousness, final user awareness, final user acceptance, decision making acceptance
	Regulations' acceptance	Compliance with regulation, enforcement, eco-driving practices before and during the journey, motivation for eco-driving practice
User uptake	Flexibility	Penetration
	Knowledge and experience transfer	Stakeholder acceptance

The indicators of the Environment impact area (CO, NMVOC, NOx, PM, N_2O, NH_3 and CO_2 concentrations) have been computed using COPERT IV (EMEP/EEA emission inventory guidebook 2013). The guidelines provide three methodologies: Tier 1, Tier 2, Tier 3. The first one has been used. The equation is the following:

$$E_i = \sum_j \left(\sum_m \left(FC_{j,m} * ED_{i,j,m} \right) \right) \quad (23)$$

Where:

$E_i = emision\ of\ pollutant\ i\ [g]$

$FC_{j,m} = fuel\ consumption\ of\ vehicle\ category\ j\ using\ fuel\ m\ [kg]$

$EF_{i,j,m} = fuel\ consumption\ specific\ emission\ factor\ of\ pollutant\ i\ for\ vehicle\ of\ category\ j$

$and\ fuel\ m\ [\frac{g}{kg}]$

The values of $FC_{j,m}$ and $EF_{i,j,m}$ are provided by the guidelines for typology of vehicle (passenger cars, light commercial vehicles, heavy-duty vehicles, and motorcycles and mopeds) and fuels (gasoline, diesel, LPG and natural gas). The emission factor has been multiplied eventually for the number of vehicles/day and the number of kilometers travelled by each vehicle per day, in order to obtain the grams of pollutant produced.

The emissions of SO_2 per fuel-type m are estimated in a different way, by assuming that all the Sulphur in the fuel is transformed completely into SO_2, using the formula:

$$E_{m,SO_2} = 2 \cdot K_{s,m} \cdot FC_m \quad (24)$$

Where:

$E_{m,SO_2} = emision\ of\ SO_2\ per\ fuel\ m[g]$

$K_{s,m} = weight\ related\ sulphur\ content\ in\ fuel\ of\ type\ m\ \left[\frac{g}{gfuel}\right] (the\ value\ of\ 2009\ has\ been\ selected)$

$FC_m = fuel\ consuption\ of\ fuel\ m\ [g]$

The noise level has been computed with the "Centre Scientifique et Technique du Batiment" guidelines. The equivalent noise emission level is estimated through the equation:

$$L_{eq} = 0{,}65 \cdot L_{50} + 28{,}8\ [dB(A)] \quad (25)$$

Where:

$L_{50} = 11{,}9\ Log\ Q + 31{,}4\ [dB(A)]$

$Q = traffic\ volume\ in\ veh/h$

The number of accidents has been computed in the "before" scenario through the analysis of historical data provided by the Rome Open-data website: https://dati.comune.roma.it/.

Here it is possible to download, in the section of "road accidents", four types of files respectively related to accidents, vehicles, people involved and pedestrian involved. The files of 2013-14-15 have been analyzed and the results, referred only to accidents dragging commercial vehicles in the Tridente area.

Then, the same values have been obtained for the "after" scenario, by making a proportion, considering the number of vehicles running through the network before/after and the total number of kilometers travelled before/after.

The proportion takes into account the total number of kilometers travelled "before" and the total number of kilometers travelled "after" as well, because a reduction of the number of vehicles may not mean necessarily a reduction of the kilometers travelled.

This is exactly the case, since the value of veh./km "before" is equal to the value of veh./km "after", so the number of accidents has been kept constant.

The remaining indicators are evaluated through a Likert scale, so a value between 1 and 5 has been supposed for each one of them, reasonably thinking of how their values could have been changed from the "before" to the "after scenario.

Other indicators could actually be computed, but in this case they have been overlooked, because data needed were not available or a significant computational effort was necessary. The simplification has been considered acceptable since this is just an example of application to an actual case study.

After the computation of the indicators 'values, they are expressed in different units (Euro, gr/day, dB(A), etc.) so they need to be all monetized.

Two different guidelines have been used for emissions monetization and accidents monetization.

In the first case it has been used the "Linee guida per la misura dei Costi esterni nell'ambito del POn Trasporti" methodology. The external cost due to pollutant emission is given by the product of the annual production of that pollutant agent (ton/year) and the external costs (Euro/ton of pollutant).

The monetization of the noise level has been made following the same guidelines. First of all, it was necessary to determine the population exposed to noise pollutions, which is done by multiplying the population density and the pertinence surface. Then, the percentage of a-few/not-annoyed people (%LA), the percentage of annoyed people (A%) and the percentage of very annoyed people (HA%), using the following equations, for road transport:

$$\%LA = -6{,}235 \cdot 10^{-4} \cdot (L_{eq} - 32)^3 + 5{,}509 \cdot 10^{-2} \cdot (L_{eq} - 32)^2 + 0{,}6693 \cdot (L_{eq} - 32) \qquad (26)$$

$$\%A = 1{,}795 \cdot 10^{-4} \cdot (L_{eq} - 37)^3 + 2{,}110 \cdot 10^{-2} \cdot (L_{eq} - 37)^2 + 0{,}5353 \cdot (L_{eq} - 32) \qquad (27)$$

$$\%HA = 9{,}868 \cdot 10^{-4} \cdot (L_{eq} - 42)^3 + 1{,}436 \cdot 10^{-2} \cdot (L_{eq} - 42)^2 + 0{,}5118 \cdot (L_{eq} - 42) \qquad (28)$$

Once the respective percentages have been computed, the total cost related to the noise level is given by the number of people annoyed multiplied by the noise costs. Eventually, the accidents have been monetized by using the methodology “Studio di valutazione dei Costi Sociali dell’incidentalità stradale”. The costs related to road accidents are computed as the sum of human costs (healthcare costs, lack of productivity, etc.) and general costs (patrimonial and administrative costs). All these values depends on the accident severity (death, serious injuries, small injuries), as reported in.

Table 10 Accident costs according to their severity (Italian Ministry of Transport data, 2010).

Accident severity	Average human cost	Average general cost
	M€	M€
Deadly	1,503	1,642
Small injuries	1,917	0,309
Severe injuries	0,017	0,032

The final accident cost is computed through the following equation:

$$C_{tot} = C_{avg,inj} \cdot N_{inj} + C_{avg,death} \cdot N_{death} + C_{avg,gen} \cdot N_{acc} \qquad (29)$$

Where:

$C_{avg,inj} = average\ cost\ associated\ to\ an\ injury$

$C_{avg,deaths} = average\ cost\ associated\ to\ a\ death$

$C_{avg,gen} = average\ general\ cost\ associated\ to\ an\ accident$

$N_{inj}, N_{death}, N_{acc} = number\ of\ injury, deaths\ and\ accidents$

After all the costs have been monetized, the values have been normalized and a minus sign is attributed to all the costs and a plus sign to all the benefits. The performance of each Impact area has been computed as:

$$LSI_i = \sum_{m=1}^{M} I_m w_m \qquad (30)$$

Where:

$LSI_i = logistics\ sustainability\ index\ assessing\ the\ performance\ of\ impact\ area\ i$

$I_m = normalized\ value\ of\ indicator\ m\ with\ a\ minus\ or\ plus\ sign, according\ to\ its\ contribution$

$w_m = weight\ of\ indicator\ m$

And the total Logistic Sustainability Index, evaluating the overall performance of the city logistics measure, is computed as the weighted sum of the LSI_i:

$$LSI = \sum_i LSI_i w_i \tag{31}$$

Where wi are the weights of the impact areas, computed as described in Phase 4.

6.4. Results

As mentioned above, the LSI_i for each Impact area has been computed together with the global LSI for both the scenarios "before" and "after" and the results are represented in a radar graph in Figure 18.

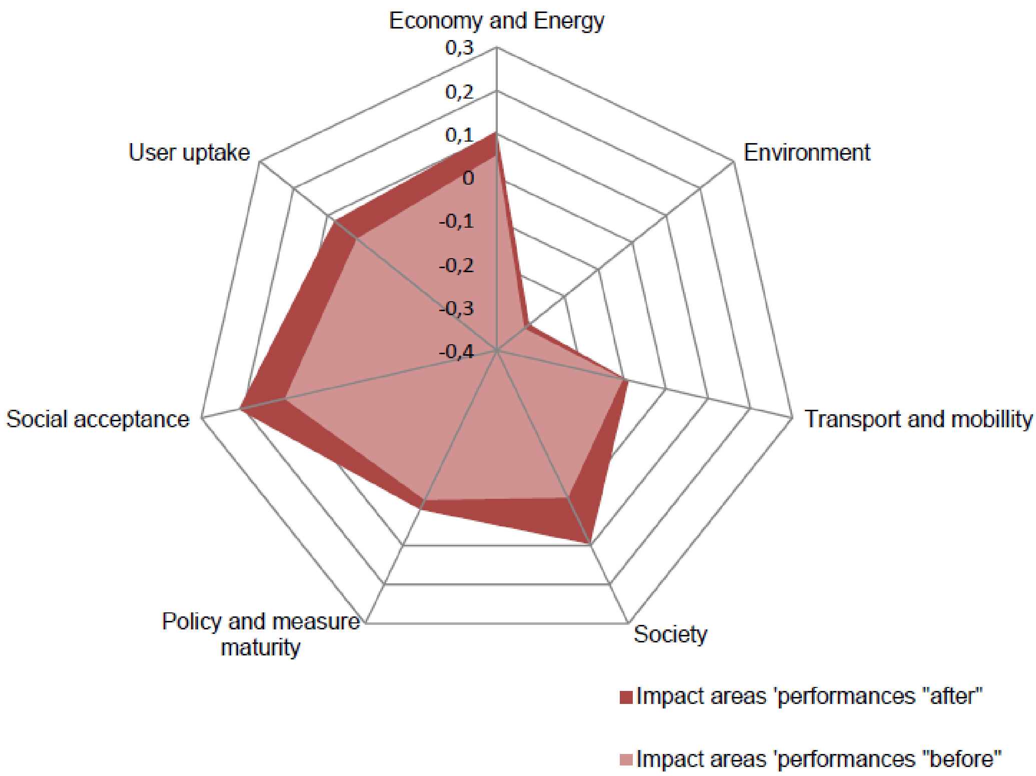

Figure 18 Impact areas' performances in the "before" and "after" scenario.

As it is possible to notice, since costs have been considered as negative values and benefits as positive ones, when the Logistic Sustainability Index increases, the overall performance of the chosen city logistics measure improves, as well.

"Economy and Energy" performance improves since there is the inception of a given number of direct employment positions related to corresponding measure and there are operating revenues aroused by measure's implementation. Both the "Society" and "Social acceptance" impact areas perceive an increase of LSI_i due to the fact that in these fields are considered the perceived quality of life and the degree the stakeholders involved in each city case that are oriented towards environmental preservation, which are necessarily represented by higher values in the "after" scenario. For what concerns "Environment" and "Transport and mobility" impact areas, their performance's increase is of little significance, this is due to the fact that the number of diesel vehicles is not significantly reduced and the veh./km are constant, so the pollutant emissions and the number of accidents almost remain the same. “Policy and measure maturity” and “User uptake” are evaluated through Likert Scale indicators. The first one assesses the stakeholders involvement level and the implemented standards/ procedures on information flow among stakeholders, and the second one the stakeholders acceptance of the implemented measure together with the possibility of replicate the application of this city logistics measures in other contexts. All these values have been supposed to increase in the “after” situation. It must be underlined, for the sake of completeness, that actually these values should be assessed through interviews and questionnaires to citizens, transport operators, etc. and in this case they have just been supposed to simplify the analysis.

In order to perceive an effective improvement in the “Environment” impact area’s performance, another assumption has been made: the “before” scenario has been kept constant, while for the “after” situation, it has been assumed that only commercial vehicles with emission characteristics similar to the UDC vehicles ‘fleet can access to the zone. This means that the UDC is served by 2 bimodal vehicles with a capacity of 25 q. and all the others supply-chains are served by electric vehicles, as well, showing a shifting trend to more eco-friendly solutions. The summary of this second analysis is reported in Table 11:

Table 11 Second analysis performed by considering a different “after” scenario.

	Scenario Before	Scenario After	
	All the supply chains	Supply chains served by UDC	Remaining supply chains
Annual deliveries	180.000	20.000	160.000
Annual quantities (q)	249.804	27.756	222.048
Daily deliveries	634	71	563
Daily quantities (q)	878	98	781
Number of vehicles	1.755 diesel vehicles	2 bimodal vehicles with 25 q capacity	1.560 bimodal vehicles with 25 q capacity

The indicators are the same that in the previous case. The number of vehicles has been kept constant, so the accident rate is constant as well, but the vehicles in this second “after” scenario are all electric vehicles, resulting in an “Environment” Impact area’s performance improvement. The results are represented in a radar graph in Figure 19, where is clearly perceivable the improvement for what concerns the Environmental performance.

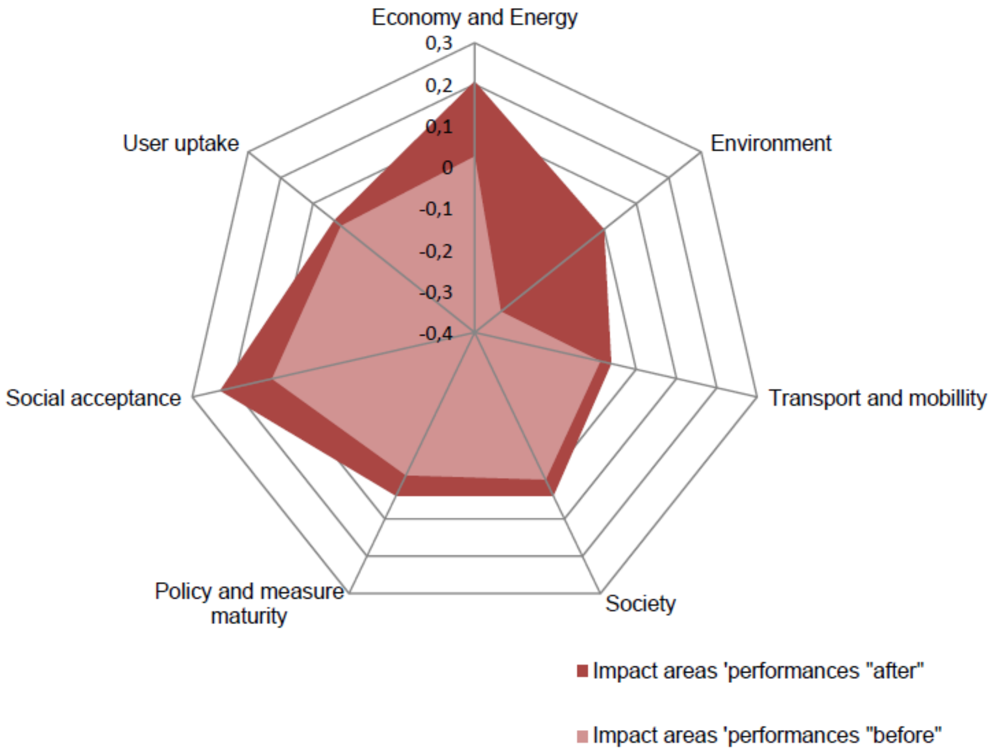

Figure 19 Impact areas’ performances in the “before” and “after” scenario.

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Annex A. Questionnaire for distribution flows

General data of the commercial activity				
Information on the shop				
1	Name	Free text	Fill in	
2	Address	Free text	Fill in	
3	Number of employees	Number	Fill in	
Type of activity				
4	Activities	List	Multiple selection	Selection 4a, 4b, 4c, 4d
Dimension of the shop (local commercial unit)				
5	Total area of the shop (m2)	Number	Fill in	
6	Area of the shop for depot (m2)	Number	Fill in	
7	Number of external depots	Number	Fill in	(0 in case of no depot)
Information on the depots (only in case answer to 7 is "1" or "more"). For any depots…				
8	Address	Free text	Fill in	
9	Total area (m2)	Number	Fill in	
10	Distance from the shop (km)	Number	Fill in	
11	Localisation in or out the study area	Yes/No	Select	
Information on the own fleet				
12	Presence of a own fleet	Yes/No	Select	
Data on vehicles of the own fleet (only in case answer to 12 is Yes). For any vehicles…				
13	Type of vehicles	List	Select	Selection 13
14	Brand	Free text	Fill in	
15	Model	Free text	Fill in	
16	Year of registration	Free text	Fill in	
17	Type of configuration	List	Select	Selection 17
18	Total weight	Free text	Fill in	Selection 18
19	Fuel supply type	List	Select	Selection 19
20	Environmental category	List	Select	Euro 0, Euro 1,…
21	Type of ownership	List	Select	Own, Leasing, Rent,…
22	Usual parking location during operation	List	Select	Selection 22
23	Details on parking location	Free text	Fill in	Details to answer 22
23a	Type of parking location	List	Select	Only in case question 22 is "loading bay at the receiver's premises"

23b	Depot	List	Select	Only in case question 22 is "At the depot"
Supplying process				
Categories of suppliers				
24	Number categories	Number	Fill in	
Supplying process for any category. To be repeated for any category in answer 24.				
25	Name of the category	Free text	Fill in	
26	Number of usual suppliers	Number	Fill in	
27	Type of goods	List	Select	Selection 27
28	Type of supplier	List	Select	Selection 28
29	Mode of delivery	List	Select	(DPP,ExWorks, Off truck)
Delivery Duty Paid (DDP). As a case of answer 29				
30	Decision on the DDP modality	List	Select	Selection 30
31	Delivery mode by the consignor	List	Select	Own account, third party
32	Destination of the delivery	List	Select	In case question 32 is "Third parties"
32a	Depot	List	Select	In case question 32 is "at the depot"
Deliveries				
33	Summary description of the process	Free text	Fill in	
34	Frequency of the delivery	List	Select	Selection 34
35	Frequency rate	Number	Fill in	
36	Periods	List	Select	
36a	Days excluded (days without deliveries)	List	Multi-select (check-box)	In case question 34 is "One or more time a day"
36b	Days included (days with deliveries)	List	Multi-select (check-box)	In case question 34 is "One or more time a week"
36c	Months excluded (months without deliveries)	List	Multi-select (check-box)	In case question 34 is "One or more time a month"
36d	Months with deliveries	List	Multi-select (check-box)	In case question 34 is "One or more time a year"
37	Type of load units	List	Select	Selection 37
38	Dimension of the load unit	Number	Fill in	
39	Weight of the load unit	Number	Fill in	
40	Maximum number of load units per delivery	Number	Fill in	

41	Average number of load units per delivery	Number	Fill in	
42	Minimum number of load units per delivery	Number	Fill in	
43	Presence of peak periods	Yes/No	Select	
43b	Peak periods	Free text	Fill in	In case of Yes to answer 43
44	Changes during peak periods	Free text	Fill in	In case of Yes to answer 43
45	Presence of off-peak periods	Yes/No	Select	
46	Off-peak periods	Free text	Fill in	In case of Yes to answer 45
47	Changes during off-peak periods	Free text	Fill in	In case of Yes to answer 45
48	Usual hours of delivery	List	Select	Selection 48
49	Definition of the hours of delivery	List	Select	
50	Preferred hours of delivery	List	Select	
51	Duration of deliveries	List	Select	Selection 51
52	Activities during reception of deliveries	Free text	Fill in	
53	Duration of reception activities	Free text	Fill in	
54	Vehicles used for deliveries	List	Select	
55	Parking position of vehicles	List	Select	Selection 55
56	Availability to receive deliveries in other hours	Yes/No	Select	
Own account collection (eventual) *This section appears just after the description of the different categories of suppliers. It has to be filled in at least one time, in case deliveries arrive to a depot instead of the shop. It is possible to describe only one trip for collection, even if during the questionnaire the respondent declared multiple deliveries to the depot.*				
57	Depots involved by the collection	List	Select	The list of the depots declared in “Information on the depots” appears
Own account collection trip description				
58	Summary description of the trip	Free text	Fill in	
59	Vehicle of the own fleet used	List	Select	The list of vehicles declared in “*Data on vehicles of the own fleet” appears*
60	Frequency of collection from depot	List	Select	
61	Frequency rate	Number	Fill in	
62	Periods	List	Select	

62a	Days excluded (days without deliveries)	List	Multi-select (check-box)	In case question 60 is “One or more time a day”
62b	Days included (days with deliveries)	List	Multi-select (check-box)	In case question 60 is “One or more time a week”
62c	Months excluded (months without deliveries)	List	Multi-select (check-box)	In case question 60 is “One or more time a month”
62d	Months excluded (months without deliveries)	List	Multi-select (check-box)	In case question 60 is “One or more time a year”
63	Type of goods collected	List	Select	
64	Type of load units	List	Select	
65	Dimension of load unit	Free text	Fill in	
66	Weight of load unit	Number	Fill in	
67	Maximum number of load units per trip	Number	Fill in	
68	Average number of load units per trip	Number	Fill in	
69	Minimum number of load units per trip	Number	Fill in	
70	Presence of peak periods	Yes/No	Select	
70a	Peak periods	Free text	Fill in	In case of “Yes” to question 70
70b	Deviations during peak periods	Free text	Fill in	In case of “Yes” to question 70
71	Presence of off-peak periods	Yes/No	Select	
71a	Off-peak periods	Free text	Fill in	In case of “Yes” to question 71
71b	Deviations during off-peak periods	Free text	Fill in	In case of “Yes” to question 71
72	Usual hours of delivery of the collected goods	List	Select	
73	Duration of deliveries	List	Select	Range of minutes
74	Parking position of vehicles	List	Select	
75	Description of another trip	Yes/No	Select	In case of Yes again to 58
Ex-Work Delivery. As a case of answer 29				
76	Decision on the modality	List	Select	
77	Delivery mode	List	Select	Own account, third party
78	Name of the third party operator	Free text	Fill in	In case question 77 is “Third party”
79	Presence of express couriers	Yes/No	Select	In case question 77 is “Third party”

80	Multi-category operator	Yes/No	Select	In case question 77 is “Third party”
81	Point of delivery	List	Select	In case question 77 is “Third party”
82	Depot	List	Select	In case question 81 is “Delivery to depot”
Deliveries (go to 33)				
Own account replenishment (description of the trips)				
83	Vehicle of the own fleet used	List	Select	List of vehicles declared on section "Data on vehicles of the own fleet"
84	Categories of suppliers interested	List	Select	The list of suppliers coming from question 29 (case “Ex works”) and from question 77 (case “Own account”)
85	Number of suppliers involved in the trip	Number	Fill in	
86	Number of suppliers in the study area	Number	Fill in	
87	Origin of the replenishment trip	List	Select	List of potential origins (shop or depots) as indicated in section “Information on the depots”
88	Destination of the replenishment trip	List	Select	List of potential origins (shop or depots) as indicated in section “Information on the depots”
89	Details on the trip	Free text	Fill in	
90	Usual hours of the trip	List	Select	
91	Frequency of replenishment	List	Select	
92	Frequency rate	Number	Fill in	
93	Periods	List	Select	
93a	Days excluded (days without deliveries)	List	Multi-select (check-box)	In case question 93 is “One or more time a day”
93b	Days included (days with deliveries)	List	Multi-select (check-box)	In case question 93 is “One or more time a week”
93c	Months excluded (months without deliveries)	List	Multi-select (check-box)	In case question 93 is “One or more time a month”
93d	Months excluded (months without deliveries)	List	Multi-select (check-box)	In case question 93 is “One or more time a year”

94	Type of goods collected	List	Select	
95	Type of load units	List	Select	
96	Dimension of load unit	Free text	Fill in	
97	Weight of load unit	Number	Fill in	
98	Maximum number of load units per trip	Number	Fill in	
99	Average number of load units per trip	Number	Fill in	
100	Minimum number of load units per trip	Number	Fill in	
101	Presence of peak periods	Yes/No	Select	
101 a	Peak periods	Free text	Fill in	In case 101 is "Yes"
101 b	Variations during peak periods	Free text	Fill in	In case 101 is "Yes"
102	Presence of off-peak periods	Yes/No	Select	
102 a	Off-peak periods	Free text	Fill in	In case 102 is "Yes"
102 b	Variations during off-peak periods	Free text	Fill in	In case 102 is "Yes"
103	Usual hours of delivery of the collected goods	List	Select	
104	Duration of deliveries	List	Select	Range of minutes
105	Description of another trip	Yes/No	Select	In case of Yes again to 82
Off truck. As a case of answer 29				
Deliveries (go to 33)				
If on questions 32 and/or 81 and/or 88 a depot has been selected, go to question 57				
Deliveries to end customers				
106	Usual delivery to end-customers	Yes/No	Select	
Deliveries to end customers (description). In case of Yes to 106				
107	Delivery mode by the consignor	List	Select	Own account, third party
108	Presence of express couriers	Yes/No	Select	In case question 107 is "Third party"
109	Name of the third party operator	Free text	Fill in	In case question 107 is "Third party"
110	Vehicles of the fleet used	List	Select	List of vehicles declared in section "*Data on vehicles of the own fleet*"
111	Origin of the delivery route to end customers	List	Select	List of shops and depots as indicated in section *"Information on the depots"*
112	Average number of receivers	Free text	Fill in	

113	Average number of receivers in the study area	Free text	Fill in	
114	Details on deliveries to end customers	Free text	Fill in	
115	Delivery frequency	List	Select	
116	Frequency rate	Number	Fill in	
117	Periods	List	Select	
117 a	Days excluded (days without deliveries)	List	Multi-select (check-box)	In case question 115 is "One or more time a day"
117 b	Days included (days with deliveries)	List	Multi-select (check-box)	In case question 115 is "One or more time a week"
117 c	Months excluded (months without deliveries)	List	Multi-select (check-box)	In case question 115 is "One or more time a month"
117 d	Months excluded (months without deliveries)	List	Multi-select (check-box)	In case question 115 is "One or more time a year"
118	Type of load units	List	Select	
119	Dimension of the load unit	Number	Fill in	
120	Weight of the load unit	Number	Fill in	
121	Maximum number of load units per delivery	Number	Fill in	
122	Average number of load units per delivery	Number	Fill in	
123	Minimum number of load units per delivery	Number	Fill in	
124	Presence of peak periods	Yes/No	Select	
124 a	Peak periods	Free text	Fill in	In case 124 is "Yes"
124 b	Variations during peak periods	Free text	Fill in	In case 124 is "Yes"
125	Presence of off-peak periods	Yes/No	Select	
125 a	Off-peak periods	Free text	Fill in	In case 125 is "Yes"
125 b	Variations during off-peak periods	Free text	Fill in	In case 125 is "Yes"
126	Usual starting hours of delivery	List	Select	
127	Usual ending hours of delivery	List	Select	
Problems and suggestions				
128	Main issues during loading and unloading	List	Select	Selection 128

129	Suggestions	Free text	Fill in	

SELECTIONS

4a: Retail	4b: Crafts	4c: Ho.Re.Ca.	4d: Others
Undergarments retail	Tailor's shops	Pastry shop	Barber's shops and beauty shops
Clothes retail	Textile laboratories	Bar	Laundry
Children's clothing retail	Upholsterers	Bistro	Craftsman of…
Leather goods retail	Leather goods laboratory	Restaurant	Retailer of…
Shoes retail	Cobbler	Wineshop	Other
Furrier's shop and leather goods retail	Picture framer	Bed and breakfat	
Hat, umbrellas, gloves, ties retail	Furniture restorers	Hotel	
Sporting goods retail	Watch repairers		
Toys retail	Gold laboratories		
Gift shop retail	Pasta laboratories		
Textiles and linen retail	Pastry laboratories		
Sewing goods retail	Bakery laboratories		
Dry goods retail			
Home furnishings retail			
Dishware retail			
Lighting retail			
Wallpaper and flooring retail			
Building materials retail			
Jewelry retail			
Antique dealers			
Philately retail			
Perfumery retail			
Pharmacy			
Herbalist's shop			
Records retail			
Kiosks			
Bookshops			
Electrical goods			
Home appliances			
Optical store and photography			

Meats retail
Fish shop
Groceries
Bakeries
Fruit and vegetables
Tobacco shop
Stationery stores
Hardware store
Flower shop

13: Type of vehicles	17: Type of configuration	18: Total weight	19: Fuel supply type	22: Usual parking location during operation
Truck	Frozen goods	Up to 1,5 t	Gasoline	Loading bay
Car	Refrigerator	From 1,5 t to 3,5 t	Electric	Depot
Van	Crane	Over 3,5 t	Diesel	
	Hydraulic ramp		NLG	
	Pick-up		Methane	
	Soft-top		Hybrid (clarify)	
	Tarpaulin			
	Armored truck			

27: Type of goods	28: Type of supplier	30: Decision on the DDP modality	34: Frequency of the delivery
Undergarments	Shop	Imposed by the suppliers/shipper	One or more times a day
Underwear	Retailer	Imposed by the shopowner	One or more times a week
Stockings	Manufacturer	Agreed upon the parties	One or more times a month
Suits			One or more times a year
Coats			
Sweaters and shirts			
Shoes and leather			
Costume jewerly			
Shoes			
Leather accessories			
Bags			

Suitcases			
Umbrellas			
Fur coats			
Leather garments			
Accessories			
Hats			
Gloves			
Ties			
Sporting goods			
Bikes			
Clothes			
Leisure suits			
Tous			
Electronic games			
Gadgets			
Home garments			
Textiles			
Sewing goods			
Fabrics			
Furniture fabrics			
Sewing fabric			
Tailors' supply			
Textile laboratories' supply			
Upholsterers' supply			
Leathers			
Leathers' laboratory supply			
Shoemakers' supply			
Picture framers' supply			
Timber labourers' supply			
Furniture restorers' supply			
Furnitures			
Home furnishings			
Housewares			
Dishes			

Flatware			
Lightings			
Wallpaper			
Floorings			
Building materials			
Tiles			
Jewels			
Silverware			
Watches			
Watches repairing materials			
Precious metal			
Semifinished products			
Gold laboratories materials			
Other			
Hairstylists' supply			
Cosmetics			
Personal care products			
Laundry			
Perfumes			
Healthcare products			
Medicines			
Patent medicines			
Medical surgical devices			
Healthcare equipments			
Personal hygiene products			
Food			
Herbal products			
Homeopathic products			
Herbal products			
Records			
CD			
Videos			
Newpapers			
Magazines			

Gadgets			
Books			
Stationery			
Electric materials			
Computers and IT materials			
Software			
Telephony			
Electrical appliance			
Glasses			
Contact lenses			
Photography devices			
Pork meat			
Beef meat			
Poultry			
Wild game			
Fisheries			
Lobsters			
Shellfish			
Milk			
Cold cuts			
Fresh products			
Bread and pastries			
Dry food			
Water and beverages			
Alcohols			
Cosmetics and personal care products			
Detergentes			
Housewares			
Bread			
Bakery products			
Bakery unpackaged products			
Fruit			
Vegetables			
Flours			

Eggs			
Fruit and vegetables			
Frozen food			
Edible fats and oils			
Equipment			
Foodstuff			
Fresh pastry			
Fresh barery producst			
Fresh packed pastry			
Icecreams			
Fresh pastry and icecreams			
Public monopoly products			
Costume jewerly			
Gifts			
Paper			
Forms			
Office equipment			
Printing			
Laundry supplies			
Hardware products			
Cut flowers			
Plants			

37: Type of load units	**48: Definition of the hours of delivery**	**51: Duration of deliveries**	**55:Parking position of vehicles**	**128: Main issues during loading and unloading**
Pallet	Imposed by the shipper	From 10 to 20 minutes	Private area	Lack of loading bays
Roll container	Imposed by the receiver	Less than 10 minutes	Public loading bay	Difficult access to loading/unloading areas
Box	Imposed by the transport operator	More than 20 minutes	On street regular parking	Delivery time
Stand	Agreed upon with the shipper		Illegal parking (bus stop, kerb)	Duration of loading/unloading
Carton box	Agreed upon with the transport operator		Double lane parking	Cargo security

	In compliance with the access regulation			Difficult movement of goods from parking to customer's premises
				Need to use lifts or cranes
				Lack of coordination of deliveries

Annex B. Questionnaire for industrial flows

1. General company characteristics

1.1 Company sector (NACE Classification with 3 digits)	

1.2 Location of Local Unit (address, zip code, city)	

1.3 Administrative location (address, zip code, city)	

1.4 Annual turnover in the last three years (€)

2014	2015	2016

1.5 Total Employees in the last three years (by typology)

Type/Year	2014	2015	2016
Workmen			
Administrative workers			
Managers			
Drivers			

1.6 Vehicle fleet

Your company owns a fleet of road vehicles? ☐ Yes ☐ No

If 'yes', please insert the number of vehicle owned by type

	≤ 1.5 t	>1.5 t, ≤ 3.5 t	>3.5 t, ≤ 5 t	>3.5 t, ≤ 12 t	>12 t
Number of vehicles					
Average age					
EURO V					
EURO VI					
Used for restocking activities (share)					
Used for distribution activities (share)					

1.7 Warehouse

His company has at its disposal a warehouse? ☐ Yes ☐ No

If 'yes', please specify:

	For production activities	For distribution activities
Your company owns it?	☐ Yes ☐ No	☐ Yes ☐ No
Dimension (m^2)		
It is close to the local unit?	☐ Yes ☐ No	☐ Yes ☐ No
If no, specify address	Address:_______	Address:_______

1.8 Rail yard

His company has at its disposal a rail yard? ☐ Yes ☐ No

If 'yes', please specify:

Number of railways

Distance from closest train station (km)

Your company owns railway wagons? ☐ Yes ☐ No

If yes, specify the number Number:_______

1.9 Freight produced and sold for freight type *(Time reference: last quarter, provide data up to main 5 freight in tons*last quarter)*

Freight type (according to a classification to be defined)	**Quantity produced (ton*quarter)**	**Quantity Shipped/outcoming (ton*quarter)**	**Quantity received/incoming (ton*quarter)**

2. Incoming and outcoming freight flows

2.2 Freight type incoming from outside the FUA *(Time reference: last quarter, provide data up to 5 freight types ordered by number of shipments)*

Freight type(according to a classification to be defined)	Number of shipments	Average quantity for shipment (ton*quarter)	Total quantity (ton*quarter)	Usually Origin from… (*)	Main Transport mode (share) (**)	Main Sender type (share) (***)	Transport cost (€)

(*) 1: North Italy; 2: Center Italy; 3: South Italy; 4: UE; 5: extra UE; it is possible to include the other provinces of the region
(**) 1: road; 2: rail; 3: other (specify);
(***) 1: Manufacturing activity; 2: Warehouse/Distribution center; 3: Retail activity.

2.3 Freight type incoming from inside the city *(Time reference: last quarter, provide data until 5 freight types ordered by number of shipments)*

Freight type (according to a classification to be defined)	Number of shipments	Average quantity for shipment (ton*quarter)	Total quantity (ton*quarter)	Usually Origin From (Address or zip code) (*)	Main Transport mode (share) (**)	Main Sender type (share) (***)	Transport cost (€)

(*) Specify the origin of the shipment
(**) 1: road; 2: rail; 3: other;
(***) 1: Manufacturing activity; 2: Warehouse/Distribution center; 3: Retail activity.

2.4 Freight type outcoming to outside the city *(Time reference: last quarter, provide data until 5 freight types ordered by number of shipments)*

Freight type (according to a classification to be defined)	Number of shipments	Average quantity for shipment ton*quarter)	Total quantity (ton*quarter)	Usually Destination To… (*)	Main Transport mode (share) (**)	Main Recipient type (share) (***)	Transport cost (€)

(*) 1: North Italy; 2: Center Italy; 3: South Italy; 4: UE; 5: extra UE;
(**) 1: road; 2: rail; 3: other;
(***) 1: Manufacturing activity; 2: Warehouse/Distribution center; 3: Retail activity.

2.5 Freight type outcoming to inside the city *(Time reference: last quarter, provide data until 5 freight types ordered by number of shipments)*

Freight type (according to a classification to be defined)	Number of shipments	Average quantity for shipment (ton*quarter)	Total quantity (ton*quarter)	Usually Destination To (Address or zip code) (*)	Main Transport mode (share) (**)	Main Recipient type (share) (***)	Transport cost (€)

(*) Specify the origin of the shipment
(**) 1: road; 2: rail; 3: other;
(***) 1: Manufacturing activity; 2: Warehouse/Distribution center; 3: Retail activity.

2.6 Freight type incoming/outcoming details. ***Considering the first filled line in tables 2.2, 2.3, 2.4, 2.5, when the transport mode is 'road', please provide the following information related to one shipment.***
If the shipment requires more than a stop, please fill a row for each stop. Consider only the first five stops.

Reference table	Vehicle type (ton) (+)	Load quantity (ton)	Load Unit (*)	Time (**)	Type of transport (***)	Sender/ Recipient (#)	Travelled distance (km)	Number of stops (##)	Number of journey	Transport cost (€)
2.2										
1)										
2)										
3)										
4)										
X										
2.3										
1)										
2)										
3)										
4)										
X										
2.4										
1)										
2)										
3)										
4)										
X)										
2.5										
1)										
2)										
3)										
4)										
X										

(+) According to the classification in question 1.6
(*) 1: package, 2: pallet, 3: container, 4: bulk, 5: other
(**) 1: Morning 1 (before 11:00), 2: Morning 2 (before 13:00), 3: Afternoon
(***) 1: own account, 2: thirdy party
(#) 1: Manufacturing activity; 2: Warehouse/Distribution center; 3: Retail activity.
(##) Total number of stops to load/unload the vehicle. If over 10, please enter "M" to indicate many stops.

3. Infrastructures and services for logistics activities

3.1 Indicate the infrastructures and the services for logistics activities that are important for your company. Indicate any problem and / or action.

Infrastructure type	Problems (i.e. congestion, lack of services)	Actions (i.e. maintenance)
Primary roads (Roads, Highways)		
______________________	________	________
______________________	________	________
Interports- rail yard-rail terminals		
______________________	________	________
______________________	________	________
Ports		
______________________	________	________
Airports		
______________________	________	________
______________________	________	________

Observations

____

____

3.2 Considering his experience, there are on the market transport and logistics companies able to meet the needs of the company?

☐ Yes

☐ No

Observations

____

Annex C. Questionnaire for transport operators

0 General information on the company

0.1 Name of the company ....

Contact person ....

Address .... Municipality ....

Type of company

☐ 1 SpA ☐ 2 Ltd ☐ 3 .. ☐ 4 … ☐ 5 … ☐ 6 … ☐ 7 Other ____________

Interviewee

☐ 1 Owner ☐ 2 Employee ☐ 3 Manager ☐ 4 Other____________

1 Transport activity

1.1 How many vehicles in the fleet (owned or leased)?

	Number of vehicles	
	Ownership	Leasing/Rent
Van		
Light Truck		
Truck		

1.2 Fill in the form below on the base of the type of vehicles above

Type (Van/Light Truck/Truck)____________________

Brand ________________________ Model ________________________

Year of registration ________________

Outfit

☐ Tarpaulin ☐ hydraulic platform ☐ Crane ☐ Dumper ☐ Traditional van

☐ Cooled ☐ Refrigerated ☐ Armored ☐ Pick-up

other ______________________________________

Weight (total) ☐ up to 1.5 t ☐ from 1.5 to 3.5t ☐ from 3.5 t

Fuel

☐ Gasoline ☐ Diesel ☐ Gas ☐ Hibrid ☐ Electric

Environmental features

☐ Euro 1 ☐ Euro 2 ☐ Euro 3 ☐ Euro 4 ☐ Euro 5 ☐ Euro 6

2 Information on the trips (Report info on the trips performed by the most used vehicle of the fleet)

2.1 Motivation of the trip

☐ Own account for delivery ☐ Own account for replenishment

☐ Third party for delivery ☐ Third party for replenishment

2.2 Origin of the trip (Municipality, typical address)

____

2.3 Sequence of movements (at least one trip is to be described)

Types of consignors/consignee. Report the number in the forms below.

1 Manufacturing facility	5 Hotel, restaurant, bar
2 Warehouse	6 End user
3 Retailer	7 Bank, public offices, …
4 Shop	8 Other__________

*Types of goods. *Report the number in the forms below.*

(The list is to be decided on the basis of the local situation. An example is provided here).

1 Undergarments	21 Bikes
2 Underwear	22 Clothes
3 Stockings	23 Leisure suits
4 Suits	24 Tous
5 Coats	25 Electronic games
6 Sweaters and shirts	26 Gadgets
7 Shoes and leather	27 Home garments
8 Costume jewerly	28 Textiles
9 Shoes	29 Sewing goods
10 Leather accessories	30 Fabrics
11 Bags	31 Furniture fabrics
12 Suitcases	32 Sewing fabric
13 Umbrellas	33 Tailors' supply
14 Fur coats	34 Textile laboratories' supply
15 Leather garments	35 Upholsterers' supply
16 Accessories	36 Leathers
17 Hats	37 Leathers' laboratory supply
18 Gloves	38 Shoemakers' supply
19 Ties	39 Picture framers' supply
20 Sporting goods	40 Timber labourers' supply

Movement 1 of N

Address ______________________________

Time of arrival ________ Duration of the movement ____________

Typer of Consignor ________ Name of Consignor ______________________

Type of Consignee ________ Name of Consignee ______________________

Operation ☐ Pickup ☐ Delivery

*Type of goods ☐☐ Quantity __________ Measurement Unit __________

ADD as many pickup/delivery operations as required by the sequence of stops

2.4 What is the frequency of the movements?

- [ ] One or more a day ______ frequency

or

- [ ] One or more a week | M | T | W | T | F | S | days

or

- [ ] One or more a month ______ frequency

or

- [ ] Some months a year

Jan	Feb	Mar		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	

months

3 Information on deliveries

3.1 Vehicles during deliveries are usually parked

in private reserved area ☐ double park ☐

in loading bays ☐ on the sidewalk ☐

in parking space on the road ☐

3.2 Are you available to deliver in other hours?

Yes ☐ No ☐

3.3 Preferred delivery hours

0-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-24

4 Main issues (example to be customized)

4.1 Which are the main issues you experience during the delivery of goods?

- ☐ lack of loading/unloading spac
- ☐ difficulty to access loading/unloading spac
- ☐ delivery hours
- ☐ duratin of loading/unloadin
- ☐ safety risk of goods
- ☐ difficulty to move goods from parking to the sho
- ☐ need to use transpallet to move good
- ☐ lack of coordinatio of deliverie
- ☐ Other ______

5 Suggestions to improve deliveries

Annex D. Indicators

A set of parameters is available for selection by each stakeholder category, including impact areas, criteria, composite indicators and indicators. Based on the selected parameters, the evaluation process may generate multi stakeholder multi criteria evaluation results, as well as results processed separately, upon user request, by each of the embedded modules.

Table 12 depicts a comprehensive list of the evaluation parameters and their association with stakeholder categories, definition and units.

There are three stakeholder category: supply chain stakeholders (SCS), public authorities (PA) and other stakeholders (OS).

Table 12 Evaluation parameter per stakeholder category.

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
Economy and energy	Energy	Energy consumption	Energy consumed (non renewable energy sources)	Mjoule	SCS
	Development	Working potential	Direct employment positions related to measure	Number of direct working positions	PA, OS
		Business development	Indirect employment positions related to measure	Number of indirect working positions	PA, OS
		Local/regional development	Effect on local or regional socioeconomic life activities and wealth. Eg. GDP/capita	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA, OS
	Benefits	Income generated	Total income generated	EURO - € (or other monetary unit)	SCS
		Strength and diversification of local economy	Change of dynamics in the domain of economy in the mean of increasing potential for growth increase in the future	Likert scale {1 (lowest value) - 5 (highest value)}	PA, OS
	Costs	Planning and managerial costs	Costs associated with the planning process (e.g. setting up a survey or a feasibility study of a project, policy or measure) also includes the managerial costs that occur only during the planning and designing phase (decision making at strategic level)	EURO - € (or other monetary unit)	SCS, PA

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Investment costs	Total additional capital costs for setting up an initiative, demonstration, action or measure in a pilot or case study (e.g. cost of vehicles, new technology, equipment, infrastructure purchased, rent or leased in each city case or required land acquisition.	EURO - € (or other monetary unit)	SCS, PA
		Management	Cumulative amount of money spent on management.	EURO - € (or other monetary unit)	SCS
		Wages	Cumulative amount of money spent on wages	EURO - € (or other monetary unit)	SCS
		Fuels	Cumulative amount of money spent for fuel. (cost per unit x unit of fuel)	EURO - € (or other monetary unit)	SCS
		Warehousing and/or handling	Cumulative amount of money spent for warehousing and / or cargo handling	EURO - € (or other monetary unit)	SCS
		Transhipment	Cumulative amount of money spent for cargo transshipment	EURO - € (or other monetary unit)	SCS
		Depreciation infrastructure	Cumulative amount of money associated with infrastructure depreciation	EURO - € (or other monetary unit)	SCS
		Depreciation equipment	Cumulative amount of money associated with equipment depreciation.	EURO - € (or other monetary unit)	SCS
		Training	Cumulative amount of money spent on staff / personnel training.	EURO - € (or other monetary unit)	SCS
		Personnel	Cumulative amount of money spent on staff for maintenance activities. (persons x duration x wage/person)	EURO - € (or other monetary unit)	SCS
		Equipment/ materials/ infrastructure	Cumulative amount of money spent on equipment and infrastructure for maintenance activities	EURO - € (or other monetary unit)	SCS
		Consumer cost	Product cost charged to the end customers (final consumer) including delivery cost	EURO - € (or other monetary unit)	SCS, OS
		Enforcement cost	Total cost usually spent by the local or regional authority for enforcing changes in transport situation and / or involved in the realization of supplementary policy measures.	EURO - € (or other monetary unit)	SCS, PA

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Shipper/ receiver costs	Amount of money paid by the shipper/receiver for shipping/receiving a product or service unit.	EURO - € (or other monetary unit)	SCS
		End of life associated costs (infrastructure)	Amount of money needed for rehabilitation or demolition of associated infrastructure.	EURO - € (or other monetary unit)	SCS, PA
		End of life associated costs (equipment)	Amount of money needed for the withdrawal of obsolete equipment, hardware, software etc. at the end of their life in order to be replaced by new, more sophisticated and integrated, advanced.	EURO - € (or other monetary unit) / item	SCS, PA
	Economics and financial risks	Tax changes	The level of tax changes (mainly increase) which can influence the budget of the project.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Inflation	The level of influence of changes in inflation rate on UFT measures	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Unstable economic situation of the country	The level of influence of unstable economic situation of a country on a UFT measure's implementation	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Rising costs	The level of influence of the rising cost of fuel, machines and materials on the budget of implementing UFT measures	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Payroll and tax increase in transportation sector in the region	The level of influence of the increase in payrolls and tax payments in transportation on the budget of UFT implementing measures	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Reduction of the foreseen capacity of freight transport system in a city	The level of changes in the budget of the UFT measure (project) caused by a reduction of the projected capacity of freight the transport system in a city	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Excessively high maintenance costs of a UFT activity	The level of cost increase in the budget of a measure caused by unexpected higher maintenance costs of the investment	Likert scale {1 (lowest value) - 5 (highest value)}	SCS

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Inadequate budget assessment	The level of differences between planned and executed budget	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Poor financial situation of stakeholder	The number (in percentage) of actors and stakeholders who have financial problems	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Shortfall of funds in the budget	The level of shortfall of funds in the budget in comparison to the planned budget	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Delayed receipt of funds	The range of delays in funds being received in relation to the schedule	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		UFT activity economic aging	The duration (in years) of the economic aging of a measure	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Funding opportunities and/or investment options	The range of opportunities for funding or and/investment options while planning and implementing UFT measures	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
Environment	Air quality	CO concentration	The maximum daily 8 hour mean CO concentration. Modelling or estimation on concentrations taking into account the percentage of freight transport and vehicle fleet composition (EC, 2015).	mg/m3	PA, OP
		SO_x concentration	The averaging SOX concentration for a 24h period. Modelling or estimation on concentrations taking into account the percentage of freight transport and vehicle fleet composition (EC, 2015).	µg/m3	PA, OP
		NO_x concentration	The averaging NOX concentration for a period of 1 year. Modelling or estimation on concentrations taking into account the percentage of freight transport and vehicle fleet composition (EC, 2015).	µg/m3	PA, OP
		VOC concentration	The averaging VOC concentration for a period of 1 year. Modelling or estimation on concentrations taking into account the percentage of freight transport and vehicle fleet composition (EC, 2015).	µg/m3	PA, OP

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		NH_3 concentration	The averaging NH3 concentration for a period of 1 year. Modelling or estimation on concentrations taking into account the percentage of freight transport and vehicle fleet composition (EEA, 2014).	μg/m3	PA, OP
		PM_{10} concentration	The averaging PM10 concentration for a period of 1 year. Modelling or estimation on concentrations taking into account the percentage of freight transport and vehicle fleet composition (EC, 2015).	μg/m3	PA, OP
	GHG emissions	CO_2	Total CO2 emissions produced (based on vehicle type, Veh-km, and fuel type)	kg	PA, OP
		CH_4	Total CH4 emissions produced (based on vehicle type, Veh-km, and fuel type)	kg	PA, OP
		N_2O	Total N2O emissions produced (based on vehicles type, Veh-km, and fuel type)	kg	PA, OP
	Noise	Noise level	Modelled / measured (based on vehicle type and speed).	dB(A)	PA, OP
Transport & mobility	Level of service	Punctuality	Proportion of deliveries and pickups made in the right time slot.	Percentage (%)	SCS
		Quantity	Proportion of deliveries and pickups made in the right quantity (no loss or theft).	Percentage (%)	SCS
		Quality	Proportion of deliveries and pickups made in the right form (i.e. not damaged).	Percentage (%)	SCS
		Market response	The proportion of times that products where available at the receiver (at the time desired by the consumer).	Percentage (%)	SCS, OP
		Customer satisfaction	The perceived customer satisfaction stated by customers based on their experience.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, OP
		Supply chain visibility	Information accessible, real time updated and visible by all interested stakeholders via internet.	Likert scale {1 (lowest value) - 5 (highest value)}	SSC, PA, OP
	Safety and security	Accidents	Number of accidents on site (e.g. UFT facility) and en route per total vehicle km covered by UFT activities' vehicles.	Number / veh-km	SCS
		Fatalities	Number of fatalities in accidents on site (e.g. UFT facility) and en route per total vehicle km covered by UFT activities' vehicles.	Number / veh-km	SCS

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Injuries	Number of injuries in accidents on site (e.g. UFT facility) and en route per total vehicle km covered by UFT activities' vehicles.	Number / veh-km	SCS
		Damages	Number of damages (property damage only) in accidents on site (e.g. UFT facility) and en route per total vehicle km covered by UFT activities' vehicles or per shipment.	Number / veh-km or Number / shipment	SCS
		Crime/ theft events	Number of incidents involving crime / theft in facilities or en route over total number of shipments	Number / shipment	SCS
		Vandalism	Number of incidents involving vandalism in facilities or en route over total number of shipments	Number / shipment	SCS
	Transport system	Delays	Total delays in traffic	Veh-hrs	SCS, PA, OP
		Violations	Number of violations over the total number of entries in restricted areas (e.g. LTZs or pedestrian zones) or circulation lanes dedicated only to authorised users focusing on UFT vehicles.	Percentage (%)	SCS, PA
	UFT vehicles	Traffic throughput	Number of veh-km	Veh-km	SCS, PA, OP
		Load factor	Average load factor of a vehicle during deliveries and pickups.	Percentage (%)	SCS, PA
		Vehicle utilisation factor	Hours that vehicles are in service, e.g. deliveries, pickups, transporting, weighting, loading/unloading over 24 hours	Percentage (%)	SCS
	IT, infrastructure and technology	Underdeveloped transport infrastructure	The level of changes in the schedule and cost of a measure's implementation caused by underdeveloped transport infrastructure or the lack of it	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Low quality of transport infrastructure	The level of changes in the schedule and cost of a measure's implementation caused by low quality of transport infrastructure	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Limitations at developing and changing the existing infrastructure	The level of changes in the schedule and cost of a measure's implementation caused by low quality of transport infrastructure	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Lack of or limited access to modern technologies	The level of changes in the schedule and cost of a measure's implementation caused by lack or limited access to modern technologies	Likert scale {1 (lowest value) - 5 (highest value)}	SCS

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Lack of information technologies (IT)	Percentage of actors and stakeholders who do not have IT dedicated to freight transport or/and existing IT infrastructure is obsolete or is not enough to commence a UFT measure's implementation	Percentage (%)	SCS
		Incorrect assumptions for the development of IT prototype	Percentage of actors and stakeholders whose needs weren't taken into account while developing an IT prototype	Percentage (%)	SCS
		Failures of IT systems and other modern technologies	The duration (in days) of disruption of a UFT measure's implementation caused by failures of IT systems and other modern technologies	Number	SCS
		Conflicting interfaces of work items	Number (in percentage) of actors and stakeholders who have conflicting interfaces of work items while implementing UFT measures	Percentage (%)	SCS
		Hacker disturbance	The duration (in days) of disruption of UFT measures implementation caused by problems with IT caused by hackers	Number	SCS
		Network barriers	Evaluation of accessibility level pertaining the seamless movement of freight vehicles because of infrastructure and constructive configuration (e.g. street narrowness and dimensioning especially inside historical centres).	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA, OS
		Urban space engagement	Urban space engaged for the storage, loading / unloading, handling or transshipment of cargo and for parking of freight vehicles inside urban area over total urban area where UFT activities take place.	Percentage (%)	SCS, PA
		Infrastructure usage	Degree of usage of infrastructure (e.g. hours / day or equipment and space engaged over total).	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
Society	Greening	Green reputation	Reputation of involved stakeholders towards implementing "green" measures.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Green concern	Degree that the involved stakeholders are oriented towards environmental preservation resulting from the measure implementation.	Likert scale {1 (lowest value) - 5 (highest value)}	PA, OP
	Convenience	Perceived visual and audio nuisance	Degree to which people are annoyed by the visual and audio nuisance, caused by goods' deliveries in the city.	Likert scale {1 (lowest value) - 5 (highest value)}	OP

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Diffusion of information	Public satisfaction concerning the diffusion of information and the informative channels and tools used to get the public acquainted with the modification of mobility standards due to goods’ deliveries in the city.	Likert scale {1 (lowest value) - 5 (highest value)}	OP
	Living standards	Perceived alternative mobility	Citizens' recording of increase in the use of environmental friendly modes and ways for goods’ deliveries in the city.	Likert scale {1 (lowest value) - 5 (highest value)}	OP
		Quality of life	Evaluation of quality of level, addressed by land use optimization, e.g. number of LTZ’s with time windows or full access restrictions for goods’ deliveries, detachment of UFT activity areas from city centre or isolation of them in special district, regulatory separation of UFT vehicles from the rest of traffic and other network users etc.	Likert scale {1 (lowest value) - 5 (highest value)}	SSC, PA, OP
		Changes in legislation at European and national level	The range of changes in legal regulations introduced at European and national level, which can have a negative influence on a UFT measure's implementation	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA
		Changes in legislation at city level	The range of changes in legal regulations introduced at a city level, which can have a negative influence on a UFT measure's implementation	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA
		Changes in the guidelines for obtaining permits for various types of investments	The range of changes introduced by a local authority (or other institutions) in the guidelines for obtaining permits for investments undertaken in a project (measure) which can cause problems with UFT measures' implementation	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA
		Extending the duration of the implementation of UFT activities due to delays for obtaining permits from local governments	The level of delays in obtaining permits from a local authority or other institution can cause overall UFT projects (measure) slips	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP
		Uncertainty of continuation of earlier activities	The level of dependency of a UFT project's (measure's) implementation on a local authority	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Changes in consumer behaviour society	The range of changes in consumer behaviour society which influences the management of a UFT project (measure)	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP
		Aging society	The level of influence of an aging society (citizens over 65) on the management of a project (measure) which may require a more complex approach to the measure's implementation	Likert scale {1 (lowest) - 5 (highest value)}	PA, OP
		Large cultural diversity of society	The level of influence of cultural diversity of society, understood as "manifold ways in which the cultures of groups and societies find expression", on the management of a UFT project (measure)	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP
		Lack of awareness of UFT impacts	The level of awareness of UFT stakeholders of the impact of freight transport on environment	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Bad habits of UFT users	The range of UFT stakeholders who have poor managerial habits in the field of UFT	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Protest interference of nearby residents	The duration of the protests and interference of nearby residents which have an influence on the management of a UFT project (measure)	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA
		War	The level of changes in the schedule of a measure's implementation caused by war	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Riots, strikes	The level of changes in the schedule of a measure's implementation caused by riots, strikes	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Natural disasters	The level of changes in the schedule of a measure's implementation caused by natural disasters	Likert scale {1 (lowest) - 5 (highest value)}	SCS
Policy and measure maturity	Awareness	Awareness level	Knowledge of the goods' delivery systems that are used in the city.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA, OP

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
	Managerial risks	Different organisational cultures	The range of different organizational cultures (standards, norms, decision making process, etc.) represented by UFT stakeholders	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP
		Lack of involvement of stakeholders	The range of involvement in the UFT measure's implementation from representatives from municipality departments whose tasks relate to the area of implementing measures	Likert scale {1 (lowest) - 5 (highest value)}	PA
		Excessive bureaucracy	The level of bureaucracy (frequency of developing detailed reports and other documents) while planning and implementing measures	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA
		Large number of stakeholders	The proportion of trade and transport companies from the SME sector in the group of all companies from this sector interested in a UFT measure's implementation	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Lack of or insufficient number of employees	Position of employees responsible for UFT in an organizational structure of a city council	Likert scale {1 (lowest) - 5 (highest value)}	PA
		Lack of or insignificant number of UFT stakeholders	The range of UFT stakeholders' involvement in the process of a measure's planning and implementing	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP
		Information flow problems	Range of implemented standards and procedures on information flow and communication among stakeholders	Likert scale {1 (lowest) - 5 (highest value)}	SCS, OP
		Lack of strong leadership	Position of leadership in planning and implementing measures	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Lack of proper organisation of tasks	The manner of organization and assignment of tasks to particular members of the team (actors, stakeholders) while planning and implementing measures	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Time planning misjudgement	The range of delays in funds being received caused by the wrong assessment of time	Likert scale {1 (lowest) - 5 (highest value)}	SCS

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Breach of contract by subcontractor	The level of breach of contract by subcontractors	Likert scale {1 (lowest) - 5 (highest value)}	SCS
		Poor or lack of know-how	The level of know-how and experience of project teams in planning and implementing UFT measures	Likert scale {1 (lowest) - 5 (highest value)}	SCS, OP
		Diversity of stakeholders	Number (in percentage) of actors and stakeholders who have completely different requirements in terms of measure implementation	Percentage (%)	SCS, PA, OP
		Lack of cooperation	Number (in percentage) of actors and stakeholders who do not want to cooperate in terms of UFT	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP
		Data sharing restrictions	Number (in percentage) of actors and stakeholders who do not want to share data on UFT with other actors and stakeholders	Likert scale {1 (lowest) - 5 (highest value)}	SCS, PA, OP
		Lack of knowledge about stakeholders' requirements	Percentage of actors and stakeholders whose requirements toward UFT are not investigated	Percentage (%)	SCS, PA, OP
		Misestimated cargo flows	Forecast error (understood as mean absolute percentage error - MAPE) about the volume of cargo flows	Percentage (%)	SCS
		Lack of data on UFT	The range of UFT data availability (in %)	Percentage (%)	SCS, PA, OP
		Failure to inform the public	Percentage of the public (citizens) who hasn't been informed about the implemented/implementing measure	Percentage (%)	SCS, PA
	Background	Experience	Analysis of results and findings from past projects and studies elaborated for this city in the same field	Likert scale {1 (lowest value) - 5 (highest value)}	PA
		Research	Level of current research on the adoption and implementation of new, innovative city logistics policies and measures	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Replication	Replication of policy or measure already implemented in another city as good practice	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Planning	Existence of related policy at local, regional or national level, regulations, master / action plan or stakeholder consensus or commitment contracts (e.g. MoUs or partnerships) towards the realization of policies and measures	Likert scale {1 (lowest value) - 5 (highest value)}	PA
Social acceptance	Social approval	Public acceptance	Attitude (behavioural change) towards intervention or degree to which people favourably receive or approve the measures, policies and any changes in UFT activities' organisation	Likert scale {1 (lowest value) - 5 (highest value)}	OP
		Social consciousness	Level of maturity and approval of new city logistics' policies and measures from the part of the local residents. Adaptability and transferability readiness, consciousness and receptiveness	Likert scale {1 (lowest value) - 5 (highest value)}	OP
		Adjustability	Level of applicability and incorporation of innovative city logistics' measures and policies in UFT activities' business as usual operability, after having been approved, accepted, successfully replicated and adopted by the involved stakeholders (including the public authorities and local community / society)	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA, OP
		Final user awareness	Percentage of stakeholders (e.g. SMEs) in the area of interest being informed before / after the beginning of the pilot deployment phase	Percentage (%)	OP
		Final user acceptance	Percentage of stakeholders (e.g. SMEs) in the area of interest using the service before and after the beginning of the pilot deployment phase	Percentage (%)	SCS, PA
		City authority's popularity	Percentage of society (public) being in favour of the current city authority's policy concerning UFT activities' organization, administration and management (not necessarily pertaining only the city case activities, but in a more generic and integrated framework.	Percentage (%)	OP
		Decision making acceptance	Number of positive / negative votes (alternatively "likes" and "dislikes" or positive / negative comments on Facebook and / or Twitter) when City authority sets decisions including policies and measures on UFT activity under public consultation	Percentage (%)	OP
	Regulations' acceptance	Compliance with regulations	Degree to which regulations are respected by the general public.	Likert scale {1 (lowest value) - 5 (highest value)}	OP
		Enforcement	Easiness of compliance with new measures, rules and regulations.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, OP

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
		Eco-driving practice before the journey	Professional drivers' intentions to practice eco-driving before they start the journey, e.g. vehicle proper maintenance, trip planning and use of on-board devices, "light" travel, etc.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Eco-driving practice during the journey	Professional drivers' intentions to practice eco-driving during the journey, e.g. compliance with speed limits, smooth acceleration and braking, minimization of the use of heating and air-conditioning.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
		Motivation for eco-driving practice	Compliance with eco-driving practice for fuel savings, reduction of pollution emissions, and increase of road safety.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS
User uptake	Flexibility	Penetration	Degree of city case policies and measures' penetration and integration in local or regional UFT policy.	Likert scale {1 (lowest value) - 5 (highest value)}	PA
	Stakeholder approval	Stakeholder acceptance	Stakeholder attitude towards the implementation of policies and measures or any changes in the city's UFT activities' layout	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, OP
		Stakeholder percentage	Percentage of stakeholders per stakeholder category in favor of the deployment of the policies and measures involved in city case	Percentage (%)	SCS, OP
		Adoption rate	Percentage of involved stakeholders willing to use, adopt or implement the city case concept beyond project duration.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Promotion	Correct specification of the benefits or of the first outcomes and successes of the major stakeholders, obtained for a given city logistics solution.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
		Integration	Potential integration and compliance with the key internal/external schedules of the stakeholders involved.	Likert scale {1 (lowest value) - 5 (highest value)}	SCS, PA
	Consensus	Contracting	Stakeholders (including private and / or public) signed special agreements such as FQP, MoU, Freight Master Plan etc. engaged to comply with special rules and regulations on UFT activities and operations.	Number or percentage (%)	SCS, PA

Impact area	Criterion	Indicator	Explanation/ comments	Data/unit	Stakeholder category
	Transferability	Replication	Percentage of involved stakeholders willing to introduce the city case concept to other partners in UFT market, replicating good practice methods, results and findings.	Percentage (%)	SCS, PA
	Success	Success rate	Percentage of city case policies and measures planned to be replicated by other cities within or beyond project duration.	Percentage (%)	SCS, PA

Annex E. Weighting methodologies

Over the last decades, many studies have been developed presenting several weighing methods. Weighing is the process of comparing two or more elements, according to decision maker's preference. While weighing is performed by following different methods, there is a standard principle: the higher the weight, the more important the corresponding element is. In literature the four most prevalent methods in terms of simplicity and effectiveness are: Pairwise Comparison method, Delphi method, Ratio Method and Rank Order Centroid method.

1. The Pairwise Comparison method

Analytical Hierarchy Process (AHP) is considered the most-widely method used for multi criteria analysis into the transportation and urban logistics fields. The results of a sample analysis confirm the frequent applicability of the method. One of the advantages of the AHP method compared to other methods is that it can deal with the same easiness level with intangible and tangible aspects and support multi objective, multi criteria and multi actor decisions. This aforementioned ability in combination with other strengths of the AHP method such as: usage in a very wide spectrum of fields, easiness of comprehend its function, flexibility and easiness for appliance into a high number of criteria set, allowance for the interdependence of different criteria and usage of both monetary and non-monetary scale, render the AHP a very flexible and robust method for evaluation.

Weighing by pairwise comparison is a method that stems out the AHP decision making framework and is performed in 3 steps:

- Comparison of each element with the rest of the elements of the component and provision of a preferential level to the element for every comparison performed.
- Calculation of elements' weights and normalization of their weights.
- Statistical assessment of the consistency of the weights matrix.

2. Delphi method

The Delphi method is a method first developed in U.S. Air Force in 1950. In the context of this method, panels by experts or involved stakeholders are formed and several rounds of interrogative communications on a topic start, coordinated by a director. Aim of these communications is the exchange of information, ideas, comments and opinions among the panels in order to achieve consensus. The director is responsible to provide the panels with a questionnaire and the panel members should assign weights to each element along with justification. Based on the justification, other panels can evaluate (accept, reject or modify) the weighing performed. This process continues for several rounds until there is a convergence of weights to the elements and final catholic consensus. The Delphi method is mostly suitable for low number of compared elements; otherwise the whole process may take too long to complete.

3. Ratio method

The Ratio method is a simple method of weighing suitable for a number of compared elements such as the pairwise comparison. Ranking is given outright to all elements based on their importance and then the elements are weighed according to the ranking. To the lowest ranked element a 10 value is given. To the rest elements multiples of 10 are assigned (the multiples should not be necessarily consecutive) and then, they are normalized. Two disadvantages of the ratio method are that any increase in weights comes from subjective justification and that the ranking may be proved to be a complex procedure, given that the number of the elements is high.

4. Rank Order Centroid method

The Rank Order Centroid method follows the structure of the ratio method by ranking all elements. The difference lies in the weighing process. In this method, the decision-maker is not responsible to assign weights to the elements, but the weights are derived from (32).

$$W_i = \left(\frac{1}{M}\right) \cdot \sum_{n=1}^{M} \frac{1}{n} \quad (32)$$

Where:

$M = numeber\ of\ items$

$W_i = weight\ for\ the\ i^{th}\ item$

The Rank Order Centroid method 'carries' the same drawback with the ratio method regarding the ranking of the elements when the number of them is high. In addition to that, the weights generated by the formula are highly dispersed.

Annex F. **Normalization methodology**

Using indicators of different context, nature and values in a common assessment methodology, requires establishment of a commensurate scale, thus making indicator values dimensionless. This is achieved by normalization of values of each criteria and indicator into the set of dimensionless real numbers. Data normalization consists of rescaling the attribute values of the data into a single specified range, such as from 0 to 1 or from 0 to 100.

There are several normalization methods available in literature, therefore only major, most influential methods of normalization will be mentioned here. A summary of other normalization methods applied in different occasions can be found in OECD (2008). Also, research on the methodology for choosing the best normalization method based on a set of criteria and on the proper matching of type of normalization in accordance with preferences of the decision-maker is scarce. Equations (33) (*Normalization by comparison with the best alternative method*) and (34) (*Classic normalization method*) present the most used normalization methods, where $\bar{r}_{ij}$ denotes the transformed and normalised value of I_{ij} for alternative *i* and indicator *j*.

$$\bar{r}_{ij} = \frac{I_{ij}}{max_j I_{ij}} \tag{33}$$

$$\bar{r}_{ij} = \frac{I_{ij}}{\sum_{j=1}^{m} I_{ij}} \tag{34}$$

In cases that the difference between indicator values are insignificant, methods A and B avoid the introduction of high distortions. These two methods avoid mapping the indicator values into the same interval [0,1] as *Max and min normalization method* does (Equation 35); therefore the same importance is not assigned to values of an indicator of a small and insignificant range as well as to values of other indicators, where deviations are greater. However, previous methods map values of such indicators to very small intervals. Additionally, these two methods can be used for the assessment of as low as two alternatives without introducing only values of zero and one by conserving the proportionality between indicators.

$$\bar{r}_{ij} = \frac{I_{ij} - min_j I_{ij}}{max_j I_{ij} - min_j I_{ij}} \tag{35}$$

In *Max and min normalization method* the best option is indicated with a 1 and the worst with a 0, and all other values are rated between these values. This makes it possible to compare the results of various indicators. This method accounts for the best and the worst values and it maps all values of indicators to the same interval [0, 1] irrespectively of index of indicator *i*. In this method extreme indicator values/or outliers could significantly affect the final index. In cases with large values and high deviations are perceived, this method maps indicator values to the range between 0 and 1 and thus making their differences significant without conserving the proportionality between indicators. The *Vector normalization method* (Equation 36) and *Statistical z score method* (Equation 37) are given below.

$$\bar{r}_{ij} = \frac{I_{ij}}{\sqrt{\sum_{j=1}^{n} I_{ij^2}}} \tag{36}$$

$$\bar{r}_{ij} = exp^{-z^2/2} \tag{37}$$

Where:

$$z = \frac{(I_{ij} - I_i^0)}{\sigma_i}$$

I_i^0 = mean of the indicators.

σ_i = deviation standard of the indicators.

Statistical z score method converts indicators to a common scale with a mean of zero and a standard deviation of one. Indicators with extreme values have a greater effect on the final index (OECD, 2008). In cases with targeted or desired indicator values due to decision maker's perception, this method should be considered.