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Analysing the impacts of technology in City Logistics projects

Supervisor:

Prof.ssa Anna Corinna Cagliano

Co-supervisor:

Prof. Giovanni Zenezini

Candidate:

Jeremy Pession

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Introduction

City Logistics is a new field of study that is gaining more and more attention from society because the externalities caused by urban freight transport are significant. This thesis aims to identify which technologies and innovations are the most used to manage these activities in urban areas, what their impacts are on project results and to evaluate the strengths and weaknesses of each technology.

The starting point of this thesis is the analysis of different literature sources in which some research gaps are found, like the few productions of works that analyze the impacts caused by these technologies, and this work aims to contribute to filling them up.

The methodology used consists of a two-steps approach. The first one is the identification of city logistics projects for detecting which technologies were used and which results were obtained. The second step is to assess the impacts that these technologies might cause by looking at specific scientific articles. In this kind of documents, it is easier to gather detailed and trustable information about the single solution used in the project.

The output of this thesis includes also the realization of a dataset, in the form of two tables, containing information about the impacts of the most important technologies deployed and the summary of different City Logistics projects results carried out in recent years. This dataset may become a useful tool in the hands of who wants to run a new initiative in the context of Urban Logistics, like authorities, researcher groups or private companies. In fact, since the current knowledge of this thematic and previous examples of those initiatives are reported in the dataset, they can easily have access to the main results achieved and they can evaluate if the technology, once deployed, might be successful or not in their context.

This thesis is organized in 5 chapters.

Chapter 1 is an introduction to City Logistics. The chapter treats the concepts of city logistics by reporting some definitions, by identifying the main stakeholders and the main solution adopted to overcome the externalities caused by logistics activities in the urban area.

Chapter 2 is “Research background and motivations” and it is about the presentation of the most recent Literature reviews that study how the scientific world has treated the topic of city logistics over the years. The motivations of the thesis are found from these studies because some research gaps are identified.

Chapter 3 describes the adopted methodology. It is organized in 2 parts: “Data collection” and “Data analysis”. The former consists of describing how the information has been gathered, which sources have been selected and it is reported a brief description of the contents identified. The latter consists of analyzing all the information collected to derive some conclusions.

Chapter 4 reports the results of the thesis. In the first part, there are the descriptions of the impacts that technologies may have on city logistics projects. In the second part, there is the focus on each technology identified, by firstly describing it and then by reporting its impacts.

In chapter 5 there is the discussion of the contents of the previous chapters and the conclusions are drawn.

According to the achieved results, in a City Logistics perspective, the most studied technologies seem to be electric vehicles, cargo bikes and the concept of crowdshipping, in fact, there is already a large literature available that treats these topics, instead there are few studies about other technologies like 3D printing or autonomous delivery robot. The results show that the technologies might have positive or negative impacts on 5 macro-areas. They are the following: “Economic impacts”, “Operating impacts”, “Environmental impacts”, “Social impacts” and “Other impacts”. In this work, each technology identified is treated by discussing its relative impacts in those macro impact areas. However, since urban areas are a challenging environment for the supply chain management, taking into account that each city has a different configuration like different rules for accessing the LTZ, different traffic conditions, different habitants behaviors and many others, it is possible that the results obtained by adopting the same technology in different cities are not the same, even strongly discordant.

1 What is City Logistics?

1.1 Definition of City Logistics

The supply chain is the network made by all the parties involved in the transformation of raw materials into finals good in order to provide a certain service level to final customers. City Logistics is the combination of two words, city and logistics. Thus, before giving a definition of it, it is important to define the term of Logistics. Logistics is responsible to obtain an efficient management for the storage and the transportation of materials through the Supply Chain. Among the literature several definitions were given and following it is proposed the one of the U.S. Council of Logistics Management: "*Business logistics is the term describing the integration of two or more activities for the purpose of planning, implementing and controlling the efficient flow of raw materials, in-process inventory and finished goods from the point of origin to point of consumption. These activities may include, but are not limited to customer service, demand forecasting, distribution communications, inventory control, material handling, order processing, parts and service support, plant and warehouse site selection, procurement, packaging, return goods handling, salvage and scrap disposal, traffic and transportation and warehousing and storage*" [1].

City Logistics focuses on providing techniques and procedures to be deployed when goods travel in urban areas. Here, there are many more constraints than areas outside cites and so it becomes a challenging environment for supply chain managers. First of all, each city is different from the others, hence finding a unique solution to solve city logistics problems is not always possible. Sometimes the activities done in one city could fit in that context, but the implementation of the same activity in another city could lead to negative effects. Then, the presence of limited traffic zone, different regulation for traffic control set by city councils, high congestions, frequently changing in the mobility due to road works, availability of parking spots or different configuration of roads as their wideness or number of lanes, make the arise of new problems and challenges, consequently, Logistics is treated as a specific field. City Logistics is the implementation of activities aimed to deliver goods to stores or directly to final customers, but also the process of collecting goods or wastes in cities may be considered. Hence, who does business in these areas principally organizes shipments either in a Business-to-Business or Business-to-customers configurations. On doing this, managers must take into consideration and try to minimize the impacts, that urban freight transportation causes to the quality of life in cities like air pollution, noise, vibration and more.

After a brief introduction, here, it is proposed the definition of City Logistics provided by Taniguchi et al. (1999) already in the 1999: "*the process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy*" [2].

1.2 Why City Logistics is gaining more and more attention

Nowadays, it is possible to recognize some trends that make City Logistics topic gaining always more attention [3]. The main drivers of this phenomenon are:

- the urbanization trend
- the fast e-commerce growth
- The increasing environmental sustainability awareness

1.2.1 Urbanization aspect

Humankind has an inherent need to socialize, this has brought to the born of the first villages, then became cities, keep on growing until reaching a big dimension as the modern metropolitan centers. The drivers of this trend were the industrial revolutions, in which people started to move from the countryside to cities, for working in the factories. More people in the cities mean the arising of new problems from a logistics perspective [4].

All the forecasts regarding the city trends show that in the future there will be always more people who are going to live in the cities, thanks to the population global growth and the positive tendency of urbanization. This is what it is possible to figure out from figure 1.1, where UN DESA (United Nations Department of Economic and Social Affairs) collected data to compute the urbanization from 1950 to 2015 and to predict future values until 2050. A clear positive trend is highlighted in the figure, the current urbanization rate is about 53.90% and it is forecasted to reach 68.40% in 2050 [5]. For this reason, it is becoming necessary to figure out new logistics solutions to optimize the shipments in these environments, always more crowded and complex.

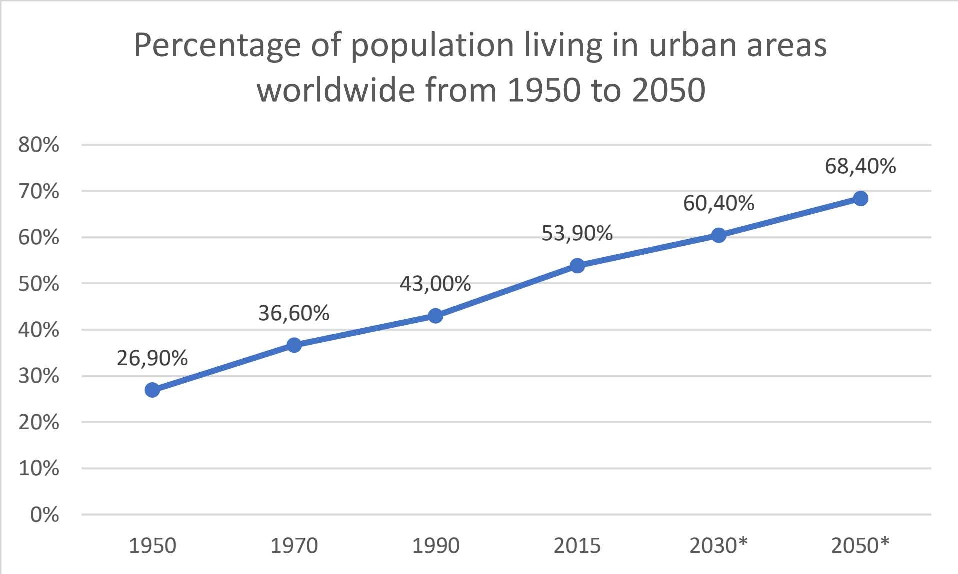

Figure 1.1: Percentage of the population living in urban areas worldwide from 1950 to 2050 [5]

1.2.2 E-commerce aspects

The Internet allowed the origin of e-commerce, where consumers have the opportunity to buy goods and services directly from the internet without the necessity of visiting physically the stores. This phenomenon had led to a really deep change in the society and it opened the door to new challenges for logistics operators. In the traditional setting of e-commerce, goods are delivered directly to final customers. The conventional way for the parcel delivery is usually done by vans, this means that drivers must take much more breaks for the downloading process than the traditional selling, because in the latter customers are the ones who have to reach stores for their purchases and vans must download parcels in only few points. An increase in E-commerce leads to an increase of these operations in the city and the arising of all the problems related to city logistics, thus a better management of the freight transportation in urban areas is required.

If it is true that the internet is the technology which allowed the birth of e-commerce, it is also true that smartphone is the technology which boosted the new way of doing commerce. Thanks to the smartphone always more persons have access to the internet and to visit the digital stores, indeed in the first quarter of 2019 64% of retail website visits were made through smartphone devices, 29% through desktop and 6% through tablets according to the Salesforce Research [6]. Furthermore, the development of the virtual stores and their app, are another important impact that smartphones had caused to the e-commerce sector, providing an easier, more comfortable and faster way to purchase goods.

Who is able to surf on the internet becomes immediately a potential customer for e-commerce companies. According to ITU (2018), the number of internet users worldwide in 2005 was 1024 million and the number forecasted for 2018 was 3896 million users, an increase of more than 280% is registered over those years [7]. Furthermore, the penetration rate pass from 15.8% in 2005 to the forecasted one of 51.2% in 2018, an increase of more than 228% [8].

Hence, for all the reasons shown above, the growth in the e-commerce sector is expected to keep on in the close future. As it is reported in figure 1.2, the percentage of e-commerce sales over total global retail sales had a fast growth in recent years, and it is expected to grow up to 22% in 2023.

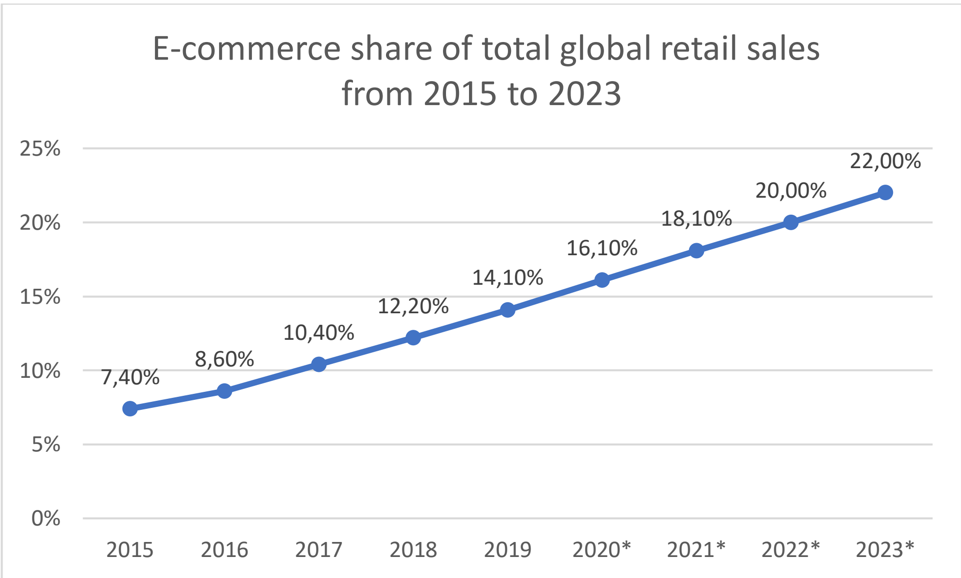

Figure 1.2: E-commerce share of total global retail sales from 2015 to 2023 [9].

Furthermore, Big players are present in the market. Alibaba group and Amazon are the two largest digital retail stores in the world, the former runs its business primarily in eastern countries and the latter in western countries. It is necessary to take into consideration these two big companies, because they can exercise their big market power, influencing logistics operations and exploiting their lobbying power.

1.2.3 The increasing environmental sustainability awareness

Climate changes are evident to most of the people nowadays. The society during these last years tried to opt for more environmentally sustainable solutions, in order to reduce gas emission, trying to improve air quality for a better human life condition. As it will be shown later, UE has had a great contribution to promote initiatives for achieving a more sustainable city environment by financing many European Projects [10]. The effort in the shifting to a more sustainable business comes not only from the public sector with incentives, new regulations, new operational strategies, etc, but also from the private sector that is active in this effort. In some cases, private companies try to opt for friendly environmental solutions, even if at the current state they result to be worse. In this case, they want to become pioneers in their sector and they want to target a specific demand segment made by people sensible to these thematic. Sustainable solutions can be an effective marketing tool that the logistics operators can choose for running their activities, even in the cities, and gaining a better brand image.

This argument is supported by the global trends to more sustainable projects and by several surveys collected from final consumers. For example, according to Bloomberg New Energy Finance; UNEP; FS-UNEP Collaborating Centre [11], the new investment in clean energy worldwide increased from 45.2 billion $ in 2004 to 288.3 billion $ in 2018. An online survey to 1000 respondents made by Motivaction in 2018 shows that in the Netherlands the 35.5% of respondents were sustainable consumers, 33.7% consumers with the intention to be sustainable and only 30.9% were consumers with no interest in sustainability [12]. A similar survey was made by Insight Intelligence; SEB Bank; Svensk Handel; SydGrönt; Hertz, in which 1000 Swedish respondents were required to answer the following question: "*To what extent do you consider sustainability to be important?*". The results show that the 66% of Swedes consider sustainability importance "very large extent", 29% "quite large extent", 1% "uncertain, do not know" and only a 4% consider it either "quite small extent" or "very small extent/not at all" [13]. In Italy, the survey made by Findomestic to 751 respondents in the 2018 shows that more than 43% choose sustainability for "I want to take part to protection of the environment", the 37% "I want to take part to well-being of the next generations" and only the 5% "not interested in the topic[14].

The examples above wants to show that at least in some markets, there are a great segment of consumers aware of sustainability when they are making their purchasing decisions. Who is operating in the City Logistics industry must take into account them by trying to pursue a better environmental condition.

1.3 City Logistics stakeholders

In city logistics, different stakeholders are present with different claims and in order to define the impacts that the technology causes to a city logistics project, a previous identification of them is necessary. The main stakeholders identified in a city logistics project are the following [15]:

- Customers
- Producers and shippers
- Employees
- Society
- Public authorities

1.3.1 Customers

In the paragraph 1.1, it was already mentioned that city logistics activities could have two different configurations of business: B2B and B2C. The former concerns couriers who deliver to stores and the latter concerns couriers who deliver directly to final customers. Both of them want to have a high service level, low price for the services and short-time deliveries. According to CTL (2012) [16], the Business-to-Business shipments generates in the EU-27 market the 80% of the total revenues of the sector and the other 20% is created from shipments directly to final customers.

The shipping time becomes an important requirement in the case of B2B. In fact, their claims could be to pursue a Just in Time philosophy in order to reduce as much as possible the stock level inside their inventories. JIT is possible only in case logistics companies are able to run their business efficiently and with distribution centers close to them. According to a survey to logistics executives and supply chain executives from retail, conducted by Supply Chain & Logistics Business Intelligence [17], 65% of their customers (merchants) want delivery flexibility, 61% speed of delivery, 51% real-time visibility, 45% delivery options, and the 41% a specific delivery slot selection.

According to the survey done by IPC (2019) [18], the delivery points selected by final customers are: home in the 68% of the cases, post office in the 23%, 15% for office and workplace, 10% for parcel lockers and 7% for neighbor's home. A well-known challenge for Logistics companies is that customers are always more demanding, because they have access to more information, switching costs are reduced and the high competition in the market leads the customers to gain always more bargaining power.

1.3.2 Producers and shippers

Included in this category there aren't only companies which their primary activities are related to the shipment service, as courier companies, but also enterprises that have to deliver in cities their products with their own fleet. Their aim is the achievement of the highest customer service by taking costs as low as possible.

According to IPC. (2019) [19] the main players in the world that provide parcel deliveries for online shopping are DHL with a rate of about 3%, UPS, DPD, GLS, FedEx 1% and 71% of the cases Post. Since in Posts there are often a public interest, in order to change their activities and to provide new city logistics solutions, the intervention of governments is required. Institutions might try to provide the best solution for the whole society instead of just focusing on the economic aspect.

1.3.3 Employees

They might be the couriers who deliver goods in the city, or supply chain managers, or planners, or administrative workers. New technologies deployed in city logistics activities can cause deep changes in the work condition. They are really important stakeholders because their behavior can affect the efficiency of the whole city logistics system and the efficacy of new technologies strongly depends on how logistics companies are able to manage their workforce. Their claims are to be always trained about new technologies, to always gain new competencies, to have guaranteed the work condition safety and to have a high satisfaction while they are doing their jobs.

1.3.4 Society

It is strongly affected by city logistics activities. The circulation of commercial vehicles in the city causes high externalities as congestions or bad air quality. The society's claim is to reduce as much as possible the externalities against them, in order to have a more secure, green and so livable city.

1.3.5 Public authorities

Public authorities are responsible to regulate the traffic condition in the urban area in order to guarantee a satisfying life condition. Hence, they must plan the urban area by providing a sufficient number of parking for the activities of downloading, they might introduce specific lanes for the only commercial vehicles, or they can regulate the access to the Limited Traffic Zone. They should pursue the implementation of policies aimed to boost the economic growth of the community and to promote sustainable activities [15]. This category of stakeholders includes national governments or even the European one but commonly the most involved in city logistics projects are the local governments, such as municipalities.

Furthermore, public authorities can establish incentives to promote the adoption of new technologies or to promote a more sustainable behavior. In fact, the incentives are sometimes a fundamental tool to convince other stakeholders to opt for the introduction of some innovations, because at the current state they would be economical feasibility only if the incentives are present. Since these incentives come from public money, they are thought for technologies that brought great results for reducing the externalities caused to society.

1.4 Solutions adopted for reducing city logistics externalities

The technologies identified in the next chapters of this thesis are solutions adopted by logistics operators to reduce externalities of urban logistics and they will be treated in chapter 4. In addition to those and apart from logistics 4.0 that deserves a brief introduction to the topic, in the final part of this chapter, there are reported other solutions that are not identifiable as technologies because they are infrastructures or policies adopted by logistic operators or imposed by authorities to deal with city logistics problems. It is important to introduce them now, because there are some technologies that work well when they are combined with these solutions. The ones treated are the following [20]:

- Night deliveries
- Consolidation Centres
- Combining Forward and Reverse logistics
- Combining passenger and Freight transportation
- Low emission zone
- Urban planning
- 4.0 Logistics

1.4.1 Night deliveries

Night deliveries consist of running city logistics operations during off-peak hours. There are a lot of benefits on doing it, because the traffic condition is not problematic and so there is the absence of congestion on the roads, deliveries can be done faster and with larger vehicles. In this scenario, assets are going to be used more efficiently, leading to require fewer drivers, fewer vehicles, higher utilization of vehicles and a better driving style because the acceleration and stops caused by traffic are minimized. A problem could arise from the supply of workers. In fact, it could be difficult to find drivers willing to work during these hours and usually their salaries are higher than those who work during the day. This policy could bring great benefit even if the fleet is made by the only traditional vehicles, indeed in a city environment vans have to keep accelerating and stopping and so the fuel consumption is much higher respect to trips among faster roads. Traveling on uncongested roads might lead to large either economic or environmental benefits, in fact, less consumption means saving in the operating costs and few emissions of pollutants in the air.

Some negative externalities might arise with night deliveries, for instance, the noise that these vehicles produce can be a problem in hours where people are supposed to rest. Hence in cities during night hours it is not possible to exceed a certain decibel threshold. To address this problem, the implementation of an electric vehicle can be a suitable technology, because running an electric vehicle leads to have low noise emissions without causing any annoyance to habitants. This effect has been treated by Holguín-Veras et al. (2014) [21] in the case study of New York.

Then, drivers must download goods to someone or somewhere, and in case of off-hours, this can be a problem because maybe people are not willing to wait for receiving their parcels during these hours. This problem is not present if drivers have the possibility to deliver parcels to parcel lockers, allowing them to access to the lockers at any time and so it is not required the presence of a physical person to collect the parcels as it happens with traditional door to door deliveries. Furthermore, drivers are also facilitated by delivering during night hours to parcel lockers, because they would easily find parking close to the lockers.

1.4.2 Consolidation Centre

Urban Consolidation Centre (UCC) is a solution implemented in many city logistics projects leading to achieve great results in terms of air quality and congestion. They can have also an economic benefit because they avoid that vehicles run in the city with low capacity utilized. They are warehouses where goods that must be delivered in the city arrive and then they are consolidated in vehicles for the last mile deliveries.

The location is an important factor for the success of a UCC. They must be near the city center and next to an access of a high-speed motorway. In the entrance of the UCC, there could be big trucks that travel for long-distance, so if they are close to a motorway, they don’t cause a big impact on the congestion of the city roads.

Furthermore, if they are close to the urban center, it is possible that several vehicles can be deployed without any problem as small electric vehicles that don’t have to travel that much and their autonomy is enough, or even smaller as cargo bikes or e-cargo bikes that can do high frequently trip passing through the UCC to get the cargo full again as it is studied in Browne et al. (2011) [22]. As it is reported above, in this setting the urban freight is made by vehicles with full capacity used and also by drivers that have experience about the city and they can exploit it to find the better way of doing their jobs.

A UCC might become really useful when it is able to receive as input goods coming from different logistics operators, because in this case, it is possible to exploit the economies of scales and to provide the best solution for them and the society. The barriers to achieve this solution might be to convince different logistics operators to collaborate in order to use UCC for the delivery of goods and to find how and by whom the UCC must be managed.

Consolidation centres may also include platforms called Construction Consolidation Centres (CCC) that are usually temporary infrastructure, installed when in the city a big building site is present, like the construction of a stadium, a bridge, a big building, etc. A building site needs to receive daily different supplies ranging from working tools to raw materials, so instead of that each supplier delivers directly to the construction site, the CCC is selected as the final destination for their deliveries. Here, the supplies are stocked and when they are required to be used in the construction site, they are delivered from the CCC to the building site.

This platform can achieve a better solution in terms of the livability of the city, because the number of trucks or vans traveling to the site in the city is significantly reduced, thus positive impacts in terms of air quality, congestions, noise are expected, and the society is satisfied. The construction company can also gain some advantages to adopt this infrastructure, in fact, the possibility to stock materials close to the building site leads to have a supply-side more reliable compared to the case in which each supplier must deliver directly to the site.

Of course, as it is already mentioned in the section of Urban Consolidation Centre, also here a strategically location of the CCC (sufficiently close to the building site but accessible by roads with high speed) is a prerequisite to have a solution that greatly reduces city logistics' externalities and offers improvements to the management of the construction site. For example, this aspect of "construction logistics" is studied in Guerlain et al. (2019) [23].

1.4.3 Combining Forward and reverse logistics

Logistics regards the movement of material among the supply chain. Hence two different directions of material flow can be identified. The first one starts from the first nodes of the supply chain as suppliers, producers, etc. to the final customers, the second one interests the flow for the disposal or return of goods and it has the opposite toward. The former can be called "forward logistics" and the latter "reverse logistics". According to De Brito and Dekker (2004) [24], Reverse logistics can be defined as: "*the process of planning, implementing and controlling backward flows of raw materials, in process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal*". Hence, the focus of reverse logistics is the management of products that customers no longer use or desire them, by trying to obtain the profitability of the supply chain as maximum as possible.

Some city logistics initiatives are trying to combine forward and reverse logistics with the aim of reducing the number of vehicles that travel in urban areas. Once the driver has downloaded the goods from the van, instead of traveling with a low load, he can transport the goods that the customer needs to send to a recovery or a disposal point, so it will be not required a further shipment only for the disposal of goods, but with one vehicle it is possible to manage the two processes. As an example of the combination of the forward and reverse logistics, the CITYLAB projects in Rome can be mentioned in which the postal deliveries were combined with the collection of recyclable plastic [25].

1.4.4 Combining passenger and freight transport

This solution can bring positive impacts in term of pollution, noise, traffic condition and accidents and here it is proposed the business model identified by Pimentel et al (2018) [26]. The modern cities have a valid network for the transportation of passengers in urban area, and this is characterized by hours of high intensity and hours with low intensity because the demand for passenger transportation change significantly during the day. For this reason, the exceed capacity of passenger transportation must be exploited for other purpose like the transportation of goods in the urban area in order to obtain a better utilization of the resources.

The passenger transportation network is made of buses, trams, metro, private cars and taxis. Since some of them are characterized by a fixed route, the passenger network can be used to bring the good that must be delivered in the city to a location as close as possible to its the final destinations. Then, it is necessary to identify, a solution able to guarantee the last mile deliveries, and if the service wants to achieve the environmental sustainability, the vehicles selected should be environmentally friendly.

1.4.5 Low Emission Zone

The introduction of the Low Emission Zone in the city centers is an initiative commonly implemented by authorities. The access to this area is not permitted to all the vehicles in all the hours. The rules that governing the Low Emission Zone are different for each city. In fact, the city council can establish hours, usually, they are only a few hours during the peak of the activities, but in some cases, they can be valid during the whole day, when some particular vehicles are not allowed to enter. Furthermore, the rules can change during the year depending on the condition of air pollutants present in the air, if the level of them is too high and above the threshold for a long period, the rules can become more restricted in order to avoid further deterioration to the air quality. The

European Commission has decided to set the quality air standards taking into account the guidelines of the World Health Organization (WHO). The values are an average annual concentration of PM_{10} below 40 μg/m^3 and an average annual concentration of NO2 below 40 μg/m^3. Further restrictions that take into consideration also hourly averages are present [27].

As it is mentioned by Browne et al. (2004) [28], authorities might decide to set this policy in order to force who do deliver in urban areas to shift to more sustainable vehicles like electric vehicles or cargo bikes.

The introduction of Low Emission Zone in the city center brings further advantages to the inhabitants of the city, in fact, it reduces the congestion condition, the noise and it offers a better image of the city that can be also exploited for the tourism sector.

LEZ is a big constraint for logistics operators who deliver the last mile and its presence affects strongly the management of shipments in urban areas. In this case, a planner must take into consideration that the rules to access the gates of a Limited Emission Zone might have changed and anyways the drivers are required to deliver the goods in a certain window time.

1.4.6 Urban Planning

As it is already mentioned in section 1.3.5, public authorities are an important stakeholder because they are responsible to establish the urban planning in such a way that the logistics efficiency is guaranteed.

An example of decision that municipalities must take when they are doing the urban planning is a good distribution of temporary parking reserved for the logistics operators. They avoid that couriers do illegal parking that can cause further problems to the congestion condition and to a potential increase in the risk of accidents. Furthermore, if the number of parking is sufficient and well spread in the city, couriers can run their activities faster and also the walking distance for delivering the last mile is reduced.

Since there are always more electric vehicles running in urban areas, authorities should also identify a proper location and number of recharging stations in order to boost the adoption of these vehicles.

1.4.7 Logistics 4.0

Industry 4.0 compounds to use many different technologies in order to obtain a smart management of the activities, instead Logistics 4.0 means to adopt the same technologies and methodologies for the management of the supply chain. According to Winkelhaus et al. [29], Logistics 4.0 can be defined as "*Logistics 4.0 is the logistical system that enables the sustainable satisfaction of individualized customer demands without an increase in costs and supports this development in industry and trade using digital technologies*". Hence, in this setting of Logistics, satisfied customers become the real focus of the business and the massive use of technologies is present.

The principal technologies implemented are under the categories of Internet of Things (IoT), Big Data, Cloud Computing and Augmented Reality. All these technologies can be also used for the management of Logistics in urban areas. According to Barreto et al. (2017) [30], Logistics 4.0 has some applications for resource planning, transportation management system and warehouse management system.

The pillar of this new approach to run the business is the exploiting of data for making data-driven decisions. The real propeller of the phenomena is the cost of producing sensors that nowadays they are really cheap compared to previous decades. An example of these sensors is the RFID technology that allows the birth of IoT in which all the things are connected to each other via the internet and they can produce a high quantity of data. These sensors are cheap and since they work with low power intensity, they can work up to two years without recharging them.

From these sensors, it is possible to produce Big Data and they are usually defined by using the 4 Vs [31]:

- Volume: they are a big quantity of data
- Variety: they are different types of data generated by different sources
- Velocity: they are continuously generated
- Veracity: not all the data will be used to run a robust analysis because some of them might have too low quality.

Hence, firstly data are generated by the sensors attached to the goods and important information as temperature, location can be measured. Then they are stored, usually by selecting a "data lake" as database configuration, because it fits well for dealing with this huge quantity of data coming from different sources [32]. When some decisions must be undertaken, data are extracted from the database, they are cleaned of eventual data wrong and finally, they are processed in order to derive some conclusions for the decision-making process.

Cloud computing is another great innovation that is adopted in Logistics 4.0, because, it is a solution that offers high flexibility to companies. There are different settings of cloud computing and one of these regards the case in which the software is not installed in the hardware of the enterprise, but they are owned by a third party that offers as a service the possibility to access to this software via the internet. This means that companies can use always the last version of the software, there is not the need to install it in each device and this is translated into time-saving and cost-saving. Enterprises are not required to maintain it or fix it in case of some malfunctions, and they are not required to pay a high initial price to purchase the software because they can pay a monthly fee to have the right to use it [33].

2 Research background and motivation

In this chapter, it is reported an overview of the existing studies that investigate through literature reviews what the academic world has produced in terms of city logistics researches. These research papers consist of looking for scientific works in this field of study and to make analysis for identifying if some trends exist, in which years City Logistics thematic has gained importance, if there are some locations where the concentration of publishing is higher, which methodologies are the most used and in which aspects of the City Logistics there are more focus on.

2.1 Literature reviews on city logistics

Different authors have run a literature review of this type, but since City Logistics is a fresh field of study, it is convenient to contemplate only the most recent ones, so that the real and current situation is considered. These are the analysis did by Wanjie Hu et al. [34] published in 2019, by Parisa Dolati Neghabadi et al. [35] published in 2018, by Lagorio et al. [36] published in 2016 and by Zenezini et al. [37] published in 2016.

Here below, there are briefly summarized each work just mentioned and the findings of them can be viewed as the motivations of this thesis. They identify some research gaps and so they are useful to understand in which topics the scientific world has focused and in which ones a further analysis would be necessary.

2.1.1 Paper "A Scientometrics Review on City Logistics Literature: Research Trends, Advanced theory and Practice"

This analysis consists of the review of 513 English-language papers published from 1993 to 2018, including the only ones published in academic journals, hence neither book chapters nor reports have been considered in this work.

The first investigation is about which are the methodologies most applied in the research of City Logistics. The 36% of all the papers analyzed use as methodology "Modelling and simulation" and it is the largest percentage, "Qualitative and conceptual studies" accounts for the 23%, "Hybrid techniques" for the 17%, "Empirical research" for the 10%, "Review" for 9%, and "Questionnaire survey" for 4%.

Then, it is reported in figure 2.1 the distribution of the papers analyzed in order to assess how it has evolved over the years. It is clearly identifiable an increase of the publications during the last years starting from 2010, and as it is mentioned by the author of this study, if the only last three years are considered, they count for the 44% of all.

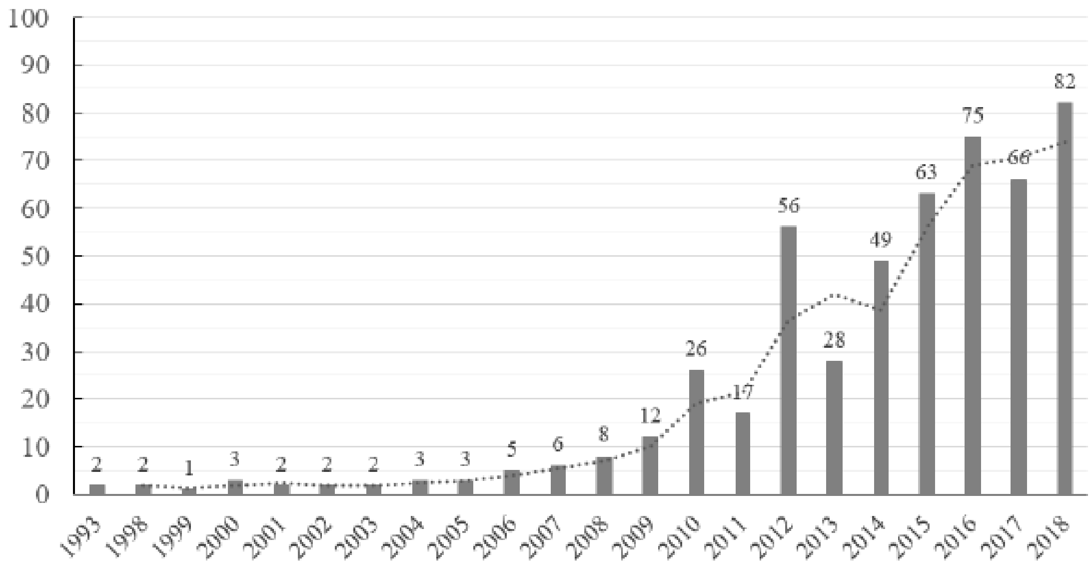

Figure 2.1: Year profile of the analyzed papers from 1993 to 2018. Source: Wanjie Hu et al, (2019) [34].

Over 513 articles analyzed, 67% were published on Regular Journals and 33% on Conference-oriented Journal. In the first positions of the former category of source of publication, there are the UK journals: "Transportation Research Part E: Logistics and Transportation Review" (2.9% of the overall papers analyzed), "Transportation Research Part A: Policy and Practice" (2.7%), "Transport Policy" (2.7%), "Journal of Transport Geography" (2.5%) and others with lower percentages. In the category of Conference-oriented Journals, there are 2 sources: "Transportation Research Procedia" (17.3%) from the Netherlands and "Procedia-Social and Behavioral Sciences" (15.8%) from the UK.

The following analysis in the paper is regarding the authors. In table 2.1, there is a summary of the most productive authors in City Logistics context, and as it is shown there, the 4.9% of the articles are made by Antonio Comi from the University of Rome Tor Vergata, then from University of Westminster there is Micheal Browne who has the 3.9% and Eiichi Taniguchi from the Kyoto university is in the third position with 3.3%. The works of this last author mentioned results also in the one most cited by other papers.

Table 2.1: Most productive authors of City Logistics articles. Source: Wanjie Hu et al, (2019) [34].

Scholar	Affiliation	Country	Count	Percentage
Antonio Comi	University of Rome Tor Vergata	Italy	25	4.9%
Michael Browne	University of Westminster	UK	20	3.9%
Eiichi Taniguchi	Kyoto University	Japan	17	3.3%
Edoardo Marcucci	University of Roma Tre	Italy	15	2.9%
Agostino Nuzzolo	University of Rome Tor Vergata	Italy	14	2.7%
Julian Allen	University of Westminster	UK	12	2.3%
Valerio Gatta	University of Roma Tre	Italy	12	2.3%
Cathy Macharis	Vrije University Brussel	Belgium	11	2.1%
Russell G. Thompson	Monash University	Australia	10	1.9%
Laetitia Dablanc	University of Paris	France	10	1.9%

The most productive countries are USA with the 16% of the articles, Italy with 14.8%, UK with 8%, France with 8.2%, China with 6.6%, Netherlands with 6.4%, Germany with 5.8%. These numbers show that Europe plays a great role in the production of City Logistics research.

In order to evaluate where is the focus of these studies, the Keywords have been tracked and the results show that the most frequent keywords attached to these articles, starting from the most frequent one, are: “urban freight transport“, “city logistics“, “sustainability“, “transportation policy“, “urban area“, “traffic congestion“, “air quality“, “last-mile delivery“, “supply chain management“ and “model“. All the keywords found are used by the author to run a cluster analysis and to identify some thematic discussion. The first cluster is made by papers in which the emphasis was on cost and efficiency of City Logistics at the industrial level, the second by articles with the focus on Operational Research to find optimization methods and the last one on the sustainability of City Logistics and its impacts to reduce the negative externalities of CL. This category is accounting for 31.6% of all the papers analyzed and the methodologies most used in it are the “Simulation-based modeling” and “evaluation methods”. The articles in this category cover topics like Green Logistics measures as the introduction of environmental-friendly vehicles, the challenges of the last mile delivery in which the Just in Time philosophy becomes predominant and customers are time-sensitive, and advanced infrastructure as Urban Consolidation Center.

2.1.2 Paper "Systematic literature review on city logistics: overview, classification and analysis"

For running this literature review analysis, the author has selected more than 370 researchers that include articles in peer-reviewed journals, conference papers and book chapters from 2010 to 2016. Thus, the time and the type of documents analyzed are already two different features respect to the analysis described above. The year with the most articles published was 2016, but a specific trend of the distribution is not recognized during these years.

Conference papers are the type of scientific work with the highest percentage, the other types are articles published in scientific journals, books and chapters of books. The author identified that almost 52% of all the analyzed literature relies on empirical data, e.g. they are based on a real case study and this percentage becomes 63% when only the conference papers are taken into account. The author suggests that in the city logistics studies the starting point seems to be the identification and understanding of the real world and only in a second moment the solutions demanded are proposed.

In figure 2.2, it is reported the number of studies about City Logistics published from 2010 to 2016 divided per region and since the European zone is the most important, in figure 2.3 the countries in the European zone are compared to figure out which ones are the most productive, and they are France and Italy.

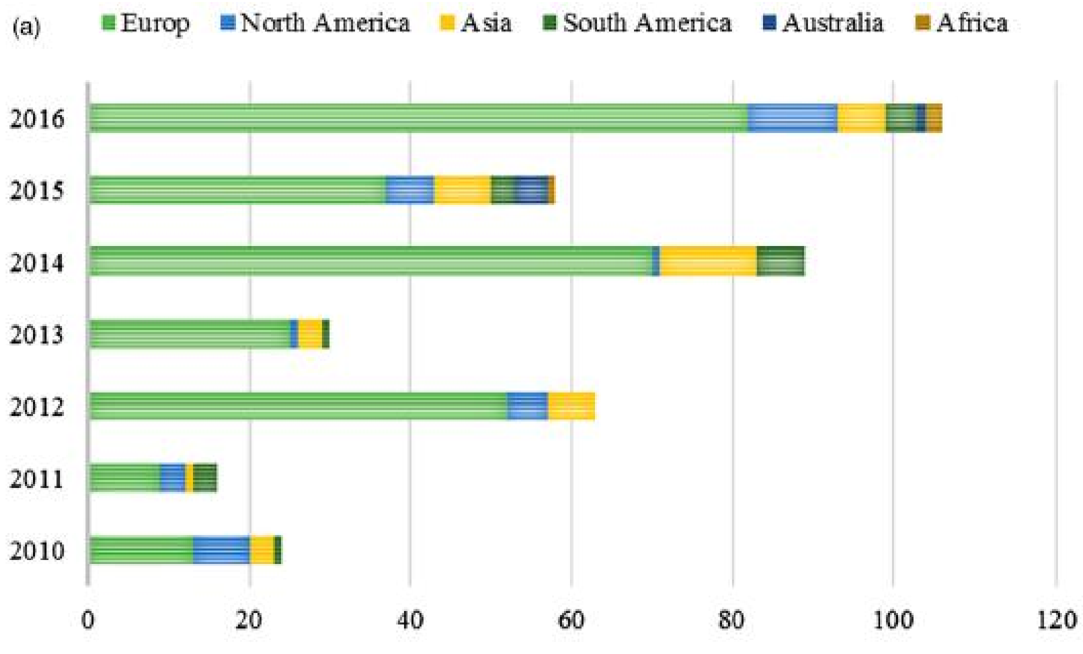

Figure2.2: Regional distribution by continents from 2010 to 2016. Source: Parisa Dolati Neghabadi et al (2018) [35]

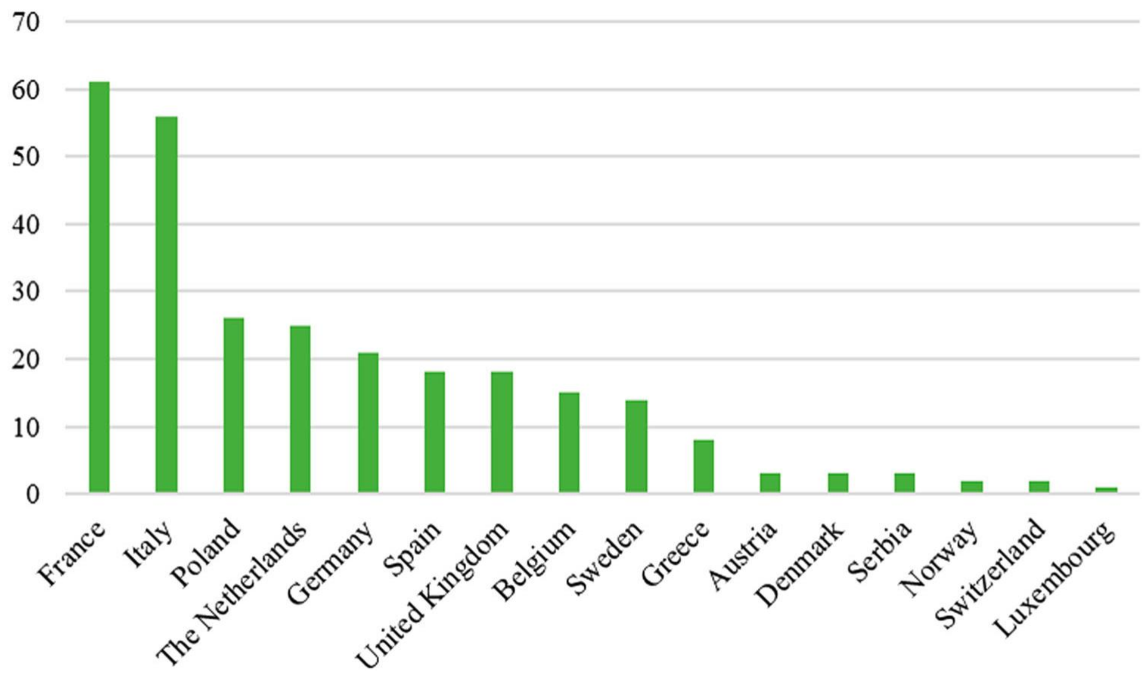

Figure 2.3: Distribution of European countries. Source: Parisa Dolati Neghabadi et al (2018) [35]

1,048 different keywords are identified from the articles analyzed and then they are organized into different classes (748), for instance by eliminating the keywords cited only once. Starting from them, the author proposes to combine them in 6 categories that represent 6 different aspects of CL:

- "Definition and Perimeters": includes 162 articles that treat this thematic and it consists of the definition of the problems and the identification of the goals. In this category, there are: Urban freight and transport, urban area, urban mobility, delivery, distribution, logistics, last mile, urban goods movement, infrastructure, management. The literature available that addresses this topic is more focused on the direct flow of the supply chain rather than the return and waste management that seems it has received less attention.
- "Policy": includes 81 articles and this category is made by three different subclasses: Governance, Planning and Measures. The keywords in this category are related to Policy, Governance, Planning, Measure, and Regulation.
- "Innovative solutions": includes 89 articles and here the focus is the identification of the solutions to mitigate the problem caused by city logistics activities. This category is made of: Collaborative solution, Consolidation, Pooling, Hub, Urban Distribution Centre, Light goods vehicles, Off-hour deliveries, Cargo cycles,

Diverse innovative solutions. The collaborative solutions are more studied in theory even if in practice it is difficult to demonstrate the profitability of adopting infrastructures like those. The literature discusses widely the implementation of light vehicles like the electric one or cargo cycles.

- "Sustainability": includes 63 articles and here there are considerations about economic, environmental and social impacts. The main issue highlighted in the academic works is related to the environmental impacts caused by the city logistics activities and so there is an underestimation of the economic and social effects.
- "Methods": includes 251 articles in this class and it consists of articles in which the focus is on the description of techniques or approaches to solve City Logistics problems. They can be: Qualitative method, Optimization, Data collection, evaluation approaches, Modelling and Case study. The most applied techniques used in the articles analyzed are mathematical programming and simulation modeling and the most explored problem in City Logistics is the Vehicle routing problem.
- "Stakeholders" includes only 22 articles and in this category, it is treated the identification of the different city logistics stakeholders. The classes are stakeholder analysis and local authority. It is the category with the fewest number of articles and so the academic world should focus more on this thematic since the importance of the stakeholders' positions in City Logistics seems to be underestimated.

2.1.3 Paper "Research in urban logistics: a systematic literature review"

This analysis was run to identify the answers to the following questions proposed by the author:

- *"What are the main topics, that is, the main subjects of discussion in a paper, in urban logistics and what are the evolutions of those topics over time?"*
- *"What are the main research methodologies employed and how are they related to the main topics?"*

Hence, 104 scientific papers about urban logistics come from peer-reviews publications ranging from 2000 to 2015 were selected. The distribution among the years is shown in figure 2.4, in which it is highlighted an increase in the number of articles published during the last 5 years. Most of the articles included in the literature review comes from the journal “Research in Transportation Business & Management” (13 over 104), “Journal of Transport Geography” (11 over 104), “Transportation Research Part C: Emerging Technologies” and “Transportation Research Part A: Policy and Practice” (7 over 104).

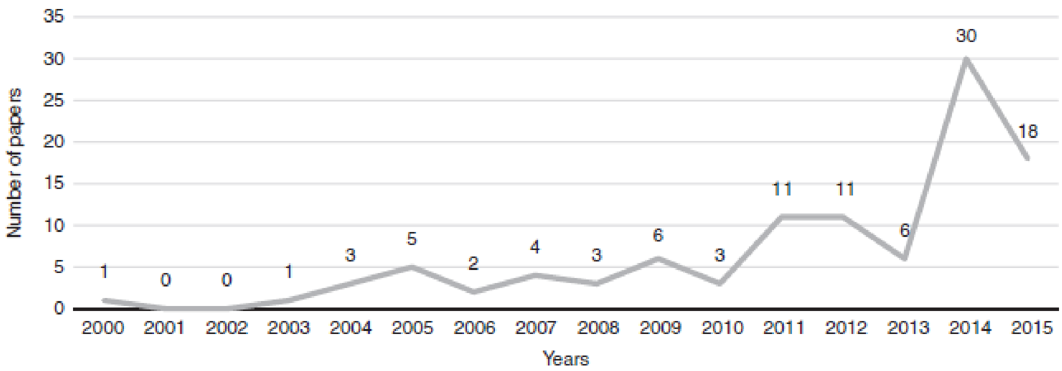

Figure 2.4: Distribution of analyzed paper by year. Source: Lagorio et al (2016) [36]

The first question is answered by identifying as the three most studied topics: the solutions of Vehicles Routing Problems (45 articles have focus on it), the involvement in the decision-making process of the main stakeholders (41 articles treat this topic) and the identification of indicators for the measurement of the main impacts of a City Logistics project (30 articles study this subject). These topics are not studied in the same way among the analyzed years. In fact, it is reported that during the first years, the articles have had more focus on topic like VRP solutions, comparison of different solutions, later on, there has been an increasing interest on thematic as stakeholder involvements or more complex solutions to VRP models and only in the recent years (from 2011 to 2015) new topics have been started to be studied like bike deliveries, e-commerce, or drone deliveries.

The second question can be answered by looking at figure 2.5, in which the main methodologies used in these scientific papers are reported. Furthermore, the author has discussed two main categories of methodologies: Quantitative and Qualitative ones. More than 41% of the sample used as methodology a quantitative approach, 31% a qualitative one and the remain 28% of articles utilize both methodologies for assessing their results. The quantitative methodologies are used for solving scheduling and optimal problems, instead, the qualitative ones are used for the estimation of the potential effectiveness of city logistics solutions. The author reports that a literature review is a methodology few implemented in the sample and it usually involves the analysis of real projects rather than other scientific publications.

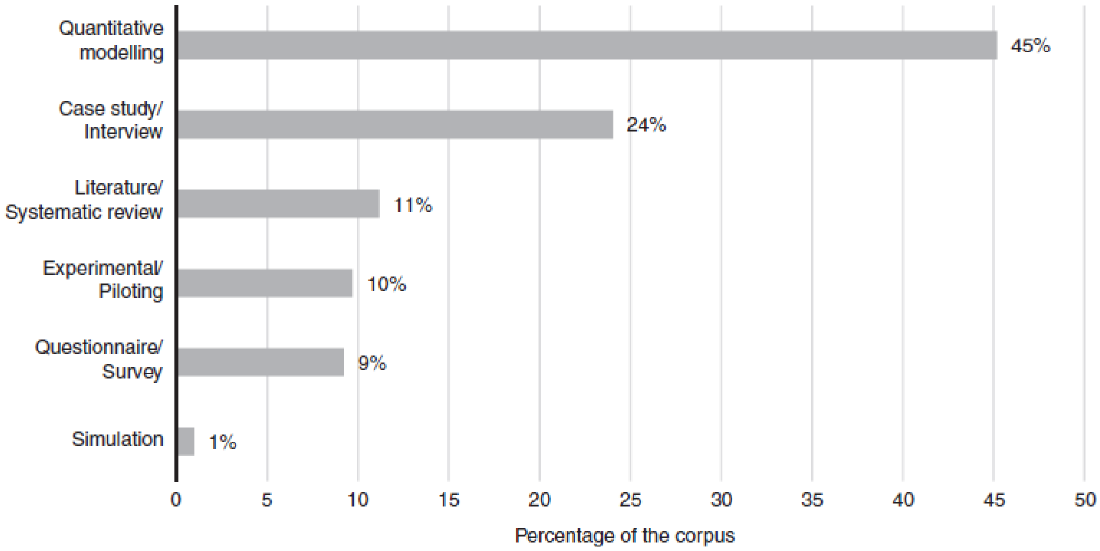

Figure 2.5: Types of methodologies identified in the sample. Source: Lagorio et al (2016) [36]

The authors recognize that, in the analyzed literature, there is a lack of the study of people and technology considered as a whole system, called socio-technical system, this means that there is not the focus on how people are going to be affected and how they are going to react when there is the introduction of different technologies for running city logistics activities.

Finally, it is also shown that a common framework of city logistics does not exist yet because the papers focus more on the implementation of the project in a single city and they do not make general conclusions that can be easily compared with other works implemented in different locations. The author proposes to create a data-sharing platform in which researchers or authorities can use it, in order to assess and to analyze relevant city logistics data for setting new regulations or identifying new solutions to urban logistics issues.

2.1.4 Paper "A review of methodologies to assess urban freight initiatives"

This literature review has focused on the methodologies implemented by urban logistics researchers for the assessment of their results. For this reason, 27 papers from 1999 to 2016 were selected and a total of 15 different methodologies were found. These methodologies are categorized in quantitative methods whenever they use data, or in qualitative approaches whenever the authors want to evaluate different options. The former consists of identifying the outcomes of urban freight transport in terms of economic, environmental or operational impacts. Some of these methodologies are agent-based simulation that works properly when the interaction of different stakeholders wanted to be analyzed or Social Cost-Benefit analysis that gives the evaluation of the stakeholders' claims. The latter methodologies are used for treating innovations or for the comparison of different solutions, i.e. Business Model analysis is a methodology of this type that is gaining always more importance.

Finally, in the paper there are identified 4 main impact areas that city logistics literature can study, they are: "Environmental", "Economical", "Social" and "Operational". For each impact area, some measurements are reported. When the literature is about Environmental impacts the measurements used are in terms of reduction in CO2 emissions or other air pollutant emissions. The operational ones might consider the service level offered to the final customers or the number of stops. The economic impacts include the cost of investments or the customer's satisfaction as measures. Finally, the measures used for assessing social impacts may comprise the condition of the employees

2.2 Motivation

The articles just mentioned show the current situation of the research background of City Logistics topics. The analysis of them leads to the identification of the motivations of this thesis and it gives some hints about how the work should be organized.

From the work done by Wanjie Hu et al. (2019) [34], it is possible to figure out that most of the articles are recent ones and it seems that there are some regions where the production of scientific papers is higher respect others. It could be interesting to investigate if there is a reason why this is happening and to identify if the same results obtained by the author are confirmed by this thesis.

The same conclusion about a higher production of city logistics works in certain areas is identified by Parisa Dolati Neghabadi et al. (2018) [35].

Furthermore, since it is reported that most of the articles rely on empirical data, the investigation about city logistics projects might be a convenient starting point for developing this thesis.

Finally, it is shown in the paper that not all the thematic has been studied in the same way. In fact, the category "sustainability" results in the one with the lower percentage of articles included and even inside this category the author states that there are some underestimations of some impacts such as economic and social ones. Thus further analysis towards these topics is necessary to be done from the academic world.

The concept of "*Urban Logistics ecosystem*" has been identified in Lagorio et al. (2016) [36]. The author states that there is a weak presence of works that treat technology and stakeholders as a single system and so it seems that the involvement of stakeholders is not considered when technologies used for urban logistics are discussed in scientific articles.

Lagorio et al. (2016) [36] state also that the scientific works in this field usually have a focus on the implementation of single projects without taking general consideration of the phenomenon described.

A weak interest in the stakeholders' involvement is also identified in the analysis done by Zenezini et al. (2016) [37], and so the academic world should put more effort on the evaluation of all stakeholders' interaction and involvement, and for pursuing this objective, some methodologies like Agent-Based simulation or Multi-criteria Multi-stakeholders evaluation method (MAMCA) result more suitable.

Hence, from the analysis of the 4 literature reviews just mentioned the following conclusions might be derived. The impacts that technologies cause to city logistics projects seem to be not studied in a sufficient number of papers and when the articles study them, only considerations about specific real cases are identified. Another topic that creates few interests by scientific authors is the role that the stakeholders play when the introduction of a new technology is studied. For all these reasons, in order to provide general conclusions about the technology impacts, it is necessary to collect information from several sources and to identify a standard classification of the impacts that makes possible the comparison between different technologies. This aim can be achieved with the realization of a dataset holding information about the technologies impacts coming from different sources as it will be discussed in chapter 3, and by classifying the impacts according to the categories identified by Zenezini et al. (2016) [37].

3. Methodology

In order to analyze the technologies implemented in City Logistics projects and their relative impacts, two different approaches have been pursued. The aim of the former is the analysis of real projects done in several cities, instead, the aim of the second is the analysis of academic articles about City Logistics.

The output of this work includes also the realization of a dataset, in which all the information and the main features of each research gathered by using the methodology described in the following chapter are reported. Since the approach used is consisting of the 2 steps just mentioned above, also the dataset is made by 2 components: one table related to the results of the projects and one to the literature reviews.

3.1 Data collection

3.1.1 Data collection of City Logistics projects

A city logistics project can belong to two different categories: public projects and private projects. In the former, there are projects in which a public institution is included in for different reasons, or because there is a public budget offered or because they are actively present in the project activities. The latter consists of projects in which there is not any public interest and they are completely run by private companies.

Regarding the public ones, all the information gathered for creating the dataset is referred to projects run in the European zone. The concentration of projects in this area is really high compared to others because the Community European provides public budget to different players like universities, city councils, private companies, research groups, to implement innovative solutions in a real environment, to create benefits for city's habitants, to collect data and to provide useful information accessible to the public for using it in future projects. Since there is a public interest behind this typology of project, their focus is aimed to have some public utility like improving the congestion condition or improving the quality of air rather than to provide a better operational efficiency to logistics operators that could lead to obtain a better financial position.

When some parties receive public budgets, they are usually forced to provide reports and presentations that show in a transparent way the actual situation of the project, and for this reason, it has been easy to access information regarding the technologies adopted and the results obtained from this type of project. Many projects were run in pilot cities, those are the ones selected by the European Commission and willing to run these missions that in case of a successful outcome their activities can be followed by other ones. Each big city logistics project generally develops also a website to make more transparent the information generated by their work, and on the websites, it is possible to see the presentations of the projects, who are the stakeholders involved, which are the expected and actual outcomes and further useful information.

Most of the information has been collected through the CORDIS website [38]. CORDIS stands for "Community Research and Development Information Service" which is a platform holding information about European projects with the purpose to bring research results to experts and it is managed by the "Publications Office of the European Union". CORDIS is offered in different languages like Italian, English, French, Spanish and German and it has been a powerful instrument for this research thanks to the possibility to access several information by surfing on it, as:

- Name of the project
- Status of the project
- Start date
- End date
- Grant agreement ID
- Project website
- Overall budget
- Coordinator
- Objective
- Reporting
- Results
- News & Multimedia

For private projects, it is much more difficult to collect a good quality of data, because private companies are not forced to disclose information and many times only positive impacts are reported and used as a marketing tool. Furthermore, during this phase of the research, only real projects deployed in some specific cities have been analyzed. In the market, there are different startups that are trying to provide great and innovative solutions, but their implementations are not referred to a specific city, so it is difficult to access if they are successful or not. In this work, only the one implemented by "Alphabet" regarding deliveries done by drones is considered, because this project consists of drone delivery in 4 different cities and some interesting considerations are found.

For each project, the following information was collected in order to create the dataset:

- The name of the project
- In which city the project is run
- the starting year of the project
- The ending year of the project
- Which technologies or solutions are implemented during the project
- Tracking the sources of information
- The impacts of the technologies used during the project organized according the categories descripted in chapter number 4

In some cases, the voice technology includes more than one value, because more technologies are implemented, and it has not been possible to identify the singular impact that it caused but only the total results of the project were reported. Moreover, it may be that the results are the output also of other initiatives that are not properly correct called them as technologies. The building of Urban Consolidation Centre or Construction Consolidation Centre, night deliveries are examples of them. Anyways, it is important to track also these projects because there are always some technologies behind, that allow a correct and efficient functioning of these infrastructures or initiatives, like electric vehicles, information platform for the management of UCC etc.

Regarding the GALENA European project (2015 – 2017), it has not been possible to identify a specific city where this project was implemented, but the countries involved were Belgium, France and The Netherlands. All the other ones were run in the following cities:

- Australia: in the cities of Canberra and Logan. They are two projects called WING of the private companies Alphabet
- Austria: the ILOS project in Graz and NOVELOG project (2015 – 2018) in Vienna
- Belgium: the NOVELOG project (2015 – 2018) in Mechelen, the CITYLAB (2015 – 2018) and the STRAIGHTSOL (2013 2013) projects in the city of Brussels
- Bulgaria: the C-LIEGE project (2011 – 2013) in Montana
- Denmark: the NOVELOG project (2015 – 2018) in Copenhagen
- England: the CITYLAB (2015 – 2018), the FREVUE (2013 – 2017), the SEUL (2017 – 2019), the UTURN (2015 – 2018), the NOVELOG (2015 – 2018), the LBCC (2012) projects in London, the C-LIEGE (2011 – 2013) and the SMARTFUSION (2012 – 2015) projects in New Castle, the CITYLAB project (2015 – 2018) in Southampton, the C-LIEGE project (2011 – 2013) in Leicester, the CIVITAS PLUS project in Bath and the STRAIGHTSOL project (2011 – 2014) in Batley
- Estonia: the MIMOSA project (2008 – 2013) in Tallinn
- Finland: the WING project of Alphabet in Helsinki
- France: the CITYLAB (2015 – 2018) and SUCCESS (2015 – 2018) projects in Paris
- Germany: the C-LIEGE project (2011 – 2013) in Stuttgart, the SMARTFUSION project (2012 – 2015) in Berlin and the TIMMI TRANSPORT project (2018 - 2018) in Leipzig
- Greece: the STRAIGHTSOL project (2012 – 2013) in Thessaloniki, the NOVELOG (205 -2018) and UTURN (2015 – 2018) projects in Athens
- Italy: the CITYLAB (2015 – 2018) and the NOVELOG (2015 – 2018) projects in Rome, the UTURN (2015 – 2018) and the FREVUE (2013 – 2017) projects in Milan, the NOVELOG project (2015 – 2018) and the PONYZERO startup (2015) in Turin, the ASPIRE project (2017 – 2020) in Lucca, the C-LIEGE project (2011

– 2013) in Piacenza, the SUCCESS project (2015 – 2018) in Verona, the NOVELOG project (2015 – 2018) in Reggio Emilia, the NOVELOG project (2015 – 2018) in Bologna, the NOVELOG project (2015- 2018) in Venice, the NOVELOG project (2015 – 2018) in Pisa and the SMARTFUSION project (2012 – 2015) in Como

- Luxembourg: the SUCCESS project (2015 – 2018) in Luxembourg city
- Malta: the C-LIEGE project (2011 – 2013) in Hal-Tarxien
- Netherlands: the CITYLAB (2015 – 2018) and the FREVUE (2013 – 2017) projects in Amsterdam, the FREVUE project (2013- 2017) in Rotterdam, the CIVITAS PLUS project in Utrecht and the CARGO HITCHING project (2017) in Millingen aan de Rijn
- Norway: the CITYLAB (2015 – 2018) and the FREVUE (2013 – 2017) projects in Oslo
- Poland: the C-LIEGE (2011 – 2013) and the GRASS projects in Szczecin
- Portugal: the FREVUE (2013 – 2017) and the STRAIGHTSOL (2011 – 2012) projects in Lisbon
- Spain: the NOVELOG (2015 – 2018), the STRAIGHTSOL (2011 – 2014) and the SUGAR projects in Barcelona, the FREVUE project (2013 – 2017) in Madrid, the SUCCESS project (2015 – 2018) in Valencia and the FREILOT project (2009 – 2012) in Bilbao
- Sweden: the FREVUE project (2013 – 2017) in Stockholm and the NOVELOG project (2015 – 2018) in Gothenburg
- USA: the WING project of Alphabet in Virginia

The following categories of technologies and initiatives used in the projects have figured out some impacts that will be described in chapter 4:

- Vehicles: electric vans, electric vessels, drones, cargo bikes
- Data driven technologies: Information Systems, Decision Support Systems, freight planning, digital platform, mobile app
- Infrastructure: Urban Consolidation Centre, Construction Consolidation Centre, recharging station for electric vehicles
- Delivery points: parcel lockers, mobile depot
- Sensors: localization devices, monitoring sensors
- Variable message signs

3.1.2 Data collection of scientific papers

The articles analyzed in this work are found by using the database of peer-reviewed literature SCOPUS launched in 2004 by the publisher Elsevier. This platform allows to have access to all research fields, and it is considered the largest database with these features. SCOPUS can count on more than 5000 publishers, 70 million items, 70,000 main institutional profiles and 16 million author profiles providing a powerful tool to researchers that can easily have access to scientific papers, conference papers, identify potential collaborators, find out what already exists in the research world and recognize global research trends [39].

Keywords attached to the analyzed scientific papers

The scientific articles in SCOPUS are found by searching with keywords and the ones selected in this work have attached the keywords reported in table number 3.1. The most important ones, that when they were used they gave as output of the research the best quality of information are: “City Logistics” (15,325 document results), “Urban Logistics” (20,342 document results) “Urban Freight Transportation” (1,387 document results), “Sustainable City Logistics” (625 document results), “Last Mile Delivery” (674 document results), “Parcel Lockers” (27 document results), “Crowd Shipping” (28 document results), “Electric Vehicles” (93,945 document results), “Drones” (13,199 document results).

Table 3.1 Key words of the articles analyzed

air pollution	electric cargo bikes	performance evaluation
automated collection point	electric duty vehicles	policy making
automated mobility on demand	electric freight vehicles	power consumption
automated vehicles	electric mobility	public service
autonomous driving	electric vans	rail traffic
autonomous robots	electric vehicle	real-world monitoring
autonomous vehicles	electric vehicles	regulatory framework
battery electric vehicles	environmental LCA[1]	road traffic
benefit analysis	environmental awareness	robotized freight handling
battery electric vehicle	external costs	scheduling
carbon emissions	eye-tracking	shared mobility
cargo bikes	facility location	sharing economy
carbocycles	fleet managers	simulation
city logistics	focus groups	simulation modeling
city logistics information system	freight transport	smart lockers
city logistics management	freight transportation	smart logistics
city logistics	good distribution	structural equation modelling
CO2	goods distribution	supply chain management
CO2 emissions	green vehicle routing problems	sustainability
collection and delivery points	greenhouse gas	sustainability urban freight transport

[1] LCA stands for “Life-Cycle Assessment”

Table 3.1 – cont.

commercial battery electric vehicle	handheld device	sustainable city logistics
commercial electric vehicles	ICT platforms	sustainable logistics
commercial vehicles	Immunization	sustainable transportation
conjoint-based choice	industry 4.0	sustainable urban deliveries
consumer logistics	Innovation	technology adoption
cooperative platforms	in-sight display	three-dimensional modeling
correspondence analysis	intelligent in-vehicle control and navigation	total cost of ownership
courier logistics	internet of things	traffic congestion
courier service	in-vehicle equipment	traffic signs
crowd logistics	IoT[2]	UAV[3]
crowd practices	last mile	underground logistics system
crowdshipping	last mile deliveries	unmanned aerial systems
crowdsourced delivery	last mile delivery	unmanned aerial vehicle delivery
crowdsourcing	local government	unmanned aerial vehicles
customer value	logistical constraints	urban consolidation center
delivery lockers	Logistics	urban deliveries
delivery problems	logistics and transportation	urban freight
delivery robots	logistics planning	urban freight delivery
RFID[4]	mixed integer linear programming	urban freight transport

[2] IoT stands for "Internet of Things"
[3] UAV stands for "Unmanned Aerial Vehicle"
[4] RFID stands for "Radio-frequency identification"

Table 3.1 – cont.

diffusion of innovation	mobile depot	urban freight transportation
discrete choice models	multi-agent systems	urban logistics
drone delivery	multi-route optimization algorithm	urban logistics delivery system
drones	oil consumption	urban sustainable development
dynamic traffic simulation	online shopping	user acceptance
early innovation adoption	parcel delivery	vehicle routing
e-commerce	parcel locker	wearable
economic analysis	parcel lockers	zero emission

As it is mentioned before, the topic of City Logistics can be considered as a fresh field of study that it is gaining always more importance. It is possible to figure out this conclusion also by exploiting SCOPUS research and identifying how many documents are created per year. By looking at the trend shown in figure number 3.1, before the year 2000 the publications were always lower than 200 per year, and later there has been a constant growth until reaching 1,515 files in 2019. The keyword "City Logistics" overall generates more than 15,352 document results (search done in November 2019).

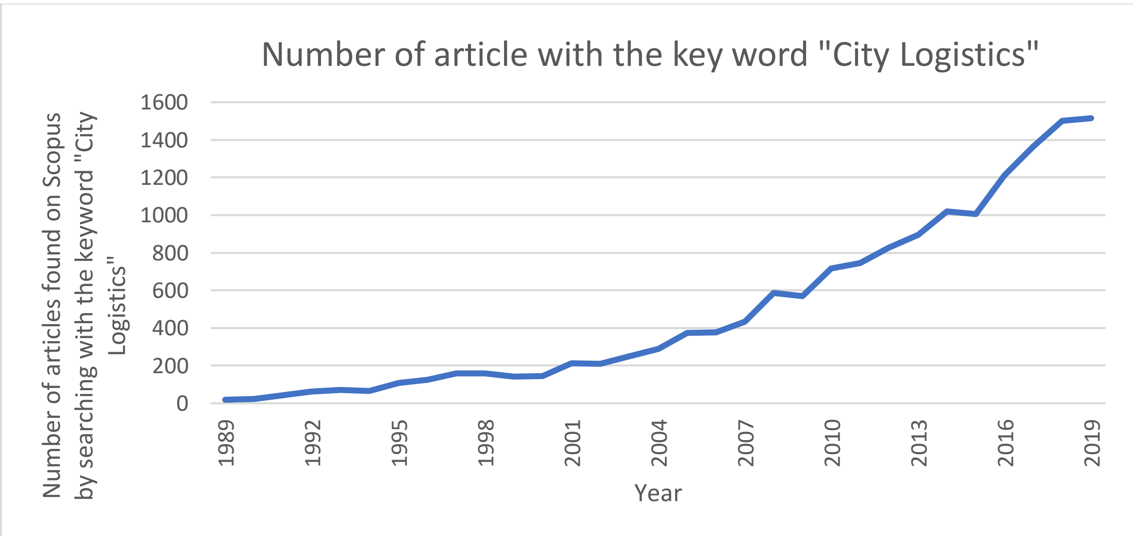

Figure 3.2 Number of document results found in SCOPUS with attached the key word "City Logistics" updated to December 2019

Keeping in mind that the aim of this thesis is to identify the impacts of technologies on City Logistics Projects a total of 65 articles are selected and they bring information about 66 technology's impacts since some of them might treat simultaneously more than one technology at a time. All the articles analyzed are reported with also their year of publication and their Authors in table number A.1 in the appendix section. The column "n." in the table is the code that it will be used, instead of mention all the time the full title of the articles, in chapter 4 of this thesis where the findings from the following articles will be reported.

Technologies identified in the analyzed scientific papers

The output of the literature review leads to analyze the impacts of the following categories of technologies:

- Technologies about vehicles adopted for city logistics activities. There are in this category: "*drones*" with 7 articles analyzed, "*drones combined with autonomous vehicle*" with 1 article analyzed, "*cargo bike*" with 8 articles analyzed, "*autonomous robot*" with 2 articles analyzed and "*electric vehicle*" with 14 articles analyzed. It is important to highlight that some technologies can belong to different categories. For instance, it is possible to have articles in which the author is speaking about cargo bikes equipped with an electric motor so this technology can belong to the category "*electric vehicles*" or "*cargo bikes*". In this work, the technology is categorized by looking if the article was focusing more on the features of one technology respect to the others.

- Technologies about the location of delivery points. In order to achieve a better management of the operations, some alternatives to the traditional door to door deliveries are proposed by logistics companies. These are: "*parcel lockers*" with 9 articles analyzed and "*mobile depot*" with 1 article analyzed

- Technologies about Industry 4.0 technologies. Industry 4.0 has a strong impact also on City Logistics and in the academic world, it has been possible to collect data of their impacts. There are: "*RFID*" with 1 article analyzed, "*RFID combined with cloud computing*" with 1 article analyzed, "*cloud computing*" with 1 article analyzed, "*wearable navigation devices*" with 1 article analyzed, "*City Logistics Information System*" with 1 article analyzed and "*intelligent in-vehicle control and navigation system*" with 1 article analyzed

- Technologies about solutions that exploit the urban infrastructure. There are in this category “underground logistics” with 3 articles analyzed and “*urban rail transit-based city logistics system*” with 1 article analyzed.
- Technologies about digital platforms that allow people to interact with them and usually matching demand and supply for shipments. In this category, there are: “*digital platform*” with 3 articles analyzed and “*crowdshipping*” with 8 articles analyzed
- Technologies about “*3D printing*” with 1 article analyzed that can be a technology able to replace some physical shipments as it will be discussed in the result chapter
- Technologies about “autonomous driving” with 2 articles analyzed that lead to facilitate the drivers’ work

The dataset is built in such a way that each row considers the impacts of only one technology at a time, at the contrary to the dataset created from the city logistics projects, in which each line was focusing on the results obtained from each project and so a row might consider different technologies. Hence, it is reasonable to expect from the research coming from scientific papers more detailed information about the impact of the analyzed technology.

To build this part of the dataset, the following information was collected:

- Title of the article
- Paper keywords
- Author
- Year of publication
- In which scientific review they are published
- How many times they are cited on SCOPUS database
- Its citation
- URL for the downloading of the article
- Technology analyzed

- Brief description of the technology
- Methodology used to identify the impacts
- Brief description of the methodology used by the authors
- The impacts of the technologies analyzed

Methodologies used in the scientific papers

The evaluation of the impacts can be done with two different approaches. One is through an ex-ante evaluation and the other is through an ex-post evaluation. The former consists of assessing the impacts of that technology without a real testing of it but by using simulations, analytical analysis or even surveys to potential customers by asking them to imagine a certain scenario. Thus, it is possible to consider this evaluation as a forecast of the potential effects that the technology analyzed might cause once it is deployed in a city logistics project. The latter consists of collecting data after observing the real implementation of the technology and to compute its impacts, for example, cases studies or survey to customers who have had some impacts from that technology can be considered as ex-post evaluation.

The methodologies used in scientific papers are categorized as follow:

- Analytical Analysis
- Case study
- Interviews and surveys
- Literature review
- Simulation
- Qualitative analysis

"Analytical analysis" is used to access the impacts of the technology through computation and math formulas. Sometimes, it is possible to compute in a quantitative way the impacts, in fact, knowing the current state, well-known proportions, mathematical formulas and what the research wants to evaluate, a robust analysis can be run. This category includes many analyses of different nature, like location problems,

analytical approximation models, binary bat optimization algorithm, problems solved by mixed integer programming and Economic analysis.

In addition, the latter analysis just mentioned is a subcategory of other analysis, In the dataset the economic results are found by using the following economic evaluations: Total Cost of ownerships analysis, cost analysis, external cost analysis, and return analysis. The external cost analysis is used to find the externalities that the technology causes to other parties and to try to give a monetary value to them. One of the most important one is the Total Cost of Ownership Analysis that is widely used to forecast the economic impacts and its result might be used by other economic analysis. The aim of TCO is the identification of all the costs that the technology would bring if it is selected and it includes pre-transactional, transactional and post-transactional costs. Qualitative information is also included in TCO by transforming them into monetary term.

With the *"Case study"* methodology, the research process of data collection, data analysis and derive conclusions is done from data generated from testing or real projects. During a project or a test, a new technology is introduced, and it is used in the real environment. Then, there is the observation of how the technology performs and data are collected. Finally, all the information gathered up to here are processed and conclusions can be derived

In the dataset, there are case studies regarding projects done in Rio de Janeiro, Porto, Stargard, Jyväskylä, Brussels, London and Lisbon and case studies regarding the test of wearable technology or intelligent transportation system installed in the vehicle.

"Interviews and Surveys": Survey research can be defined as: "*Survey research comprimes a cross-selectional design in relation to which data are sectional design in relation to which data are collected predominantly by questionnaire or by structured interview on more than one case (usually quite a lot more than one) and at a single point in time to collect a body of quantitative data*" [40]. To access the impacts of technologies in city logistics initiatives, surveys are a wide instrument used in several scientific researches and they might be used to assess different impacts to different stakeholders. They are a fundamental tool if the impact is related to innovation not present in the market or not used at its full potential yet. Indeed, in this case, the only way to predict the impacts of city logistics solutions is by asking experts their opinion. They can use their know-how in order to foresee a possible future scenario. Questionnaire is usually used to collect

information from customers, users or workers when the sample is large and personal interview is used to talk with experts, or more generally when the sample is not that large and qualitative information are difficult to be gathered from a questionnaire [41].

An interview can also include Focus Groups. It consists of interviewing a small-sized group, usually ranging from 6 to 12 participants, with the presence of a moderator. In a City Logistics context, it is possible to discuss about potential barriers that an innovation can bring, to assess the critical success factors and the risk factors, to identify the value that the technology might bring on the hands of the final customers [42].

"Literature reviews" are papers that summarize, compare and analyze the results obtained from other authors and sources or that highlight the lessons learned from various projects and initiatives. It allows to have a picture of the actual state of knowledge in the academic world about that technology discussed and to have a recap of the results achieved in different occasions.

"Simulation" permits the researcher to create several scenarios, typically selecting by different degrees of probability that a certain event may happen, and to compare those with the current state. The modern simulation models exploit the computer power to create a virtual and complex environment composed by digital entities, called agents, who interact each other in a smart way. This kind of simulation model is called Agent-Based and it works well in a city logistics context where several stakeholders as logistics operators, final customers, shop owners, society are present and each of them has different characteristics and claims [43].

"*Qualitative analysis"* compounds the articles in which the results are found from exploratory studies, discussions about some particular design aspects, and more generally in cases when authors take some considerations about aspects which it was not possible to use numbers for assessing their impacts. Exploratory research is about some particular problem that it is not well defined yet and it uses a mix of other methodologies like expert interviews, literature review or case studies, in which the author reasons about the impacts that certain technology can bring in the future.

3.2 Data analysis

After having presented how the dataset is created, in this section, it is analyzed in order to derive some conclusions that will be discussed later on. First, there will be the analysis of city logistics projects and finally the analysis of scientific papers.

3.2.1 Data analysis of City Logistics Projects

The dataset holding information about real projects is made of 68 rows, which are the analysis of 68 different projects' impacts.

Time and place are two variables tracked for building the dataset. It has been possible to identify the starting date for only 59 projects and the finishing date for only 56 projects. The starting dates give an idea if, during some years, there has been more attention to this thematic than others. For this reason, it has been analyzed and the results are reported in figure 3.2. The earliest starting date is 2008 when the MIMOSA project in Tallinn began, 2015 is the year when most of the projects analyzed began, more than the 43%. Other important years are 2011 with 15% of the projects, 2013 with 13%, 2012 with 7%, 2017 with 4%. There aren't any projects that started in the years: 2010, 2014 and 2016. It is not possible to recognize a trend and it is normal than during the most recent years there are few projects analyzed because the data for discussing the valuation of the impacts achieved during the projects are not collected yet. Unfortunately, the 13% of the projects don't have a starting date, most probably because it was not possible to recognize a precise date. Hence, it is possible to state that the projects are quite recent, and this is fundamental because the change in technologies is really fast and old results might be not relevant anymore if the industry has had deep alterations.

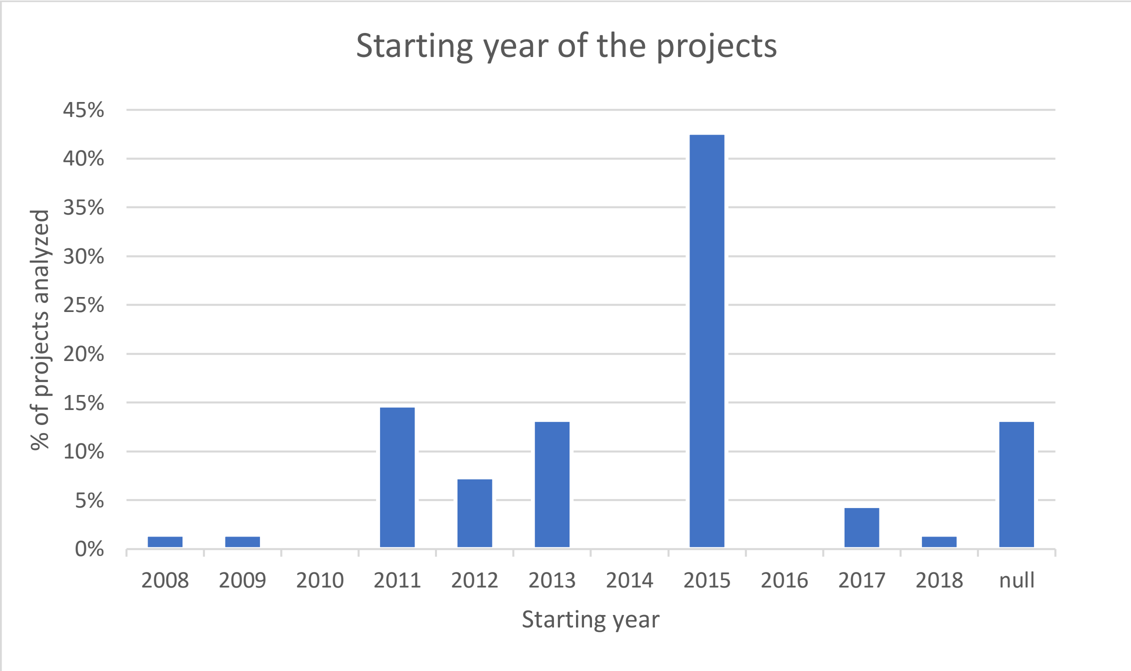

Figure 3.2: Starting year of the analyzed projects

As it is mentioned in the data collection part, most of the projects come from the European zone. In figure number 3.2. it is shown a map considering only this region, so excluding the project WING in Australia and the USA. The intensity of the color of the countries indicates the percentage of projects run in that country, the darker is the intensity, the more projects have been done in that country. The two main countries with more projects analyzed are Italy with the 21% and the UK with the 18%. Over a total of 12 projects studied in the UK, half of them were in the city of London., instead if we consider the capital city of Italy, only 2 over a total of 14 were in Rome. After these 2 countries, there are Spain with 9%, the Netherlands with 7% and all the others with lower percentages. There is not any information about projects done in Swiss cities, in the Czech Republic, Lithuanian, Leetonia, and apart from Greece and Bulgaria the entire Balkan region.

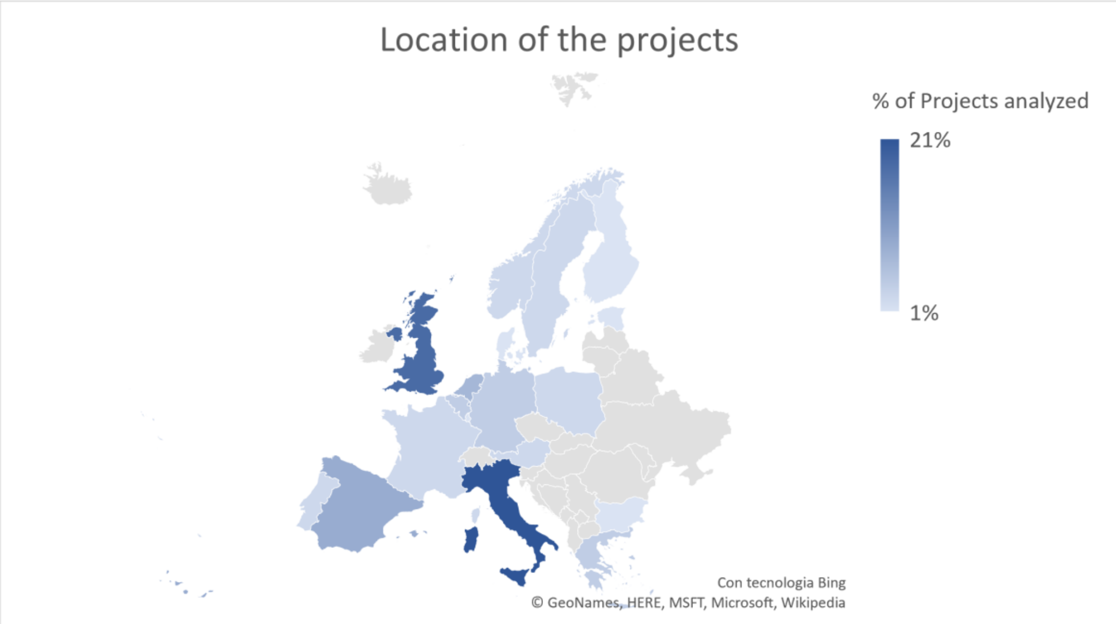

Figure 3.3: Location of the analyzed projects

Then, it has been considered only some important impacts obtained from these projects, in order to see which are the most highlighted when the results of the project are published. To do this, it has been identified only the projects that their results were given in a quantitative way, when the results are communicated through numbers. For instance, if the project manager reports that there has been an improvement in a category of impact, this information is not considered quantitative if it is not supported by data. This analysis is made with the goal to assess if there are some impacts that are more important than others that who run the projects and then communicate the results have more emphasis on disclosing them. The results are shown in figure 3.4. More than the 63% of the projects analyzed has quantitative results about impacts related to the quality of air in term of reduction of different pollutants. More than 35% about the congestion problem where the results are in terms of reduction of traffic, reduction of km traveled by logistics vehicles that should lead to the improvement of the congestion as well, reduction of the dimension of the fleet, and other considerations. An important matter, as the economic one, is reported only in 31% of the results of the project and the noise level is studied in the 15% of the cases. These are only the main important categories of impacts, in the discussion section there will be the comparison of the results found in this analysis with the results found with the papers analysis. It was predictable that most of the project's results are focusing on impacts with a higher social utility as the improvement of the traffic condition or of the quality of air than economic ones, since most of the projects are financed with a public budget.

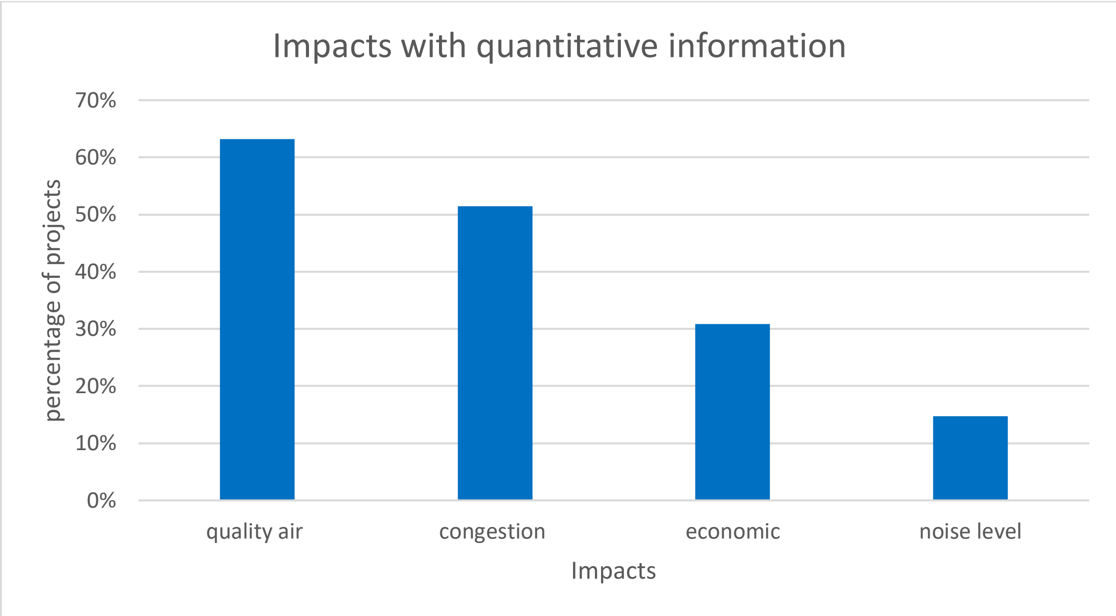

Figure 3.4: Principal Impacts disclosed with quantitative information

Finally, this chapter wants to analyze the technologies, solutions and innovation deployed in these projects and the main results are summarized in table 3.2.

The 13% of the projects analyzed consider the introduction of an *Urban Consolidation Center* or *Construction Consolidation Center* combined with other technologies. The earliest of these projects began during the 2011 and they were done in different countries as Sweden, the UK, Italy, Spain, France, Luxembourg and Greece. It is interesting to mention that all the projects report quantitative information about results obtained in terms of improvement in the quality of air, 8 over 9 projects about congestion condition and economic impacts and only one about the noise emission.

The 26% of the projects have some *electric vehicles* as technology deployed for urban freight transport. The earliest project started in 2011 and the 33% of them were done in the UK, 4 over 18 in Italy, 3 over 18 in the Netherlands and the others in Spain, Germany, Norway, Sweden and Portugal. The 56% of projects that involve the introduction of Electric Vehicles have quantitative information about air quality, 3 over 18 about economic impacts and 2 over 18 about the noise level.

Another vehicle quite deployed in these projects are *cargo bikes* that it is present in more than 10% of projects analyzed. The earliest project started in 2013 and they were done in Italy, Germany, UK, Netherlands, Austria and Belgium. The findings of the starting date make arise some questions. In fact, the technology behind these vehicles is less complex than other ones as electric vehicles, but the deployment of this kind of bike for running city logistics activities seems happened later. Hence, it is not a matter of technical feasibility the fact that they were not present in any previous projects. Only 3 over 7 focuses on quantitative results in terms of congestion conditions and only 1 on the economic aspect. Also, in this case, the most studied impact seems to be the air quality improvement because 5 over 7 projects with cargo bikes communicate quantitative information about it.

Table 3.2: Main solution adopted in City Logistics projects

Solution adopted in the project	**% of projects in the dataset**	**Earliest starting year**	**Location**	**Main achievements disclosed**
Electric vehicles	26%	2011	United Kingdom, Italy, Netherlands, Norway, Sweden, Portugal	56% of the projects quantify air quality improvement
Cargo bikes	10%	2013	Italy, Germany, United Kingdom, Netherlands, Austria, Belgium	5 over 7 projects disclosed quantitative impact to air quality
UCC or CCC	13%	2011	Sweden, United Kingdom, Italy, Spain, France, Luxembourg, Greece	All the projects report result in term of air quality and 8 over 9 about congestion and economic impacts

3.2.2 Data analysis of scientific papers

The dimension of this section of the dataset, as it is summarized in table 3.3, consists of 65 scientific papers used as a source for identifying 66 technologies impacts when they are deployed in City Logistics.

Table 3.3: Dimension of the scientific papers section of the dataset

Number of papers analyzed	65
Number of rows in the scientific papers section of the dataset	66

In this case, the considerations about the time of these sources are made by looking at the year of publication. As it is reported in figure 3.5, the earliest paper is dated 2006, then only 2 over 65 are dated 2008 and all the others are concentrated from 2011 to 2020. The 25% of the papers have been published in 2018, 17% in 2016, 17% in 2019, 11% in 2017 and lower percentages during the other years. If the only papers published from 2016 up to nowadays are considered, they represent the 71% of all papers present in the dataset, hence, also in this case, it is possible to expect that the results found from the dataset show a current situation of city logistics technologies.

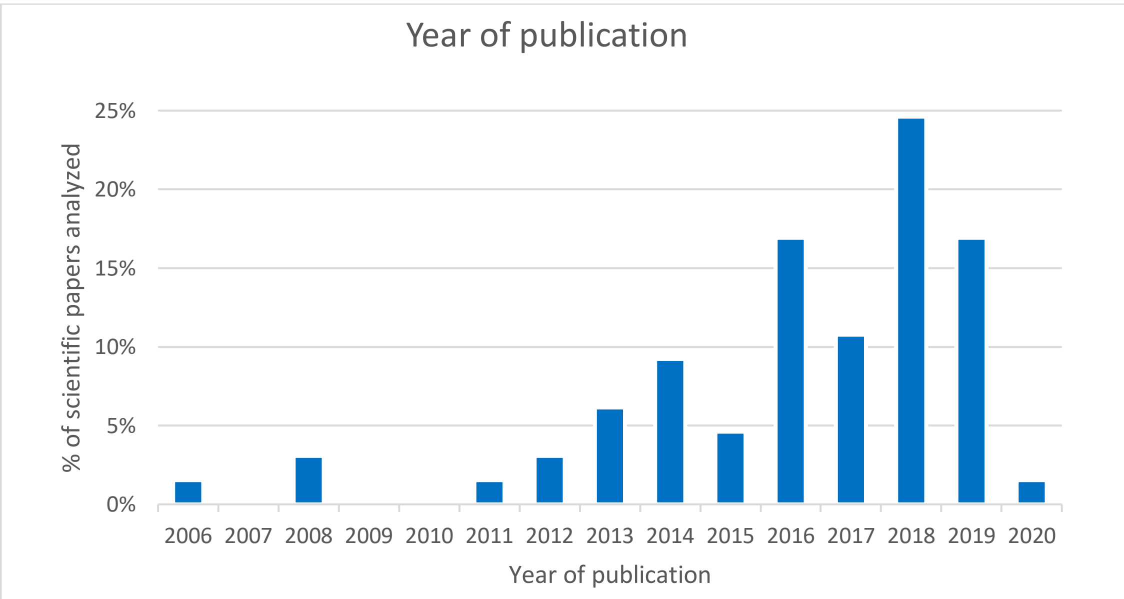

Figure3.5: Years of publication of the analyzed papers

The technologies studied in the papers selected are organized as it is shown in figure 3.6 and they will be discussed in the result chapter of this thesis. The largest part of the papers (22%) treat the impacts of electric vehicles, the 15% are about crowdshipping, the 12% are about cargo bikes, the 12% are about drones, the 14% are about parcel lockers, the 9% are about 4.0 Logistics technologies and lower percentages for the other technologies, like Autonomous driving and autonomous robot, Underground and rail-based logistics, 3D printing and Mobile depot. Since, in some ways, cargo bikes can be considered as small electric vehicles when they are equipped with an electric motor, they both together represent the most studied technology in this dataset with the 34% of articles that treat them.

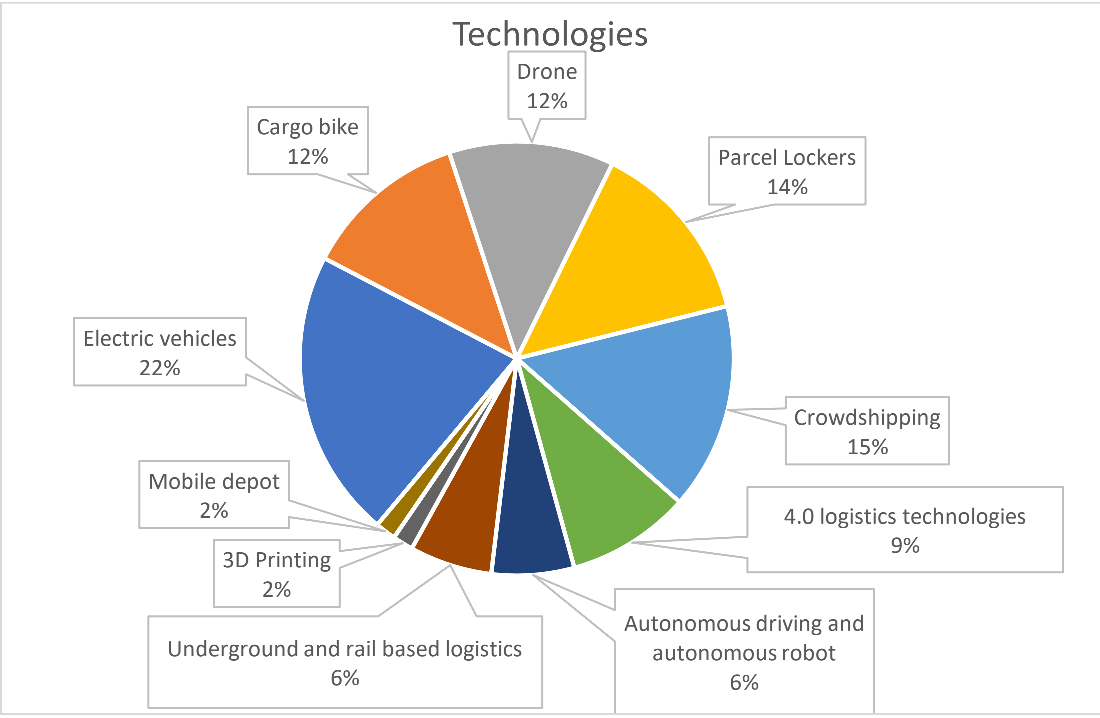

Figure 3.6: Technologies studied in the analyzed papers

A total of 70 methodologies used for assessing the technology impacts by authors are found, because some scientific papers might use more than one in order to figure out their results. These methodologies are organized as they are described in the data collection section of this chapter and in this analysis, it has been considered which ones are the most used in the papers selected for building the dataset. The results are reported in figure number 3.7. If the survey and interview are considered together, they are the most frequent methodology used for the identification of the technologies impacts in the dataset with more than 26% of the cases, analytical analysis are the 19% of the cases but it is important to highlight that this category is a generic term that includes many classes of analysis. Simulation, with 17%, is another important methodology, and generally speaking, it seems from the figure that it doesn't exist a methodology that is predominantly used than the others.

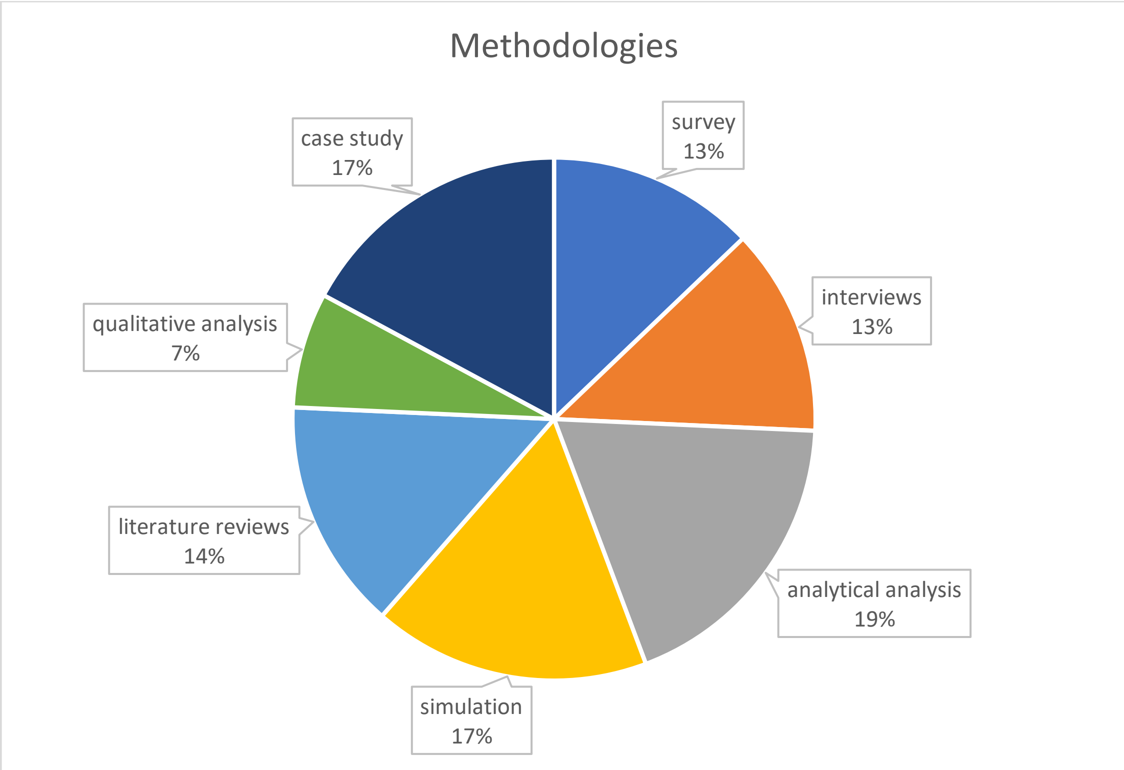

Figure 3.7: Methodologies used by the authors of the analyzed papers

For the same reason described in the data analysis of city logistics projects, and for the possibility to compare the results obtained there with the ones obtained here, also, in this case, an analysis of the principal impacts that are disclosed with quantitative information is done. The results are reported in figure 3.8 and they have a completely different distribution than the project ones. The impacts on quality air are quantified in the 29% of the scientific papers analyzed, the congestion condition in the 15%, the economic impacts in the 26% and there aren't any papers that treat in a quantitative way the noise level. Comparing these percentages with the ones previously found, it is evident that they are smaller because a scientific paper treats the topic just in some particular details and so it generally has the focus only on few impacts at a time.

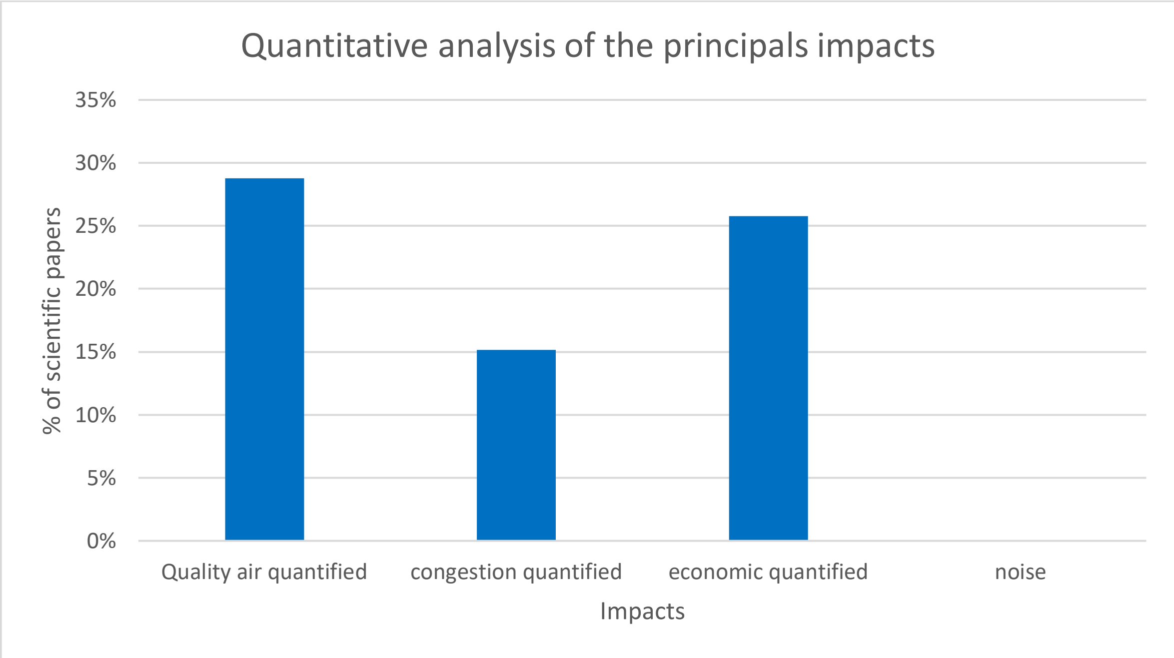

Figure 3.8: The percentage of the analyzed papers that treat in a quantitative way the principal impacts

Analysis of the main technologies treated in the scientific papers section of the dataset

Following there is the analysis of the main technologies identified in the city logistics literature. For each technology the following investigations have been done:

- Number of articles in the dataset that address the technology
- Consideration about the year of publication of the scientific papers, in order to see the earliest year, the latest year and if in some years there are more articles published than others
- Identification of the relevance of the articles in the academic world by looking for the number that other articles have cited on the database SCOPUS the paper analyzed (data updated to November 2019). Two dimensions are computed, the sum of the citations of each article included in the category and the average citation per article in the category
- Which methodologies are the most used by the authors for evaluating the impacts of that technology
- Which impacts are the most quantitative studied

Electric vehicles represent 22% of the impacts identified in the dataset. The earliest scientific paper is dated 2011, the latest is dated 2018 and 2016 is the years when the most part of the papers analyzed were published, 4 over 14. Electric vehicles are a technology quite studied in the academic world, in fact, if all the citations on SCOPUS that each article has generated are summed up, a total of 475 citations are identified and on average each article is cited by almost other 33.93 papers. The methodologies used by the author for the identification of the impacts are in 4 cases analytical analysis, 4 case studies, 3 literature reviews, 2 interviews and only one simulation used. The most studied impacts studied in a quantitative way are the computation of the improvement in the air quality and the economic ones, in fact, 6 over 14 papers focus on these issues. Also, the noise emission is quantitative evaluated in 4 over 14 papers analyzed. Unfortunately, only one article has focused on the customer attitudes to this technology, but 6 over 14 state some considerations about the work conditions of the employees after the introduction of these vehicles.

Cargo bikes are discussed in 13% of the dataset. The earliest paper is published in 2014, the latest in 2019. It is a more niche topic than EVs, in fact, on average each article is cited by other 16.25 papers on SCOPUS, and they overall generate 130 citations, thanks to article number 65 that itself generates 58 citations. There are 9 methodologies used by the authors identified, because article number 65 uses the literature review and interviews with cycle logistics operators as a methodology to state its results. The simulation is used 2 times over 9, a case study is used 3 times, literature review 2 times, and just one paper uses the survey method and one paper the interview. Half of the papers analyzed state quantitative information about the quality of air impacts, only one about economic aspects and the impacts on congestion is quantitative evaluated in 2 over 8.

Drones are discussed in 13% of the dataset as well. The earliest year of publication is 2014, the latest 2019, and the mode is identified with the year 2018. The total citation on SCOPUS generated from these papers is 156, also because article number 57 has a total citation from other 82 authors and the average citations per article is 19.5. The methodologies used are 2 analytical analysis, 2 interviews, and one qualitative analysis, a simulation, a literature review, and a survey. The impacts quantified in economic terms are just found in 2 articles and only 1 tries to quantify the congestion impacts. No one of the articles analyzed treats the work condition aspects.

Parcel lockers are treated in 9 articles. The earliest year of publication is 2016 and the latest one is 2019. The total citation created from these articles is 92 on the SCOPUS database and on average each article is cited by other 10.22 other scientific papers. Survey and interview are methodologies quite used for the assessment of the impacts, 3 over 9 the former and 2 over 9 for the latter, the other methodologies used are case study, simulation, analytical analysis, and interview. 8 over 9 articles that analyze this technology have a focus on the customer perspective, trying to identify the customer satisfaction of the users or how they should change their behavior to use the service. Only 2 articles treat economic aspects in a quantitative way, 2 over 9 articles take quantitative considerations on the quality air impacts and congestion conditions. There aren't any considerations about the work condition.

16% of the dataset is about *Crowdshipping***.** The earliest publishing year is 2016 and the latest is 2019. The citations generated on average are 11.9 per article and an overall of 119 citations. Since, also in this case, there are some articles that use more than one methodology, 13 methodologies are used for analyzing the impacts. 4 over 13 are Simulation, 3 over 13 are analytical analysis, 2 over 13 are survey and literature review and only 1 over 13 are interview and case study. The impacts seem to have great emphasis on the customer perspective and on the work condition, in fact, the former is analyzed in 7 papers over 10 and the latter in 6 papers over 10. Quantitative information about the economic aspect is given in only 1 paper, congestions problem in 3 and quality of air is another well-studied impact cause 5 over 10 of the analyzed scientific papers address this phenomenon in a quantitative way.

Autonomous driving and *autonomous robot* are discussed in 4 articles, with the earliest year the 2013 and the latest year 2018. The total citations generated from this category on SCOPUS are 12, on average 3 per article. The 4 articles are analyzed with 4 different methodologies: interview, analytical analysis, qualitative analysis and literature review. The economic impacts are quantified in only one article over 4 and the work condition is addressed in only 2 papers over 4.

Underground logistics and *rail-based logistics* are studied by 4 articles present in the dataset. The earliest year of publication is 2008, the latest the 2019 and 2 over 4 articles are dated 2008. A total of 63 citations are generated from the 4 articles and on average they are cited by 15.75 other scientific papers. The 4 methodologies used by the authors of these articles are Survey, analytical analysis, qualitative analysis, and a simulation. The impacts were quantified in 1 article regarding the economic ones, in one regarding the air quality impacts and 1 regarding the congestion condition.

In the *4.0 logistics technologies* category, there are 6 articles, the earliest date is 2006, the latest is 2020 and 2 articles in 2019. Thus the 50% of the articles analyzed in this category are really recent. The total citation generated in SCOPUS is only 6. The methodology used is in 2 articles case studies and the other are survey, analytical analysis, qualitative analysis and literature review. It is difficult to identify quantitative information regarding these technologies impacts from the articles in this category and actually only in one article it is quantitatively estimated the impact related to the travel time.

Minors technologies, that their impacts are related to a city logistics aspect, but few literatures were available, are 3D printing and Mobile depot. *3D printing* is treated only in one article dated 2016 in which the impacts are figure out through a qualitative analysis instead *Mobile depot* is treated in one article published in 2014 in which there is the analysis of a case study.

The main findings from this data analysis are summarized here below, and this also allows to compare the results of the identified technologies.

It is possible to figure out from the dataset that the technologies most studied by scientific authors when they are discussing about city logistics studies are *Electric vehicles.* In fact, electric vehicles result not only in the technology most present in the dataset, 22% of all the found impacts and 35% if included with *cargo bikes*, but also in the topic that generates the highest total citations and with the highest average citations per article. This is shown in table 3.4, in which it is possible to compare the two dimensions just mentioned.

Table 1.4: Citation generated by the articles in the dataset

Technology treated	Total citations generated	Average citations generated per article
Electric vehicles	475	33.93
Cargo bikes	130	16.25
Drones	156	19.5
Parcel lockers	92	10.22
Crowdshipping	119	11.9
Autonomous driving and autonomous robot	12	3
Underground logistics and rail-based logistics	63	15.75
4.0 logistics technologies	6	1

Furthermore, it seems that there are some technologies that only in recent years they have been started to be studied. In table 3.5 the earliest publishing years of all the technologies found are reported. Parcel lockers and crowdshipping have the most recent articles, in fact, the oldest article in those categories are published in 2016. In the category 4.0 Logistics technologies, there is an article published in 2006 even if in that year industry 4.0 was not a topic treated yet. It is like this, because the technology presented in that work has the same idea of industry 4.0 in which real-time traffic data are processed and used to obtain a smart car navigation system able to compute the fastest route as possible. Cargo bike is also a quite recent vehicle studied for urban freight transport even if the technology behind is not complex and logistic operators might have used that for a long time before 2014. This discussion about cargo bikes is the same made in the projects part of the dataset.

Table 3.5: Earliest publishing year in each category of technology

Technology treated	**Earliest year**
Electric vehicles	2011
Cargo bikes	2014
Drones	2014
Parcel lockers	2016
Crowdshipping	2016
Autonomous driving and autonomous robot	2013
Underground logistics and rail-based logistics	2008
4.0 logistics technologies	2006

The technologies impacts are not studied in the same way for all the categories identified. For example, even if crowdshipping is a technology well represented in the dataset, only one article takes quantitative consideration about the economic aspect despite the fact that building a profitable business model for crowdshipping might be not easy and many decisions that have economic impacts must be taken. Articles that treat electric vehicles, cargo bikes and crowdshipping usually focus their results on air quality impacts, instead, parcel lockers that indirectly can cause impact to air quality are treated only in 2 over 9 articles.

Table 3.6: Impact quantified in each category of technology

Technology treated	Air quality quantified	Economic quantified	Congestion quantified
Electric vehicles	6 over 14	6 over 14	-
Cargo bikes	4 over 8	1 over 8	2 over 8
Drones	-	2 over 8	1 over 8
Parcel lockers	2 over 9	2 over 9	2 over 9
Crowdshipping	5 over 10	1 over 10	3 over 10
Autonomous driving and autonomous robot	-	1 over 4	-
Underground logistics and rail-based logistics	1 over 4	1 over 4	1 over 4
4.0 logistics technologies	-	-	-

3.2.3 General conclusion of the data analysis

Through the data analysis of the dataset created in this work, similar findings to the literature reviews reported in chapter 2 are found.

The timing shows that the selected scientific articles are recent ones, and this is a good feature in order to capture an actual and current situation of the technologies deployed for city logistics. Also according to the motivation treated in chapter 2, some authors have identified that only in the most recent years the scientific publications are focusing on this thematic.

In chapter 2 it is reported that the most productive academics in this field of the supply chain management were from Italy and United Kingdom, and a reason why this happens is reflected in the high number of city logistics projects done in those countries, as it is shown in figure 3.3. Universities play an active role in many projects that address city logistics problems, so it is reasonable to state that the result obtained from these projects are used to produce scientific articles that can be disclosed to the society and this is also a finding identified in chapter 2 where it is reported that a large share of literature available about urban logistics relies on empirical data. Before there is the observation of the phenomenon and only in a second moment there is the study of it.

A lack of stakeholder involvement was identified in chapter 2 as well. This is not true for some specific categories of technology. There are some, like autonomous driving, autonomous robot, crowdshipping and parcel lockers, that their impacts on workers and customers are well studied. This most probably happens because the introduction of such solutions requires a complete change of paradigm of the services and the customer and worker acceptance must be studied.

4 Results

In this chapter, there is firstly the introduction of which impacts the technologies might cause when they are implemented in city logistics projects and after this, it is reported for each technology what is its impacts taking conclusion from several sources.

4.1 Impacts found

As it is reported in chapter 2, the methodologies used by academics to assess the impacts caused by City Logistics activities can be categorized in 4 impact areas. In this thesis, it is proposed a classification of the impacts in the following way:

- Economic: Operating costs, Investment required
- Operation: Operation efficiency, Product Features, Shipping time
- Environmental: Air quality
- Social: Vibration, Noise, Congestion, Safety on the streets, Work condition, Customer satisfaction, Change in customer behavior
- Others: Other

4.1.1 Economic impacts

When the new technology is implemented this can lead to a change in the cost structure of the service in a positive or negative way. Hence, it affects directly the logistics operators, but it might affect the final customers as well, because the price of the service might increase or decrease. For building the dataset, two values are identified in this category. The former regards the impacts on Operating Costs and the latter to Investments required.

Generally, companies are really focused on these impacts, because the principal aim of enterprises is to make profits and either operation costs or investments required are two dimensions that can be easily computed and so they become the main driver in the decision making process to adopt or not a new technology. There are different analysis that can be run in order to evaluate if a new investment leads to achieve a positive or negative return. One of these is the discount cash flow, all the cash flow, either the in-cash or out-cash flow, that the new technology will bring to the company are estimated and then all the sum of them are discounted to compute their current value. It is necessary to highlight that sometimes an investment is undertaken even if the expected return is negative for other reasons as new regulation that requires the adoption of new technology, reputational images, or a too conservative way for computing the cash flow generated.

Operation costs are the ones generated when the resources are used and in the financial world, they refer to costs generated to run the everyday activities. Usually, they are proportional to the use of the resource, the higher the utilization of it is, the higher the costs are. The operation costs are money that companies must spend over all the period that the technology is used. They include costs as salaries, maintenance, fuel, energy, insurance and more generally all the others that occur for running the core business of the company.

Investment required, at the contrary of the operation costs, concerns the financial of the company once at a time, when logistics operators have to acquire the new equipment. They are identified with the purchase price of the technology, with the costs necessary to prepare the asset to be used like training for the workers, additional costs for assembling or transporting it, etc. In some case, the adoption of one technology might require a high investment not for the purchasing of that technology, but because a new infrastructure is required in order to use the technology, as it happens with electric vehicles that companies need also to invest in a recharging station at the depots as it will be shown later.

Table 4.1: Economic impacts

Economic impacts	**Brief description**	**Examples**
Operating costs	Costs to run everyday activities, proportional to the use of the resources	Maintenances, insurances, fuel…
Investment required	Concerning the financial of the company once at time	Purchase price, new infrastructure required...

4.1.2 Operation impacts

In this category, there are all the impacts that affect the operations of logistics companies to deliver parcels, by introducing new restrictions on it or allowing a more efficient work.

With *Operation efficiency* is meant all the effects that address the efficiency of running logistics activities. Thus, there is an improvement in the efficiency when for doing the same activities it is required fewer input factors as employees that they affect directly the operating costs, or when with the same input factors it is possible to do more activities as increasing the number of shipments per day. There is a worse efficiency in the opposite cases.

The adoption of new technology might cause new requirements that the product characteristics must satisfy. In the dataset, whenever it has been possible to recognize that the technology brings some restriction to the products, it was reported under the voice *Product features*. The main reason that it happens is due to the vehicle selected for the transportation of goods. In fact, choosing a vehicle rather than another one means also to have different constraints about which products can be transported in the cargo of the vehicle and so it is possible that the products in order to be delivered with that technology must respect some requirements in term of weight, dimension or material of construction. This argument will be clearer when drones or 3D printing technologies will be discussed later on in this chapter.

Finally, *shipping time* is the last voice in this category. Customers are really sensitive to the time required to receive their goods, because they expect always faster services and a reduction in the shipping time gives the opportunity to logistics companies to have satisfied customers. Also in this case shipping time is linked to other impacts as the economic ones, because a faster technology might be more expensive to be acquired or have higher running costs.

Table 4.2: operation impacts

Operation impacts	**Brief description**	**Examples**
Operation efficiency	The good utilization of resources like time and energy	Increasing shipment per day with the same input factors
Product features	New requirements of the product after the adoption of the technology	More restricted requirements in term of weight or dimension
Shipping time	Time required to receive the good	Decreasing in the shipping time

4.1.3 Environmental impacts

The improvement of *air quality* is an objective pursued by the implementation of different technologies in urban freight transportation. First of all, it is necessary to distinguish two different categories of pollutants: the ones with global effects and the ones with local effects.

Greenhouse emissions are made by different gasses like CO2, CH4, N2O and O3 that the effect of their presence in the atmosphere is a problem for the whole planet and not only in the area where they are produced. During the last years, the global temperature has increased due to the greenhouse emissions that do not allow the full re-emission to space of infrared radiation by the earth. A further critical issue of these gasses is that they have a long life in the atmosphere and so having a radical and fast improvement of the current situation is not possible.

The second category is pollution composed by different gasses and chemical compounds which their effects have a strong impact in the area where they are produced. Included here, there are atmospheric particulate matter (PM), they are a mixture of organic and inorganic particles suspended in the air. They are typically labelled by a number which indicates the dimensions of them as PM10 and PM2.5 that stand for PM with a diameter respectively lower than 10 and 2.5 nanometers. PM might hold different particles like sea salt, soil particles and soot particles released after the combustion of fossil fuels. Another dangerous pollution is SO2, it is formed when the sulphur present in some fuel, like diesel, reacts with the atmosphere to give sulphurous anhydride. The incomplete combustion releases in the air CO, dangerous gas that in high concentration can even lead to death. Finally, there are some pollutants that are the main responsible of doing smog in the city. They are NO2, which absorbs the light in the visible range and the ozone which causes a chemical reaction with the atmosphere where the result gives to the atmosphere a reddish-brown appearance.

The impacts of bad air quality in the locality causes huge damages to the society. The death rate is higher, there are more cases of respiratory illness and all this causes indirect effect as higher public expenditures in the health sector or more days of workers at home due to illness. Other indirect effects, in this case, related to smog are higher maintenance costs of buildings or monuments that require architecture restoration more frequently and more dangerous roads due to weak visibility coming from smog. As it will be shown later, several solutions in city logistics operations involve the substitution of a vehicle propelled by fossil fuel with greener alternatives and they will be able to reduce local emissions at least in some sensitive areas as hospitals, nurseys, schools or parks.

Table 4.3: Environmental emissions

Environmental impacts	**Brief description**	**Example**
Air quality	Emissions of pollutants with local or global effect	Decreasing of CO_2, CO, NO_2, PMx emissions

4.1.4 Social impacts

Social Impacts are the consequences of the technologies deployed in City Logistics to the following stakeholders: workers, customers or society.

Congestion is a serious problem in the cities and vans are a large component of vehicles on the cities' roads and so they can lead to cause further problems to traffic. Congestion means that traffic flow is not regular, vehicles have to take many breaks during their journey in the city and consequentially the travel time of all the vehicles increases respect the case of no congestion conditions. Vans are responsible for this phenomenon also because, for their business nature, many stops for downloading and unloading of parcels are required. The institution should contemplate an adequate number of specific parking areas for city logistics operators, if they are not enough, illegal parking will arise leading to worse traffic condition.

Congestion is a problem addressed by many innovations and technologies because indirectly it causes several other impacts. An increase in operating costs is reasonable due to a less regular driving style. The continue breaking and accelerating driving leads to an increase in operating costs as higher consumption or an abnormal deterioration of mechanic parts (e.g. breaks). Furthermore, the higher consumption translates into higher pollution emissions. The more time spent in the traffic might cause frustration to employees and inefficiency management of resources because their productivity decrease spending time in non-valuable activities. Last but not least, congestion can bring to a more dangerous condition on the roads, where the number of accidents increases, because drivers are more distracted in traffic condition or because the illegal parking let the other drivers to take more dangerous paths to surpass vans. Hence, congestion has an important impact on the quality of life in the cities.

Another important impact that affects the society and in particular the life condition of citizens is the *noise* that logistics activities generate in cities. Generally, noise is a consequence of the traffic condition and since commercial vehicles cause high problem to the congestions of roads, it becomes an important matter also for the City Logistics context. The noise of the traffic is generated from two different sources: the one generated from the contact of the tires and the asphalt of the roads and the one generated from the engine propulsion. Studies show that the first one is the dominant cause of noise when cars are traveling above 55 Km/h or trucks are traveling above 70 Km/h. There are several variables that produce noise like the types of the asphalt, the typologies of engines, the presence of sound barriers, the types of tires.

The implication of traffic noise to the city's inhabitants might be really dangerous for their health. They can cause not only damages to the physical organs as hearing loss, but also psychological effects as sleeplessness, stress generation, annoyance or even to the work performance as confusion about what is heard or reduction on the productivity. According to the World Health Organization [44], 40% of the European population is exposed to traffic noise above 55 db, 20% above 65 db during day-time hours and more than 30% above 55 db during night-time hours. Above the threshold of 55 db during night hours, a large part of the population accuses sleep disturbance, annoying and there is evidence that some cardiovascular diseases have a higher probability to occur. For this reason, authorities set regulations that try to reduce this externality depending on the hours and on the location when/where the noise is measured.

Safety on the street is another consequence of the traffic condition on the streets. It is reasonable to expect a reduction in the number of accidents if the traffic condition becomes better because drivers will be less distracted and stressed. For instance, this is evident in many articles in which it is reported that a reduction in the dimension of the fleet leads firstly to improve the congestion condition and subsequently to create benefits in terms of safer conditions on the streets.

Another consequence of the traffic in cities is the generation of *vibration* caused by the high flow of vehicles on the roads, this phenomenon is identified as physical pollution of the environment. It can generate frustration to people who live close to high traffic roads leading to have problems similar to the case of high noise as sleeplessness or stressed but it can also be a source of the deterioration of building if they are crossed by vibrations for a long period and in the worst case they can lead to the collapse of a building. Hence, vibrations are caused by the movement of vehicles on the roads and the variables that affect the dimension of the vibrations are: the speed of the vehicles (higher speed leads to have higher vibration), the vehicles weight, the characteristics of the building (the dimension, the shape, the distance from the road), the types of grounds and furthermore.

Finally, the social impacts compound effects caused to the final customers that are using the service or to the employees who work for logistics company.

Customers can be affected from the technology used in city logistics because they are required to change their behavior, or their satisfaction might change.

Customer satisfaction is an important dimension that companies are really interested in because there is a strong degree of competition in the market and in order to achieve a larger market share the companies must address customers' requirements. This dimension is constantly tracked by marketing departments and it can be measured through several market research techniques. There are some technologies that affect directly the final customers and that can be easily understood by them, others that are behind the customers' eyes and they can perceive a better or worse satisfaction of the service based on its quality.

Then, there are technologies that cause change to *Customer behavior*. A new approach to the service can be a barrier to the adoption of it, in fact, in this case, companies must be sure that customers are willing to change their behavior to utilize the service before the introduction of a new way to run the city logistics activities. The marketing department is also here an important resource for the communication with the customers, because it must be able to explain how the customers have to deal with the service and to highlight all the benefits that the new technology creates to them or to the society.

Finally, in the social impacts category, there are all the impacts caused to the workers and they are reported as *work condition*. The employees might be strongly affected by the introduction of innovation and it is important that their degree of satisfaction is always high in order to have a productive workforce, with low turnover and few workplace accidents. Thus, indirectly the saving under an economic aspect are significant when there is an improvement in the work condition. Better productivity means to increase the output with the same input factors, less turnover means to have employees with a good experience that they can do their job autonomously and so there is not the necessity to train new employees, few workplace accidents means that globally the workers will do fewer days of illness and so companies can count on a more reliable workforce. If the introduction of the new technology wants to pursue also a better work condition, it must create a secure, safe and not stressful work environment.

A current topic regarding the technologies is the replacement of the workforce with them. In City Logistics there is this phenomenon as well, it is an issue that the whole society must deal with and for sure some interventions for regulating the human work in the future will be necessary in order to reach a balance in the human living condition.

Table 4.4: Social impacts

Social impacts	**Brief description**	**Examples**
Congestion	Traffic flow is not regular	Increasing in the traffic condition of the urban center
Noise	Sound produced by city logistics activities	Decreasing of noise level after the introduction of Commercial Electric vehicles
Safety on the street	Dangerous situations on the roads caused by city logistics vehicles	Decreasing of the number of accidents
Vibration	Vibrations caused to the environment by city logistics activities	Deterioration of building caused by the ground vibration
Customer satisfaction	Measuring if companies address customers' requirements	Higher customer satisfaction after the improvement of the service level
Customer behavior	How customers must deal with the service	Selecting parcel lockers as delivery points instead of the traditional door to door delivery
Work condition	Conditions of the employees operating in city logistics activities	Higher degree of employees' satisfaction

4.1.5 Others

The impacts sometimes are so specific that it is not useful to create a specific field in the dataset for them, because there would be too few values in that, and it would lead to build a dataset too complex where some information could get lost. For this reason, all the other impacts identified, for which it was not possible to recognize them in a previous category, are listed with the label *others*.

4.2 Impacts found for each technology identified in the dataset

In this section there will be reported for each technology analyzed which impacts are identified by using the two typologies of sources: real projects and scientific papers. For each category, there is a first part that is an introduction of the technology and only in a second moment the impacts found in the dataset are reported with also attached information about which source have been used as it is summarized in table 4.5. N.B: as it is mentioned in chapter 3 of this thesis, the ID code present in the Appendix section is used in this chapter to identify the selected articles for building the dataset. Furthermore, for the technologies with more information, a table that summarize the main findings is reported at the end of each category.

Table 4.5: Identification of the articles for each technology category

Technology	**Articles in the category**
Electric vehicles	5, 14, 21, 22, 25, 31, 43, 44, 48, 52, 53, 54, 64
Cargo bikes	9, 23, 26, 28, 33, 55, 56, 65
Mobile depot	39
Drones	3, 19, 27, 45, 46, 47, 49, 57
Parcel lockers	1, 8, 15, 35, 36, 50, 59, 60, 63
3D printing	3
Crowdshipping	6, 10, 12, 13, 29, 37, 40, 41, 51, 58
Autonomous robot and autonomous driving	11, 17, 38, 42
Underground and rail-base logistics	4, 32, 61, 34
4.0 logistics technologies	2, 7, 16, 20, 30, 62

4.2.1 Electric vehicles

EV is one of the widest technologies deployed in city logistics projects when stakeholders want to achieve a more sustainable solution for freight transportation. They can be cargo bikes, cars, vans or even trucks and in many projects, they are deployed because they bring new characteristics that have positive effects on the logistics operations and on the externalities caused to society.

Inside the vehicle, there is a set of battery that usually it has enough capacity for the daily activities of vans in the city. They don t produce any emission when they are deployed and this allows to logistics operators to obtain a more flexible solution for their deliveries, because in some cases the vehicles might be allowed to pass through areas where traditional ones are not permitted to enter like specific traffic limit zones, or pedestrian areas, and often authorities introduce in the planning of urban areas specific parking reserved to the only electric vehicles. Another factor that can give more importance to them is that they are almost soundless. Then, the electric vehicles can be used in combination with other city logistics solutions as night deliveries or Urban Consolidation Centre without causing further externalities.

The operators who decide to introduce this kind of vehicle in their fleet must gain new experience in the planning process, because now the charging of the electric vehicles requires time and it can be done only in certain places. Due to the limit autonomy of these vehicles, they are often charged in warehouses in the city or close to it and they are charged during night hours when the fleet is not working. A planner must take into account in this case when to charge the vehicles, the level of battery when they arrive after finishing their daily activities, and if the generation of electricity of the plant is enough to cover all the demand for electricity for recharging the vehicles.

So, the efficacy of this technology strongly depends on which city it is adopted. For examples, it depends if there are some incentives to buy them, the costs of electricity, the presence of TZL, the presence of preferred lanes or parking.

They become a really environmentally friendly solution when the source of electricity comes from renewable energies like solar panels installed on the roof of the warehouse or wind turbines, because in this case also the production of electricity doesn’t produce any emission. If it doesn’t happen, their introduction is anyways a good fact because they bring a local improvement in the city by avoiding local emissions and it could be even a good solution in some sensitive areas, for instance by reducing local emissions in the proximity of schools, hospitals or gardens. Furthermore, the efficiency of big and modern energy production plants is much better than engines installed in vehicles.

Surveys show that drivers are usually happier to drive an electric van than a traditional one, thanks to the soundless in the cabin, a faster and more regular acceleration and a more sustainable impacts of their jobs to the environment.

Electric vehicles usually have lower operating costs than traditional ones. An electric motor is a simpler technology respect the internal combustion engine, there are less moving parts and all these require less maintenance. Oil motor is also not required in this kind of vehicle. Nowadays, fuel is more expensive than electricity, but it is reasonable to expect in the long run an increase in the electricity price because if the demand of fuel will decrease authorities will collect less money from fees charged to oil price and so they will need a new source of revenue that most probably could be charged to electricity price. The taxes paid for the possession of the vehicles are usually lower for electric vehicles than traditional ones because authorities are trying to attract more people and companies to adopt this technology by offering different incentives to them. The presence of these government incentives is also fundamental for the purchasing decision. In fact, the main driver of the cost of the electric vehicles is the cost of batteries, they are expensive, and they need to be replaced with new ones after a certain number of charging cycles. Even if in the near future great improvement in their operational life and costs are expected, the technology is generally adopted by users only in case of the presence of incentives that lead to obtain a positive return of their investments in the electric fleet.

An obstacle to the adoption of the electric vehicles could be the worry of operators to have a weak or a lack of car mechanics who repair electric vehicles or the difficulties of finding replacements parts in case of damaged vehicles.

As it is already treated above, the introduction of electric vehicles could also require the investment in charging station, because charging a vehicle requires some hours and so, even if in the city there are areas where they can be charged while the vehicles are parked for the downloading operations, they are a more expensive solution, they might be not free or out of order or the time might be not enough to achieve a complete recharging. For these reasons, the vehicle planner must count on a reliable charging station that can be used during hours of not deliveries and that assures the correct functioning of all the activities.

Last but not least, the marketing department of companies can consider to exploit the adoption of these vehicles in order to provide their customer a better company image and to try to attract new customers sensible to environmental issues.

After a brief introduction of the technology, it is necessary to identify the impacts in a more quantitative way by using the dataset created. Electric vehicles are treated on articles number: 5, 14, 21, 22, 24, 25, 31, 43, 44, 48, 52, 53, 54, 64.

It is reported an impact on operating costs about a saving of 20-30% in 14, 25-50% in 24, up to 59.9% in 31, 50% in 52, 65% in 54. These values are not the same because different assumptions are taken. All the savings on operating costs reported are comparison with the traditional City Logistics technologies, where the vehicles run with fossil fuel like diesel vans. In article 48 is stated that an improvement of the efficiency of the electric powertrain about 30% is expected from 2010 to 2050, so this could lead to greater saving on operating costs in the future.

Regarding the investments required, all the articles mentioned before highlighted the higher purchase price respect traditional vehicles caused by the high cost of the battery. An increase of 43% in the purchase price is reported in 54, but article number 48 shows that a decrease of more than 60% of battery cost is expected in the near future. Hence, it is reasonable to expect in the market always cheaper electric vehicles, thanks to the lower cost for batteries but also to the continuous increase of demand for electric vehicles.

On average, it is identified an autonomy about 100 miles for the current electric vehicles. There aren't articles in which this is highlighted as a big constraint for companies who adopt this vehicle because they agree that the autonomy is enough for running logistics services in the city during a normal day. Interesting findings are in article number 64 that highlights that the autonomy can be affected by the external temperature (lower autonomy during cold days) and in article number 53 that includes the case of electric vehicles with solar panels installed on the roof in order to extend the autonomy by recharging the batteries of the vehicles with solar energy. Further operation impacts are a better acceleration respects fossil propelled engine and the possibility to have access where traditional vehicles are not allowed.

Thanks to the better acceleration that allows having a higher average speed and to the possibility to have access in some particular roads where other vehicles are not allowed, the travelling time and also the Km traveled are lower with the introduction of this technology, as it is shown in article number 31 that reports a reduction in the travel time of 8% and in article number 54 that reports an increase of the average speed about 5%. This fact might be translated also in an improvement in the shipping time.

High environmental impact improvements are identified. In 24 there is the comparison of electric vehicles with diesel vans in the over life cycle leading to a reduction of greenhouse gas emissions by 44-47%, in 31 a reduction of CO2 emissions by 59.2%, in 43 a reduction of CO2 emissions per parcel by 54% and in 64 is stated that diesel vans release 1.0375 KgCO2 per mile and Electric vehicles release 0.01915 KgCO2 per mile. Also in this case, it is not possible to have a single value that different sources agree because the variable to quantify environmental impacts are too much. Environmental impacts of electric vehicles are straightly related to the source of energy, for example in article number 48 is stated that the impact on Greenhouse gas emissions in USA is not significant considering the current mix of how energy is produced there.

In articles number 14, 22, 31 and 64 it is observed a reduction of noise emission, but no one has quantified this impact.

Some impacts related to the work condition are identified in article number 5 and 64 in which itis stated that supply chain managers need to acquire new competencies in the routing problems because electric vehicles add new constraints in the planning process, and a better satisfaction of the drivers in articles number 14, 22, 31 and 64 thanks to the better acceleration, soundless of the driving and more parking areas that allow to the driver to walk for a fewer distance in the last meter delivery.

Finally, article number 21 reports that some customers are willing to pay more for their services if the vehicles used for running their shipments are ecofriendly as electric vehicles and many other articles shows that companies can improve their image with the adoption of this kind of vehicles.

Electric vehicles are deployed in the following projects: CITYLAB in London and Southampton, FREVUE in Rotterdam, Amsterdam, Lisbon, London, Madrid, Milan, Oslo, and Stockholm, SEUL in London, C-LIEGE in Stuttgart, NOVELOG in Reggio

Emilia and Pisa, SMARTFUSION in Como and New Castle, CIVITAS PLUS in Utrecht and Bath.

In the case of projects, it is more difficult to comment on quantitative values of the impacts, because as it is already said previously the results are globally and a project might include several actions. Of course, the consideration made with the analysis of the articles concurs with the results obtained from these projects. Lower operation costs, high investments for purchasing the vehicles and requirement of a charging station at the depot, a better quality of the air obtained, less noise and positive attitudes to electric vehicles from either workers or customers are identified in the results of the projects.

The CIVITAS PLUS project in Utrecht considers the case of using an electric vessel for city logistics services, where goods are transported to shops, bars, clients and restaurants by a zero-emission electric boat by exploiting the canals of the city. The impacts are quite similar to the case of vans and it is observed an improvement in the environmental impacts about a 13% reduction in CO2 emissions, a 6% reduction of NOx and a 10% reduction of PM10 emissions.

Table 4.6: Electric vehicles impacts

EVs Impacts	**Achievements**	**Some findings**
Economic	• Low operating costs • High purchasing price for the battery • Requirement of recharging station	• Operating cost savings: 20-30%, 25-50%, 59.9%, 50%, 65% • Expected decreasing of battery price: 60% • Higher purchasing price: 43%
Operating	• Sufficient autonomy • Access to area where other vehicles cannot • Higher average speed	• Autonomy: 100 miles • Reducing in travel time: 8% • Increasing in average speed: 5%
Environmental	• Reduction of CO2 emissions • Reduction of Greenhouses emissions	• Reducing in greenhouses emissions: 44-47% • Reducing CO2 emissions: 59.2%, 54%
Social	• Reduction noise emissions • Better work satisfaction • New skill required for the planners • Happier customers	-
Other	• Better brand images	

4.2.2 Cargo bikes

Cargo bikes are a wide vehicle used for running the last mile deliveries thanks to the high flexibility they provide to those who adopt them. They consist of bicycles or even tricycles with an appropriate place where goods can be transported in the city and in order to facilitate the work of the drivers, they can be equipped with an electric motor that assists the pedaling. For this reason, they are in some way comparable with electric vehicles and they can be categorized with SEV that stands for "Small Electric Vehicles". Hence, it is reasonable that cargo bikes will bring similar impacts of electric vehicles on city logistics projects once they are deployed by Logistics companies.

As it is mentioned before, one of the greatest features of these vehicles is that they provide a flexible solution for the transporting of parcels in the city, because they can have access to areas where other vehicles, including electric vans, are not allowed, they can be easily parked and the drivers are not required to have a driving license in order to ride them.

Also in this case, the impacts of this vehicle, strongly depend on which city they are used. In fact, if in the city it is present a great bicycle infrastructure with a proper number of bicycle paths or bicycle parking, cargo bikes can bring positive impacts to the society in term of environmental impacts, reduction of vehicles on the roads, noise, vibration, to the customers that they keep having a high service level and in some ways also to the logistics operators. Workers can be negatively affected if they ride a bicycle rather than drive a van, because for sure the risks that they are exposed in the former case are much higher than driving a normal vehicle. This risk is pronounced in cities where a proper bicycle infrastructure is not present.

Cargo bikes are an eco-friendly solution because they don't produce any tailpipe emissions, they can affect the quality of air in case they are equipped with an electric motor and the source of energy is not renewable, but anyways great improvements are expected if logistics operators substitute traditional diesel vans with cargo bikes.

Operations are strongly affected as well, since a cargo bike can transport only a few parcels per trip due to the low load capacity of the cargo installed in the bicycles, drivers are generally required to pass through a depot several times in a normal day of working to upload parcels. The limitation of the cargo dimension leads to create a difficult scenario for obtaining an economic advantage than traditional diesel van deliveries, because the consolidation is difficult to obtain, more vehicles are required and so more drivers are required as well, and the shipping time might increase. In order to reduce this problem, cargo bikes can be associated with mobile depots as it will be reported later on.

By looking in more detail at the dataset, cargo bike is a technology analyzed in the following articles: 9, 23, 26, 28, 33, 55, 56 and 65.

The economic aspects identified are the lower operating costs due to avoid fuel costs, avoid insurance costs, lower maintenance costs, no parking costs, however, an overall increase in operating costs might be expected because of the additional driving time that leads to the increase of the driving costs. In 9 the increase in operating costs is estimated as 9%.

The purchasing price might be high in case they are assisted with the electric motor for the same reasons of electric vehicles, this is the high costs of the batteries.

Instead, focusing on the authorities perspective, if they want to incentive the deliveries by bicycle, they must deeply invest in the bicycles infrastructure to provide a secure environment for running bicycle safety in cities.

In 33 the autonomy of the vehicles assisted with the electric motor is settled at 150 Km and in 56 range between 50 to 100 Km, however, they both agree, also article 55, that the autonomy is enough for the daily work of the messengers. In 33 is also estimated the average speed in the case study of the city of Stargard and the result shows that the average speed of cargo bikes and cars are comparable in the city, 14.4 Km/h for the former and 18 Km/h for the latter. Also in 56, the two speeds are compared, and it reports an average speed for the bicycle shipments of 15.9 Km/h and for car shipments of 17.9 Km/h, and 56 highlights that electric bicycles can assist the riders up to 25 Km/h.

55 identifies the dimension of the cargo capable to hold 200 liters and a maximum payload of 90 Kg and 56 identifies the same dimensions with 176 liters and 100 Kg. Of course, different models of cargo bikes are present in the market but similar values for the dimension of the cargo are found.

The articles analyzed agree with the high benefit that this solution brings in terms of environmental impacts. In 23 it is reported that the introduction of cargo bikes in this context might avoid up to 73% of CO_2 emissions, in 28 the reduction of CO_2 is identified up to 7.5t per year and this is mainly due to the reduction of Km traveled by diesel trucks and 65 reports a reduction of CO_2 emissions about 55% in a case study run in London. 26 evaluates the total emission of CO_2 by using a life-cycle approach with 0.35 Kg of CO_2.

The reduction of noise in the city is identified in article number 33 and 65.

Congestion can be either positive or negative be affected as it is reported in article number 23. Here it is identified a better traffic performance only if up to 10% of vans are replaced with cargo bikes. In the opposite case, when more than 10% of vans are replaced, traffic condition might get worse because the number of cargo bikes in the city would be too high. In 33 is also identified a possible reduction of the congestion depending on the bicycle paths present in the city. Of course, the better condition of traffic might be translated indirectly in a decrease of the shipments' delay, estimated up to 4% in 23, and so in customers happier for the service provided.

In 55 and 56 it is identified that workers have generally a positive attitude to the adoption of this technology in City Logistics for being a green solution that has lower negative impacts to the environment than traditional vehicles.

In conclusion, in 9 it is estimated a decrease in external costs per delivery by 40% and in 23 an overall reduction of external costs up to 25%.

Cargo bikes are vehicles used in the following projects analyzed: CITY LAB in Amsterdam, NOVELOG in Graz, PONY ZERO in Turin, UTURN in London, ASPIRE in Lucca, STRAIGHTSOL in Brussels and TIMMI TRANSPORT in Leipzig.

Cargo bikes deployed in PONY ZERO have a payload of 180 Kg, and the ones used in TIMMI TRANSPORT of 250 Kg and a volume of the cargo about 1.7 m^3.

Project results insist on environmental impacts. In fact, the CITYLAB project in Amsterdam consisting on the adoption of cargo bikes instead of diesel vans shows reduction on the emissions of NO_2 from 0.7291 to 0.4019 g/shipments, PM 2.5 from 0.0738 to 0.0292 g/shipment and this is mainly caused on the saving in the fuel consumption that passed from 0.1918 to 0 liter per shipment, NOVELOG in Graz estimated an ex-ante reduction of CO_2 emission about 15%, PONY ZERO in Turin a CO_2 emissions reduction of 12.6 ton/year, STRAIGHTSOL in Brussels where cargo bikes where used together a mobile depot reports a reduction of CO_2 emission by 24%, PM2.5 by 59%, PM10 by 22%, SO_2 by 24%.

A further interesting finding is the reduction of noise, estimated (ex-ante) of 2% in Graz and also in Amsterdam is expected thanks to 3900 Km traveled by vans avoided.

The projects results show also a positive customer satisfaction of cargo bikes and also by workers even if the work condition becomes more dangerous.

Table 4.7: Cargo bikes impacts

Cargo bikes Impacts	**Achievements**	**Some findings**
Economic	• Increasing in operating costs for additional driving costs • Requirement of bicycle path infrastructure	• Increasing in operating costs: 9%
Operating	• Sufficient autonomy if equipped with electric motor • Comparable speed with car in urban areas • More constraints in the product features	• Autonomy: 150 Km, 50-100 Km • Product volume: 200 l, 176 l • Product weight: 90 Kg, 100 Kg
Environmental	• Reduction of CO_2 emissions	• Reducing of CO_2 emissions: 73%, 55%
Social	• Reduction of noise level • Better or worse congestion condition • Positive work attitudes • Happier customers	-

4.2.3 Mobile depot

Mobile depot is a solution that can be combined with the use of cargo bikes in city logistics in order to create a synergies able to overcome in part to the problem that riders are required to pass through the distribution center several time for the loading of new parcels, since cargo bikes have only a small capacity of the tank. The adoption of a mobile depot allows to create a small depot in the city, that it can be parked in the city center and from where cargo bikes can be loaded of new shipments. The depot leaves in the morning from a big distribution center, then it is moved and parked in the city center by a truck, it is used as an hub for couriers and at the end of the working day, it is reattached to the truck that it brings it in the distribution center for loading the parcels for the day after.

This solution can be considered as an innovation, the first results show that the adoption of the mobile depot can have positive impacts in term of congestions and air quality if it is used instead of traditional diesel vans, but the economic aspects and the quality of the service offered to clients might be worse in this case. This is the conclusion of the project STRAIGHTSOL run in Brussels also discussed in paper number 39. The project consisted of a mobile depot that was parked in the city center of Brussels from where 4 electric cargo bikes carried parcels to the final customers.

The operating cost results two times more expensive than traditional vans, this increase is mainly due to the rise of new costs as wages of the bicycle couriers, cleaning of the depot and longer loading activities. Since a mobile depot is still not present in the market as a standard good that it can be purchased, the high initial investment to develop and manufacture the depot is required. If in the future the industry will have more interest in this solution, it is reasonable that economies of scales will lead to a reduction in the purchasing price.

The improvement of air quality is remarkable, comparing this solution with traditional diesel van fleet the following reductions in term of air pollutants are achieved: CO_2 emissions -23.97%, SO_2 emissions -24.23%, PM2.5 emissions-58.81% and PM10 emissions -22.07%.

A delay in the shipping time is registered, hence a worse service level is provided to the final customers. In fact, before the introduction of the mobile depot and cargo bikes, the on-time shipments were 95.27%, after the introduction of it they became 87.56%. It is important to highlight that the results are the output of the project run only for few months, so it is reasonable to expect that if this solution becomes permanent the riders will gain always more experience and so the service level would increase as well. However the society has a positive impression of this solution, indeed they believe that mobile depot combined with cargo bikes can bring positive impacts in a more pleasant neighborhood, better accessibility to the city center and improvement in traffic safety.

4.2.4 Drones

Unmanned aerial vehicles are a relatively new technology used for delivering goods. Drones are born for military uses and in the mind of the most, they are a good instrument for capturing images or videos. Recently some startups or company projects try to implement them for the last mile deliveries. A parcel is attached to the vehicle, this travels through the sky avoiding congested roads and it downloads the parcel to the customers. The major benefit is that they don t have to follow any road paths and so the distance traveled is lower and they are not conditioned to the traffic at the ground level. This leads to the possibility to do fast shipments and in fact, they are often used for rescue or emergency conditions where the factor time becomes of primary importance. Actually, many implementations of this technology in logistics are for rural areas rather than a city context. This because in the city it becomes fundamental to find a proper landing zone where goods can be downloaded, but in some cases, it is not possible to find it, and this is more pronounced in the case of high-density cities. Instead in rural areas, houses have enough space to be able to collect parcels because drones can easily leave them on the garden of houses, and this avoids vans to travel long distances only for the shipment of one parcel.

A problem with drones is the autonomy of the battery. It is about few minutes and so once a delivery is done, a recharge of it or change of battery is required. For this reason, they are often combined with other vehicles in order to provide a better city logistics solution where a truck or a van brings drones and parcels close to their final destination and then the drone will run the last meter delivery. Thus, drones aren't required to travel for long distance because once they have left the parcel they don't have to return back to the distribution center but only to the van that it can be viewed as a mobile depot and finally they can be recharged while they are traveling to another destination by van.

Drones can transport only small parcels with usually a low weight, even if it is true that in the ecommerce industry most of the parcels would be suitable for drone deliveries for their dimensions, it is pretty hard that they will become the main delivery system in high density areas. Here, the number of shipments would be too high to be done by drones, the noise in the sky would be no bearable and, in that case, also safety problem would arise, as possible crash between two vehicles, because the sky would become congested of UAVs. Finally, the current distribution centers would be not proper for drones deliveries and so high infrastructure investments are necessary in order to have depots close to the city center so that drones autonomy is sufficient to do the delivery.

Drones technology for the delivery of goods is a category well represented in the dataset, in fact, it is present in articles number 3, 19, 27, 45, 46, 47, 49 and 57. Article number 27 considers the case of drones combined with autonomous vehicles.

Since it is not possible to consolidate the shipments by using drones because they can bring few parcels per flight (usually just one, but the modern ones even more), the economic feasibility is difficult to achieve. Article number 3 identifies a higher operating cost due to the ratio of 15 drones to replace 1 van, in 46 the economic feasibility is imputed to the too low lasting of batteries that leads to long recharging time. Instead, article number 49 reports a saving in a specific case of delivering vaccines about 0.08$ per dose administrated due to the absence of drivers that reduces the labor costs.

High investments can arise for the infrastructure of depots. In fact, the location of the current Distribution Centres might be not ideal for the adoption of this technology because they are too far from the delivery points. Thus, a new concept of decentralized DCs is necessary if the technology must delivery from the depot directly to the final customers. This high investment can be avoided, as it is shown in articles 19 and 27, when drones are combined with other vehicles as a van that travel close to the delivery point and then the drones will execute the last meter delivery.

Article 57 identifies a maximum range of 10 Km for the delivery of parcels with drones and this fact is also found in article 47 where it is stated that drones are ideal for the delivery of goods to places close to the depot because they have to return back once the delivery is done for being recharged.

In 49 is settled maximum payload of 1.5 l and in article number 57 a maximum payload of 2 Kg, for this reason only a certain category of goods can be delivered by drones.

The most important impact identified is the great improvement in the shipping time, thanks to the possibility to avoid congested roads. An air speed of 45 Km/h is reported in 57.

Improvement in the quality of air is also shown in 19, 45, and 47, but problem related to the possibility arising of noise emission in the sky might occur if they become the widest technology used for delivery services, as it is reported in 3 and 19.

Great improvement in the congestion of roads is expected, but since the vehicle per mile traveled per recipient increases a lot in case of drones respect road vehicles, as it is evaluated in 47 in which the author finds this distance 0.16 mile by truck and 10.17 mile by drones, problem related congested sky might arise.

Since the implementation of drones in logistics is a new technology, also new regulation settled by authorities is required, because as it is stated in 3, 27, 45, 46 there might be safety problem related to possible drones crashing onto people or property, and also problem concerning the privacy might arise as it is treated in 45 and 46 because drones are equipped with sensors that can collect sensible private information.

Customers might be required to install a proper landing station if they want to receive parcels by drones as it is reported in 3.

It has not been possible to find projects in CORDIS where the objective is the implementation of drone deliveries in cities. A private project run by Wing, held by Alphabets, that provides drone deliveries in the cities of Helsinki, Canberra, Logan and Virginia is analyzed. The company ensures that its offer might bring positive environmental impacts because the vehicles are eco-friendly, the fast shipping is ideal for urgent deliveries because they can avoid the congested city. This project consists also on providing to their customers the digital platform called OpenSKy [45] which is designed to help the drones drivers to safely access the sky by providing information as rules, plan flights and many others.

Table 4.8: Drones impacts

Drones Impacts	Achievements	Some findings
Economic	• Difficult to achieve the economic feasibility • High infrastructure costs for decentralized depots	
Operating	• No big and heavy products can be transported • Low autonomy • Quick shipping time	• Autonomy: 10 Km • Maximum volume of product:1.5 • Maximum weight of product: 2 Kg • Air speed: 45 Km/h
Environmental	• Better air quality	
Social	• Noise emission in the sky • Better congestion condition • Customers should be required to install landing station	• 15 drones are required to replace 1 van
• Other	• need for new regulation • Possibility to combine them with vans	

4.2.5 Parcel lockers

They are lockers holding parcels where customers can collect their shipments instead of receiving them at home. Once the customer makes his online purchase or he needs to use some delivery services, he is informed about the time the parcel will be at the locker and he will be provided with a temporary code that he will use to open the locker and to take his parcel. Hence, they can be an option of the final location for the delivery, because customers have the possibility to choose if they want to receive their shipment at home or if they are the ones who will collect it by going to the parcel locker. When choosing the parcel lockers as delivery point is offered as an option to the customers and it is not imposed by who delivery, it gives a more flexible solution to the final customers, hence, it creates values on the hands of the final customers, because they are not required to stay home when couriers arrive to receive the parcel, but they can take the parcels when they are more comfortable leading to gain a more flexible alternative to the traditional home deliveries.

With parcel lockers value is created also for logistics companies that in this case, they avoid the home delivery failures, when the couriers don't find anyone who can bring the shipment and they have to return another time, usually up to three-time, in order to conclude just one delivery. All the operations to manage failure deliveries, that compounds also wasting time, new documents required, additional kilometers traveled lead to a dramatic increase in costs, and so just one delivery can cost as more than three in the worst case.

The effectiveness of this solution is strongly linked to the location of parcel lockers in the city. They can have positive impacts when they are located near customers' houses or places of working, along the way from home to work location without big detouring from the normal way, or in a place where customers are supposed to go as supermarket or petrol station. When customers are able to take their parcels without making an appropriate travel to the lockers by cars, the positive impacts in terms of congestions or air quality are expected to be obtained. A common location for parcel lockers is the station of underground or similar public transport. The idea here is that a passenger of the public transport might get off from the train in a station located from the departure to the arrivals of his trip, only for taking the parcels from a locker. This takes only a small effort from the final customers and there is not the creation of negative externalities because additional travel distance for taking the parcel is not generated.

Parcel lockers are discussed in articles numbers: 1, 8, 15, 35, 36, 50, 59, 60 and 63.

A decrease in operational cost is expected if customers use more frequently the service. In fact, in 8 it is identified a decrease in variable operational costs per delivery about 0.01€ for each additional 1% of self-pick up customers, in 60 it is compared the parcel lockers solution with the traditional home delivery and travel costs are reduced by 55-66% in the former case, finally also in 59 e 63 they register lower operating costs because customers are involved in the process and logistics companies avoid failure and redelivery.

In 60 the price for a parcel locker is identified ranging from 1000$ to 6000$. They are required to work 24/7, to be in a secure place and it is important to have a big number of them in the city in order to have a good density of parcel lockers spread in the city because, as it will be shown later, customers expect them to be close to their place.

Improvement in the operation efficiency is obtained when they are located in the proper location. If they are in an area with easy parking, it is easier and faster for the couriers to download parcels in there, but also for customers to collect them. The consolidation of parcels leads to improve the utilization of the vehicle assets because they will run with almost full of their payload. This technology is also suitable for night deliveries, because they can be fulfilled of parcels also during the nights by operators and as it is already mentioned in chapter number 1, night delivery might have many advantages compared to daily hours delivery thanks to the low congested roads and not time constrained services.

In 50 there is the analysis of the case study of parcel lockers in Christchurch city and since in New Zeland there is a strong car dependency, improvement on air quality is not recognized because only few people travel to the delivery points by bicycle or walking, hence additional travel distance is identified leading to create further externalities to the environment. Instead, improvement in the quality of air is identified in 50 by analyzing the case of inPost in Poland cities where CO2 emission is reduced by 30984 tons per year, in 36 where an agent-based simulation gives a reduction of fuel consumption up to 30% as result.

The same considerations can be done for the congestion problem. 35 reports that in the case of parcel lockers, logistics companies are able to deliver 600 parcels with 70 Km of distance traveled against the traditional delivery system that it requires 150 Km of distance traveled in order to deliver 60 parcels. In 36 the simulation finds a reduction in the number of trucks used for city logistics between 17% and 33%. Also 15, 60, and 63 highlight potential benefits in term of congestion if the parcel lockers are located in a convenient location as schools, offices, subway stations, and thanks to avoid the redelivery after a failed delivery.

All the articles address the customers' reactions when they adopt this solution for their shipments. In 1, the authors have measured the customers satisfaction with an average grade of 8.7 on a scale from 1 (minimum) to 10 (maximum), in 35 the 28% of respondents gave 10 points on the same scale. The satisfaction in parcel lockers users is mainly due to the availability to collect parcels 24/7 leading to flexible collection hours and in the cases where parcel lockers are installed in a strategic, safe and secure place with easily parking. In 15 it is identified a threshold of 5 minutes of driving time for a customer to adopt the technology. Since in this case customers are involved in the process, some of them can expect a lower price for the service if they select parcel lockers as location instead of traditional door to door delivery. Customers' transaction costs are also reduced in this case because they avoid waiting time at home for late delivery or not delivery.

Finally, a new business model can be created with the introduction of parcel lockers in the city. In 1 it is proposed as example the case where parcel lockers give discounts or coupon to spend in the store where they are located and this can be really effective because as it is reported in 35, the 52% who goes to a locker visits the store as well, or in 36 where it is said that for every 4 users of parcel locker, one will make a purchase when they collect their orders.

Table 4.9: Parcel lockers impacts

Parcel lockers Impacts	**Achievements**	**Some findings**
Economic	• Decreasing in operating costs	• Decreasing in operating costs: 55-66% • Purchasing price: ranging from 1000$ to 6000$
Operating	• Improvement of the assets utilization • Suitable with night deliveries	
Environmental	• Worse condition if customers use cars to reach the lockers • Better condition if customers use public transportation	• Reduction of CO2 emissions: 30%
Social	• Worse condition if customers use cars to reach the lockers • Better condition if customers use public transportation • High customer satisfaction • Change customer behavior	• Reduction in the number of trucks: 17-33% • Driving time to adopt the technology: 5 minutes
Other	• Possibility to create new business model	

4.2.6 3D printing

The impacts of 3D printing in city logistics are treated on article number 3, unfortunately, this is a niche topic and the literature available that addresses this topic is few. A 3D printer is a machine able to transform a digital good into a physical one, so customers are provided with a file holding all the data needed to be passed to the printer or they are the one who creates by their own the digital good and they can produce it at their home by using a 3D printer.

The industry of this technology is gaining always more importance, but their use is principally dedicated to the enterprise context, where the goods printed are mainly prototypes or some particular component that only by printing them it is possible to obtain a satisfying quality of the product. The use of 3D printers by households or generally speaking by the final customers is not frequently and only few adopters are willing to purchase a printer like this, also because its price is relatively high. Only the ones that are more likely to test new technology and enthusiastic from innovations can afford to buy a 3D printer.

In terms of social benefit, the use of this technology can bring positive impacts, in fact, the shipment of the physical final good is avoided and this leads to improve traffic congestions, vibrations, noise and air quality. In this case, customers must be provided of only the material for alimenting the printer, but they can stock this material at home, and they can use it time by time also because the space that the row material takes is much lower than the space that all the row material transformed in final goods would take. So as it is mention in 3, using 3D printing could lead to a substantial reduction of the cubic metre-Km and tonne-Km of freight movement in the city center

The current technology cannot achieve a better economic condition compared to the traditional production of goods in big plants and then delivered to final customers or stores. The cost to print goods at the current state of the art is much higher than producing them in big quantity and then deliver them as it happens in the normal condition. The time required to print goods is still too high and small private printers cannot exploit the advantage of economies of scales. Furthermore, even if today there are always more row materials that they can be used to print, there are still limitations and only some particular goods can be done from a 3D Printer.

Hence, 3D printing can have some roles in order to minimize the externalities created by city logistics activities, but it is reasonable to state that in the near future they will difficulty become a technology able to reduce considerably the freight movement in urban areas due to the limitation reported above.

4.2.7 Crowdshipping

The coming of Information and Communication Technologies (ICT) facilitates the birth of the sharing economy in which an indefinite number of people, called crowd, can voluntarily undertake a proposed task proposed by someone. ICT is a fundamental pillar for the sharing economy, because it gives the possibility to create a digital platform, to provide all the technologies necessary to manage the interaction between different people and it makes working this innovative way of doing traditional services. Hence, the task proposed to the crowd in the crowdshipping setting is the delivery of freight, that it can involve long distance deliveries, but also the movement of goods in the only urban areas. This last case is the one that is interesting to be analyzed in a city logistics context.

The adoption of this delivery system can have different impacts on the basis of the vehicles used by the drivers. In the best scenario for the society, Crowdshipping may bring positive environmental impacts if the people who take the delivery are using eco-friendly vehicles like bicycles, public transport or even if they are doing their activities by walking. Worse externalities are generated when they move with their own cars.

The Digital platform deployed for crowdshipping can be a website, a mobile app or even a computer application in which it is collected information regarding the supply and the demand side, in this case of shipments and it matches the requests and the offers. The introduction of a platform like this requires to take some decisions in order to define who is the responsible of the platform, who bears the costs for managing it, what are the rules for matching supply with demand and, last but not least, how data protection can guarantee the privacy of the users. During the designing phase of the platform, the designer must take into account all these problems and figure out the best settings to provide to the crowd an easy to use and great solution.

A worker or a student might need to travel in the city for going from home to his workplace or school and in the opposite way as well. During this movement he can assess the crowd logistics platform and look for the requests of shipments available at that moment. In case the detouring time and distance are not that much large, he might take into consideration to undertake the delivery and gain some compensation for this service. Anyways, it is possible that the crowd couriers take more seriously this service and it becomes a micro-job which gives a considerable economic help as a second job. In the latter case, several social issues arise with crowdshipping in terms of work condition and tax regulation. Since, the share economy is a new reality, that it is always more gaining interest from the society, the intervention of the authorities that regulate the rights of the crowd-couriers and that identify a proper taxation for the income generated from these micro-jobs might be necessary because the current laws might not be suitable to this phenomena.

Crowdshipping and digital platform are treated in article numbers: 6, 10, 12, 13, 29, 37, 40, 41, 51 and 58.

Since these articles treat different settings of crowdshipping depending on how the freight is moved in the urban area, it is possible that in some cases the impacts observed after the introduction of this initiative are quite different from a case to another. For instance, in article number 37 a reduction on operating costs per stops by 25% is identified, in article number 6, in which it is considered the case of movement of freight adopting public transport (underground), is also registered a reduction in operating costs, but in article number 10, in which is studied the case of shipment done by private cars, an increase about 8% of operating costs is found because it is not possible to exploit economies of scales as it happens with trucks and the wages costs for car drivers are higher than a single truck.

The same discussion can be done for the quality of air and congestion conditions. In article number 13, it is run a simulation that forecasts a 35% improvement of greenhouse emissions when the 50%of the demand is matched with the supply and the crowd shippers use the only public transport, and it forecasts an increase of air pollutants about 3% and greenhouse emissions about 4% when the 10% of the demand is matched with the supply and the shippers use their private cars. In the case study of Finland libraries treated in article number 41, it is reported a saving of 1.6 Km by car per delivery because all the deliveries under 5 Km were done by bicycles. In article number 12 is treated the case of a public transport-based crowdshipping in Rome and the saving of nitrogen oxide per year is estimated to be 376 tons, of carbon monoxide about 2.24 tons and carbon dioxide about 1098 tons. Regarding the congestion problem, article number

40 identifies a worse condition because analyzing the crowd logistic platform in Belgium it is found that more than half of the trips are dedicated to delivering a parcel rather than another purpose, in article number 41 the detour of the drivers from their daily path is on average 2.2 Km per delivery, in article number 10 the crowdshipping solution has a total trip distance 35% longer than the only truck system, instead it is identified a better congestion condition when the crowdshipping is combined with public transport.

The literature agrees that crowdshipping gives high flexibility to companies that need to deliver their products in the city. It can be a great solution for startups or small companies that cannot afford a high investment in the fleet to deliver, because there will be the crowd that it will replace trucks with their own vehicles and the companies has only to pay a small commission to the couriers. For example, in 58 it is mentioned that small physical shops can exploit the features of a crowdshipping service to offer to their customers a same day delivery without any high investment required.

Article number 40 highlights that some potential benefit in term of noise is possible to be obtained as well, because the crowd uses vehicles less noise than vans like passengers cars, bicycles or even by walking.

The work condition is an important aspect for crowdshipping. In fact, as it is mentioned in article number 51 and 58, the couriers are willing to undertake the task if they have a high flexibility and self-defined working hours in demanding, because they are usually casual drivers. They can be paid not only with a monetary compensation, but also with health, social benefits or, as it is reported in article number 6, with tickets for the public transport. Another consideration made in article number 37 regarding the safety of the crowd couriers, is that since they must interact with the platform, to communicate with the receivers or senders, to look notifications of new shipment requests, etc, it can be a safer work condition if the shippers are equipped with wearable devices.

Trust is an important aspect when digital platforms are designed. A lack of trust on the platform in itself or on the other users can be a reason why the service is not adopted. In article numbers 51 and 58, it is suggested to overcome this problem with a reputational mechanism in which it is possible to assess the historic behavior of the couriers before accepting the delivery and it is important that the digital platform uses a secure payment method for its transactions.

Final customers are interested in the services if they have the possibility to plan the date and its time schedule, and since in the case of crowdshipping a network effect is present, the more customers there are, the more couriers there are and the higher the service level becomes. The problem of this kind of platform is to achieve the critical mass because it is relatively high, as it is mentioned in 58, and if few users are using the platform it becomes difficult to attract new ones to adopt it.

A digital platform that manages crowdshipping services can be easily developed without any advanced IT skills and it might become a great source of revenues for the platform providers. The revenues can be generated thanks to advertisements present in the platform or with a percentage of the transactions that occur between the users.

Table 4.10: Crowdshipping impacts

Crowdshipping Impacts	**Achievements**	**Some findings**
Economic	• Increasing or decreasing of operating costs depending by the vehicles used • Avoid high investment in the fleet	• Increasing of operating costs when cars are used: 8% • Decreasing of operating costs when public transport is used: 25%
Operating		
Environmental	• Increasing or decreasing of air pollutant emissions depending by the vehicles used	• Decreasing of CO2 emissions of 1098 tons when public transport is used
Social	• Increasing or decreasing of congestions depending by the vehicles used • Couriers undertake the work if it is high flexible • Customers need to have trust in the platform • Difficult to achieve critical mass	• In Belgium more than half of the trips are dedicated to deliver a parcel • Average detour distance 2.2 Km • Better congestion condition if public transport are used
Other	• Possibility to create new source of revenues for the owner of the platform	

4.2.8 Platform

The concept of platform consists of different scenarios and limiting it to just the case of crowdshipping would be too reductive. Generally speaking, this terminology can be used when in the supply chain the parties involved want to achieve coordination and promote collaboration in order to obtain an efficient flow of materials. For this reason, it is possible to speak about platform when there is the introduction of Consolidation centers or other similar initiatives. Finally, when it is used an information system in order to manage this situation it is possible to speak about digital platform, in which all the parties can interact with a mobile app, a website or a generic software to run their activities.

Many city logistics projects treat the case of platform solutions to reduce externalities.

During the CITY LAB project run from 2015 to 2018, different examples of platforms were established in Brussels and Paris.

In the city of Brussels, the project was done with the collaboration of the company Procter & Gamble. It tried to supply directly many small independent stores in order to avoid that the owners have to go to a retailer or wholesaler, hence by increasing the capacity loading of the vehicles. To make all working properly a website was introduced in which the store owners could easily place their orders. This initiative required a deep change in the behavior of the store owners, and it has not been always possible to convince them to adopt this new service. The lead time to receive the orders increased because they had to order and to wait for receiving the goods compared to the opposite case in which the store owners went directly to take their supplies only when they were required. This platform should bring to the society great improvements, a better condition of the congestion can be obtained by reducing the freight kilometers per shipments, the quality of air as well, thanks to the reduction of fuel consumption and possible improvement to the noise phenomena is possible to be obtained even if in this case, the sample was too small for achieving significant results.

In Paris, a collaboration platform was introduced where 80 organizations established general goals for City Logistics and an online forum was created for managing freight movement in the city. A simulation shows that after the introduction of this project a -8% of noise level is obtained and the emissions of air pollutants are decreased, like -

47.8% of NO2 emissions, -52.40% of PM10 emissions, -50.4% of CO2 emissions thanks to this collaboration behavior.

The project UTURN run in the city of Athens, Milan and London consists of the introduction of a collaboration platform that allows to use a matching tool for the distribution of freights in these cities. More in detail, the project in Athens consists also of the introduction of an Urban Consolidation Center and it interests the distribution of packaged goods from local manufacturers to retailers. In this case, the vehicle loading factor increased about 11%, a 7% of CO2 reduction emissions are registered, and a reduction of 10% of vehicles and 19% of Km traveled should lead to have better congestion condition in the city. Instead, the project in London involves also the introduction of electric cargo bikes for the distribution of food to final consumers and the results obtained show a 50% increase in fleet utilization, a 40% reduction in the number of trucks and a 25% of distance traveled.

The ASPIRE project run in Lucca from 2017 to 2020 is another example of platform introduced for facilitating the activities of city logistics. During the project, LOCMAP (Logistics Credit Management Platform) is introduced and it allowed to process all the data generated by RFID sensors installed in the city. This allows to access to information like the number of vehicles present in the ZTL or free parking available and it becomes a powerful tool for planning deliveries in the urban areas. The introduction of cargo bikes is combined with this platform and the output of the project is the reduction of air pollutants like -11.6% of CO, -10.6% of NOX, -10.7% of CO2, then it is also registered a decrease of the commercial vehicles running in the city center leading to benefit for the pedestrian safety, congestion condition and fewer vibration that in this case it is really important for the monuments installed in the historical center of Lucca.

Finally, there are many projects in which there is the introduction of some infrastructures like UCC or CCC. During the NOVELOG project run in Barcelona, there is the introduction of a UCC and electric vehicles for deliveries leading to an ex-ante estimation of 15% CO2 emissions reduction, 2% noise level reduction, 15% traffic condition reduction and 2% of accident reduction. Always NOVELOG project run in Gothenburg is about the introduction of an UCC combined with low emission vehicles obtaining an ex-ante estimation of 15% CO2 emissions reduction, 4% of accident reduction, 2% of noise level reduction and 8% of traffic reduction. The LBCC in London and the STRAIGHTSOL in Barcelona are two other examples of the introduction of UCC combined with more sustainable vehicles leading to obtain great benefits in terms of air quality and congestion. Furthermore, the project of London highlights that the UCC leads to an increase in the buying power and the operators could negotiate a better discount on the purchasing of the goods ranging from 5 to 7%.

The case of the introduction of CCC, construction consolidation center is treated in the project SUCCESS in the city of Verona, Valencia, Luxembourg and Paris. The introduction of an infrastructure like this gives a payback period for the investment of only 1 year, thanks to a great reduction of the operating costs. In all the cases, the load factor increased: up to 22% in Verona, up to 44% in Valencia, Up to 41% in Luxembourg and up to 52% in Paris. In Verona it is estimated a reduction of transport related pollutant emissions about 19% of CO2, 22% of NOx and 19% of PMx, in Valencia about 31% of CO2, 39% of NOx and 26% of PMx, in Luxembourg about 33% of CO2, 41% of NOx and 30% of PMx, and in Paris about 13% of Cos, 8% of NOx and 23% of PMx. Then there has been a reduction of congestion up to 48% in Valencia and Luxembourg, up to 54% in Verona and up to 42% in Paris.

4.2.9 Autonomous robot and Autonomous driving

All the technologies that allow to obtain a certain degree of autonomous in traditional city logistics activities can bring huge impacts to the stakeholders. In this category, there are technologies labeled with autonomous driving and autonomous robot. The former means that a human driver is still present in the vehicle, but he is not in charge to actually drive it, but he can dedicate his attention to other activities or just control that the vehicle is doing what it is supposed to do. The latter means that the vehicle is moving in the city without any human intervention.

They are really new technologies and the studies about their impacts are still few in the academic world. Autonomous robot is treated in articles number 11 and 17, instead, autonomous driving is treated in article numbers 38 and 42.

Regarding articles number 11 and 17, they both consider the case of combining trucks with autonomous robots. In 11 it is treated the case in which the robots are launched from trucks to deliver shipments for the last meters and then they can return in small decentralized depots where they can be recharged, and the truck has not to wait for the returning of the robots. These depots can be simple garages spread in the city. In 17 the robots are equipped with 6 cameras, they can reach a maximum speed of 6Km/h, their autonomy is up to 5 Km and there is the possibility to combine them with a van, the robovan Mercedes Benz in that particular case.

The introduction of these robots might obtain a situation with a fewer number of trucks required, thus fewer drivers needed. The reduction of shipment cost per delivery is settled up to 1$ in 17.

Since they are moved by an electrical motor, there is not any emission of local CO2, different impacts can be obtained depending on the propellent of the trucks that bring them close to the final destination.

The Congestion condition should improve because the number of trucks required is reduced and this robot can travel on pedestrian roads.

It is necessary to identify a way of how the final customers can collect their shipments. If the goods are just downloaded in front of customers' houses, then it is possible that someone can steal the parcels. A solution proposed by 11 is that the parcel inside the robot can be taken by the customer only if he is at home and he uses a temporary code provided by the logistics company to unlock it, as if it would be a small mobile parcel locker.

Finally, a new regulation for autonomous vehicles on the streets is required, because it is necessary to establish rules for the identification of tort liability for eventual accidents caused by them and a regulation related data protection might be necessary as well, since these vehicles are equipped with cameras that are able to collect big amount of data.

Regarding autonomous driving, in 38 it is considered the case of a vehicle with the active presence of the driver and in 42 it is treated the design aspect of Furbot that it is a light-duty electrical vehicle used for urban freight transportation with a solar panel of 2 m^2 installed on the roof for increasing its autonomy and reducing the recharging costs. The introduction of these vehicles should bring positive impacts to the work condition of the employees, in fact during the driving time there could be relaxing pauses, or they can be engaged in value adding activities as preparing the next delivery or administrative ones. Furbot is designed with human-machine interface, so that drivers are not required to have specific skills, with many sensors that facilitate human activities and with a fully automated operation for loading and downloading of pallets that doesn't require a manpower.

All the technologies installed in these vehicles should lead to have a more safety condition on the streets either for the pedestrian or for the drivers. The human inside the vehicle, with his active presence, can easily intervene by using an emergency leverage to stop the vehicle in case it is in autonomous driving and a dangerous situation occurs.

4.2.10 Underground and rail-based logistics

Underground and rail-based logistics is an innovative approach to move freights in urban areas, in which an already existing rail system is exploited to bring the freights as much closer possible to their final destination by avoiding congested roads. The rail system could be a working one used to transport people in the city, and when it is combined also with the transportation of goods it is possible to call this system rail-based logistics or underground logistics when the trains are metro ones. The advantages to adopt this solution can be really significant, but of course, the introduction of a system like this requires to adapt the train station in order to be able to run all the activities for downloading and loading of the pallets in the trains, because the already existing ones might not fit for this purpose.

This topic is treated in articles number 4, 32 and 61 as underground logistics and in article number 34 as urban rail transit-based city logistics system. The 32 considers also the problem of adapting the train station to make possible that the customers can take their parcels autonomously. This article proposes the case of an underground rail network for transporting goods by a single automated driver module followed by several cargo modules that they can be easily separated from the others and parked in some unloading bays where customers can take their shipments from the module by using a secure code. Hence, actually article number 32 treats the impacts of different technologies like mobile depot, parcel locker, autonomous vehicles and underground system.

The economic aspects show that with this solution the operating costs can be significantly reduced thanks to the possibility to avoid congested roads. In fact, in 4 it is estimated that the congestion losses can be reduced up to 28% and since in 32 the author speaks about autonomous vehicles, no driver salaries are taken into account. High investments are required if a new rail system is needed to be built. In 4 it is reported an investment of at least 11.5 billion dollars for building an underground logistics network able to cover a density of 80% in a city like Beijing. For this reason, already existing urban rail transit as the metro is selected for either passengers or goods transport.

The operations of this system can achieve a better efficiency thanks to the possibility to use it 24/7 without annoying any inhabitants and it can be used for achieving Just In Time refilling from remote warehouses. The greatest impact is that it is able to provide a fast service to the final customers in which the goods can be delivered to them in a few hours. In 4, a simulation is run for comparing the delivery without an underground system with the case of an 80% density one in the city of Beijing in the 2035 and the results show that in the former case the delivery time would be 2.2 hours and in the latter case, it would be only of 1 hour.

Since these wagons are propelled by electric power there is not any local emission of air pollutants, and this is also true if customers reach the collection point by walking or the really last meter deliveries are done by ecofriendly vehicles as bikes.

This system might bring positive impact in term of congestion condition by reducing the circulation of commercial vehicles on the city center streets. This fact also causes less noise emitted by city logistics activities and to achieve a more safety condition on the streets thanks to the reduction of traffic. The same simulation done in 4 shows that the average speed of freight movement in the urban area estimated in the 2035 with the underground system is 17.3 Km/h against the 13.5 Km/h in a traditional setting.

4.2.11 4.0 logistics technologies

As it has already been discussed in chapter number one where the topic of Logistics 4.0 was introduced, the technologies in this category can be of different nature and in this section, we will consider the following technologies: RFID sensors, cloud computing and wearable devices. N.B: also the technologies deployed for having autonomous vehicles and driving should be considered belonging to this category, but they were treated separately.

The articles included in this category are numbers 2, 7, 16, 20, 30 and 62. Since they are different one from the others, because in this category there are different technologies, their impacts will be treated separately.

In article number 2 it is discussed the use of RFID sensors installed in traffic signs. The vehicles can capture the signal of the sensors for recognizing and communicating the traffic signs to the drivers with the aim of increasing his attention. The introduction of this technology should lead to reduce the number of accidents in the streets, because the drivers are constantly updated about the traffic sign without looking at them.

Article number 7 treats the cloud computing technology for having a smart city logistics information system. Cloud computing offers the possibility to avoid a huge initial investment for purchasing the hardware and software resources because enterprises pay a periodic fee. The operating costs should be lower because they can only pay for the services they are going to use and not for the whole packages. They have the possibility to access to the information anywhere and at any time via the internet. Finally, managers can analyze all the data generated from this system to provide better solutions in terms of congestions, air pollutant emissions and number of accidents.

Article number 16 considers the implementation of 4.0 technologies such as RFID sensors or cloud computers for having smarting bins. In fact, this case study is about to equip industrial waste containers with sensors able to generate and to store in the cloud real-time information about the status of each containers. The scheduling of the collection of this kind of waste is performed by taking into account this information leading to a more efficient system. The operating costs, energy consumed, and emissions might be significantly reduced because the better routing solution avoids low capacity travels of trucks.

The number 20 is about an information system for city logistics that it is able to generate and to process data for planning, coordinating and organizing the flow of goods in a better way with the aim of improving the city traffic, and of reducing noise and CO2 emissions. In fact, a system like this is able to measure the level of noise in the city and eventually all the data generated can be processed to assess if new regulation in the city regarding noise emissions is required or not.

Article number 30 is a case study about a wearable navigation device worn on courier's' glasses that communicates with him with text or arrows to reach his destination. A logistics company should provide this technology to its couriers in order to facilitate their jobs so that they can deliver the right product at the right place at the right time in a more secure way. This is the result of this case study in which there is the comparison of these innovative devices with traditional handheld devices. The couriers who were using the former device fixed for a shorter time the insight display than the traditional devices and never for more than 2 seconds. This device can be really useful for bike couriers who work in a dangerous environment where they must pay attention to many other vehicles.

Finally, article number 62 treats the case of an intelligent In-Vehicle control and navigation system that is able to compute the faster route taking into account real traffic data stored in a navigation platform that collects ground traffic information. This technology has brought a decrease in the traveling time during peak hours about 12%, thus the driver's trip became more convenient and thanks to the multi vehicle route optimization algorithm the congestion condition has improved as well.

The real projects in which the main activities were the introduction of technologies like those just mentioned are the GALENA project and the STRAIGHTSOL project in Batley and Thessaloniki.

The GALENA project is an European project that studies the utilization of the GALILEO system in City Logistics instead of the traditional GPS signal. Through a mobile app all the players of the supply chain can access the platform and see information about the freight transportation in a cheap, innovative, precise and real-time way. The better management of the logistic process leads to maximize the economic benefit, to increase the efficiency of the operations and to have potential improvement of the environmental impacts.

In Batley, sensors were installed to gather up-date-information about the fill level of collecting bank bins' in order to have a more efficient scheduling of the vehicle routes. Over the project period, from 2011 to 2014 the saving of CO2 emissions were estimated about 464 Kg, the saving in term of time was registered as 3%, the distance traveled by the vehicles decreased about 3% leading to better congestion condition and lower fuel costs. The increase in the quantity of the information to be processed required to the managers to deal with more complex system and to work 2 extra hours per day on average.

In Thessaloniki, localization devices (GPS) were tested to track in a precise way the rail wagon arriving to the city. This project required an high investment for the purchasing of the devices, 6 GPS devices equipped with GSM cards were acquired for 1,650\$. The better information gives the opportunity to have savings in terms of time (-9%), CO2 emissions (4.5%), total truck Kms/month (4.5%), and a cost saving (2,700 €/month). All these consequences can be exploited to provide a better service to the customers and to have more satisfied clients. In fact, in the project, the punctuality of the shipments increased by 4%.

Actually also the project ASPIRE in Lucca, treated in the section above about digital platform, has several elements of logistics 4.0. In fact, the platform provided to users stores real-time information generated by RFID sensors installed in the city able to recognize the number of free parking places or the number of trucks running in the limited traffic zone area.

5 Discussion and conclusion

5.1 Discussions about the results

As it is already mentioned in chapter number one of this thesis, to identify the objective impacts of the technologies in City Logistics projects is not always possible due to the different settings of the urban areas. It is possible to mention, as an example in which this phenomenon happens, the cases of crowdshipping or parcel lockers. The former might cause different impacts on the basis of which vehicles are selected by the couriers, and the latter on the basis of how the citizens reach the lockers.

Furthermore, it does not exist a unique solution that once deployed leads to obtain the best scenario for running urban logistics activities, that minimizes the externalities caused to the society, and/or maximizes the profit for the operators who manage this last part of the supply chain. The best scenarios are always a combination of different technologies, innovations and infrastructures that only together can bring significant results, as it has already been reported in chapter 1. For example, there are some technologies that are more suitable for night deliveries like electric vehicles that produce low noise emissions or parcel lockers that allow the couriers to download the parcels to places reachable 24/7. The introduction of cargo bikes might be integrated with wearable devices to make more secure the work condition of the bikers, with digital platforms that allow establishing a crowdshipping services, to a mobile depot that reduces the distance that a bike should travel. The establishment, the identification, or the management of a limited traffic zone (LTZ), can be done with decisions undertaken after processing data generated by sensors installed in the city that are able to communicate, even in real-time, information like the current traffic condition, quality air, availability of parking and much more. Furthermore, operators might be required to adopt new technologies for their fleet, more friendly environment, that allow them to keep having access to these areas. There are infinite possible technology combinations to execute the last-mile deliveries, and some of these are reported when the project results are summarized in the dataset. What it comes out by looking for them in the dataset, is that often Urban Consolidation Centres are combined with the introduction of greener vehicles, those can be cargo bikes, electric vans, hybrid vehicles or just greener vans and recharging stations at the depots when required.

The implementation of electric vehicles in city logistics projects is a widely studied topic. In fact, 26% of the analyzed projects in the dataset consider the case of this kind of vehicle and 22% of analyzed scientific papers in the dataset are about electric vehicles for running logistics activities in urban areas. This is due to the high benefit that the society can gain if logistics operators adopt this innovation, by avoiding local emissions and obtaining great results in terms of CO2 emissions and other air pollutants. For this reason, environmental impacts are the most studied by academics and the most disclosed results when project achievements are published. The fact that the production cost for the batteries is expected to decrease in the near future leads to expect also the economic feasibility in the short term of this technology, thanks to the forecasted decrease in the purchasing price and to the keep saving on operating costs. Furthermore, the always more restricted urban policies regarding vehicle pollution, make this technology becomes promising for future City Logistics. Regarding the reaction of the stakeholders to electric vehicles, final customers are not considered by authors who treated this technology in Urban Logistics because their service is not highly affected if logistics operators opt for this vehicle, instead, the considerations and the reactions of workers are often studied in this context.

Despite that many authors have mentioned that drones will difficulty become the predominant technology used for the delivery of goods in the urban area, it is a topic wide studied by academics as well. Public projects that involve drones delivery haven't been found, this innovation seems to interest to some private companies which adopt a pioneer behavior in the market. For example, UPS in the US is already combining vans with drones or in the dataset it is reported the case of Alphabet that it is already run this service in some cities. The current situation doesn't make drones vehicle to become an interesting technology for the delivery in urban areas, but some companies can identify market segments in which drone delivery might be used and they might bring great advantages.

People are always more interested in micro jobs, also because they don 't only provide a potential further income but also some health benefits can arise from them. This is the conclusion done by different authors who investigate about how workers react to this new form of employment. For instance, this may happen when couriers use bicycles during a crowdshipping service. Since several positive impacts are reported when city logistics projects involve technologies such as cargo bikes or crowdshipping, and disruptive innovations that are able to replace the couriers employment in the near future are not found yet, it is reasonable to think that such technologies will be always more deployed for running the last meter deliveries.

Regarding the impacts, the most studied in the analyzed academic works are the impact on the quality of air and the economic ones. In the “Data Analysis of Scientific Papers” section, it has been considered the percentages of articles that were taking quantitative considerations of those impacts just mentioned: the quality air impacts were quantified in the 29% of the articles and the economic ones in the 26%. This happens because a large number of methodologies to run this kind of analysis are available. An interesting finding is that there is no quantified information about the impacts that the technology can cause to the noise level. This last one impact can be easily figured out from simulation methodologies, but it actually didn’t occur in the analyzed articles. Some noise level impacts are quantitative estimated, most of the time through an ex-ante valuation, in the project's results. Hence, the information is included in the “Data Analysis of City Logistics Projects” section of the dataset, but it still remains the impacts with the lowest focus on. Generally speaking, when City Logistics is discussed, the noise that the urban logistics activities generate is often identified as a big externality caused to the society, so it is surprising that there is a lack of interest in it either in scientific papers or in projects results. Instead, it is not surprising that the most discussed project results are related to the quality air and the congestion (quantitative identified in 63% of the analyzed projects for the former impact, and 51% for the latter), because since there is a public interest in these projects, the goals are usually to provide a more livable environment to citizens.

5.2 Practical considerations

As it is mentioned in chapter 2 and proposed by the literature review of the author Lagorio et al. (2016), a common framework of city logistics does not exist yet because the literature available generally focuses only on the implementation of the technology in a single city, without making general considerations. Hence, the dataset developed during the thesis aims to address this issue, in fact, the comparison of different technologies or of the same technology with different settings can be easily done thanks to the classification of the impacts according to the categories discussed in chapter 4.

The dataset is a useful tool in the hands of authorities who want to implement a new urban logistics initiative in their area because they can exploit it for assessing the following information:

- About which technology has brought the best improvement in the impact area that authority wants to focus on.
- About the results of previous projects run in different cities that adopted the technology they want to introduce.
- About which technologies are used in cities that have similar characteristics to their town.
- About the impacts of the technology that they want to implement in the project from scientific articles sources.

Also, the academic world can benefit from this work, because it can be viewed as another literature review about City Logistics since all the information gathered for developing this thesis is found by collecting data from other existing works as scientific articles, websites, reports. The difference with the other literature reviews is that here, the focus is only on the impacts of the technologies deployed for urban freight transportation and to the best of our knowledge, it has never been done before this work.

5.3 Confirmation of the hypothesis identified in chapter 2

It was already expected to find the most part of the City Logistics projects run in European countries, because as it is reported in different literature reviews, European academics are also the most productive and the most cited all over the world. Furthermore, Italy results in our dataset the country where the largest part of projects were run (21% of all the analyzed project) and according to the literature reviews of Parisa Dolati Neghabadi et al. (2018) [35] and Wanjie Hu et al.(2019) [34], Italy results in the second most productive country in the former article and with the most productive author (Antonio Comi) in the latter analysis. Also, the United Kingdom plays a great role in the publication of scientific articles about city logistics and this is reflected in the dataset because the UK is the second country for the number of projects run (18%).

The distribution of the publication years of the scientific sources highlights that academics have started to assess the technology impacts only in the most recent years, in fact, 71% of the analyzed articles in the dataset are papers published from 2016 up to nowadays. If this result is compared to the literature review done by Wanjie Hu et al. (2019) [34], who considers papers up to 2018 addressing all the aspects of city logistics, it is possible to figure out that it is also present a considerable publication of articles in the previous years, starting from 2010. This means, that the thematic addressed in the earliest years seems to be not focused on the technologies or innovations adopted to overcome city logistics problems, but they are more focused on other topics as optimization methods through Operational Research techniques.

5.4 Directions for future research

It is reasonable to state that the concept of "autonomous logistics" will become an interesting aspect that will affect city logistics in the mid/long term. Only a few scientific papers treat the potential impacts of these technologies once deployed in City Logistics, thus further investigations done by the academic world are necessary. Most probably the first step will be the presence of autonomous driving also in commercial vehicles, and those will assist the work of the drivers, and only in a second moment the innovation will lead to the creation of vehicles able to deliver parcels in the city without the presence of a driver. In this case, a huge impact on the work condition is expected because drivers might be not more necessary. Autonomous driving has been already tested in passenger vehicles, and its current state is satisfactory. Hence, the same process that happened for electric vehicles might occur for Autonomous vehicles. In fact, in the beginning, the introduction of electric vehicles was thought for the transport of the only persons by private cars and only later the logistics operators might start to use this kind of vehicle in their fleet.

Another topic that deserves a further investigation is the impact of 3D printing on City Logistics because in the dataset it is treated only in one article. The use of 3D printers instead of the normal delivery process is a complete change of paradigm that can bring huge impacts to the industry. In the future, there will be a larger proportion of population who will have access to technology such as smartphones or personal computers, who will have informatic skills, also basic knowledge because the modern software provides a user-friendly interface, and all these are favorable thematic for a potential use of 3D printers by final consumers in a future City Logistics system.

Despite the fact that in the dataset "4.0 logistics technologies" is a category that includes a wide and different range of technologies, it is still a minor category of relevance respect others. In fact, their scientific articles result also in the category in which it has generated the fewest number of citations. The potentiality offered by the introduction of technologies like those seems underestimated by City Logistics researchers. The impacts of these technologies are identified thanks to the utilization of them in different city logistics projects, in which data, mainly collected from RFID sensors, became an important resource for the institution to set new regulations and to manage the urban traffic flow.

5.5 Limitation of the thesis

Making conclusions that are valid for every country is not always possible since most of the projects discussed are related to the European zone, and only a few cases of technologies deployed in non-EU countries are found. This happens, because the Europe is the part of the world that is currently more sensible to address city logistics problems. In fact, regarding the city logistics projects part of the dataset, all the projects in which there was a public intervention were run in EU countries. The European Union has had in recent years a big effort to promote these initiatives and to disclose the findings to the society in order to obtain a more sustainable urban condition. Instead, assessing information about other regions is more difficult and it is reasonable to state that this happens because abroad the projects in urban logistics are mainly carried out by private companies that are not forced to disclose their results to other competitors. This limitation must be considered when it is necessary to do a comparison of the results from the dataset with a potential implementation in another country. Usually, the European Cities are characterized by the presence of historic centers where the roads are narrow, and different monuments might be present. Furthermore, the culture of European people is similar among the different countries, but it could be significantly different compared to Asiatic or American cultures. For instance, the same customers' reactions to the introduction of an innovation can be expected from customers who live in different European countries, but it is not possible to state the same if it is compared with a customer from another region.

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Appendix

A.1 Article analyzed with ID code

Table A.1: article analyzed

n.	Article	Year	Author
1	Usability of the parcel lockers from the customer perspective – the research in Polish Cities	2016	Lemke, J., Iwan, S., Korczak, J.
2	Traffic signs in urban logistics with the use of RFID technology	2016	Balog, M., Szilagyi, E., Mindas, M.
3	The possible impact of 3D printing and drones on last-mile logistics: An exploratory study	2016	Mckinnon, A.C.
4	The Impact of Underground Logistics System on Urban Sustainable Development: A System Dynamics Approach	2019	Dong, J., Xu, Y., Hwang, B., Ren, R., Chen, Z.
5	Technical and operational obstacles to the adoption of electric vans in France and the UK: An operator perspective	2018	Morganti, E., Browne, M.
6	Sustainable urban freight transport adopting public transport-based crowdshipping for B2C deliveries	2019	Gatta, V., Marcucci, E., Nigro, M., Serafini, S.
7	Smart City logistics on cloud computing model	2014	Jerzy Korczak, Kinga Kijewska
8	Simulation of B2C e-commerce distribution in Antwerp using cargo bikes and delivery points	2018	Arnold, F., Cardenas, I., Sörensen, K., Dewulf, W.
9	Shared mobility for last-mile delivery: Design, operational prescriptions, and environmental impact	2018	Qi, W., Li, L., Liu, S., Shen, Z.-J.M.
10	Scheduling last-mile deliveries with truck-based autonomous robots	2018	Boysen, N., Schwerdfeger, S., Weidinger, F.
11	Public transport-based crowdshipping for sustainable city logistics: Assessing economic and environmental impact	2018	Gatta, V., Marcucci, E., Nigro, M., Patella, S.M., Serafini, S.
12	Potential last-mile impacts of crowdshipping services: a simulation-based evaluation	2019	Simoni, M.D., Marcucci, E., Gatta, V., Claudel, C.G.
13	Possibilities and Barriers for Using Electric-powered Vehicles in City Logistics Practice	2016	Quak, H., Nesterova, N., Van Rooijen, T.

14	Parcel locker systems in a car dominant city: Location, characterisation and potential impacts on city planning and consumer travel access	2018	Lachapelle, U., Burke, M., Brotherton, A., Leung, A.
15	Optimization of Municipal Waste Collection Routing: Impact of Industry 4.0 Technologies on Environmental Awareness and Sustainability	2019	Bányai, T., Tamás, P., Illés, B., Stankevičiūtė, Ž., Bányai, Á.
16	On the Regulatory Framework for Last-Mile Delivery Robots	2018	Hoffmann, T., Prause, G.
17	Leveraging Socially Networked Mobile ICT Platforms for the Last-Mile Delivery Problem	2012	Suh, K., Smith, T., Linhoff, M.
18	Last mile delivery by drones: an estimation of viable market potential and access to citizens across European cities	2019	Aurambout, J.-P., Gkoumas, K., Ciuffo, B.
19	Information system for city logistics. The case of Poland	2019	Kiba-Janiak, M., Cheba, K.
20	Factors influencing fleet manager adoption of electric vehicles	2014	William Sierzchula
21	Exploring the choice of battery electric vehicles in city logistics: A conjoint-based choice analysis	2016	Lebeau, P., Macharis, C., Van Mierlo, J.
22	Evaluating the impacts of using cargo cycles on urban logistics: integrating traffic, environmental and operational boundaries	2017	Melo, S., Baptista, P.
23	Environmental and economic comparison of diesel and battery electric delivery vans to inform city logistics fleet replacement strategies	2018	Giordano, A., Fischbeck, P., Matthews, H.S.
24	Electrifying light commercial vehicles for city logistics? A total cost of ownership analysis	2015	Lebeau, P., Macharis, C., Van Mierlo, J., Lebeau, K.
25	Electric vehicles in the last mile of urban freight transportation: A sustainability assessment of postal deliveries in Rio de Janeiro-Brazil	2019	de Mello Bandeira, R.A., Goes, G.V., Schmitz Gonçalves, D.N., D'Agosto, M.D.A., Oliveira, C.M.D.
26	Drone-delivery Using Autonomous Mobility: An Innovative Approach to Future Last-mile Delivery Problems	2019	Yoo, H.D., Chankov, S.M.
27	Design and Operation of an Urban Electric Courier Cargo Bike System	2018	Niels, T., Hof, M.T., Bogenberger, K.
28	Crowdsourced Delivery for Last-Mile Distribution: An Agent-Based Modelling and Simulation Approach	2018	Chen, P., Chankov, S.M.

29	Comparison of in-sight and handheld navigation devices toward supporting industry 4.0 supply chains: First and last mile deliveries at the human level	2020	van Lopik, K., Schnieder, M., Sharpe, R., (...), West, A., Maguire, M.
30	Comparing the Use of Small Sized Electric Vehicles with Diesel Vans on City Logistics	2014	Sandra Melo, Patricia Baptista, Álvaro Costa
31	Automated Vehicles and the Rethinking of Mobility and Cities	2015	Alessandrini, A., Campagna, A., Site, P.D., Filippi, F., Persia, L.
32	Analysis of using cargo bikes in urban logistics on the example of Stargard	2019	Nürnberg, M.
33	Analysis of the Concept of Urban Rail Transit Based City Logistics System	2008	Yubo, L., Ketai, H., Jie, L., Yihang, X.
34	Analysis of Parcel Lockers' Efficiency as the Last Mile Delivery Solution – The Results of the Research in Poland	2016	Iwan, S., Kijewska, K., Lemke, J.
35	Agent-based simulation model for evaluating urban freight policy to e-commerce	2019	Alves, R., Lima, R.S., de Sena, D.C., de Pinho, A.F., Holguín-Veras, J.
36	A mobile platform for collaborative urban freight transportation	2018	Mariangela Rosano, Claudio Giovanni Demartini, Fabrizio Lamberti, Guido Perboli
37	(How) will autonomous driving influence the future shape of city logistics?	2017	Mitrea, O., Kyamakya, K.
38	Does a Mobile Depot Make Urban Deliveries Faster, More Sustainable and More Economically Viable: Results of a Pilot Test in Brussels	2014	Verlinde, S., Macharis, C., Milan, L., Kin, B.
39	Shipping outside the box. Environmental impact and stakeholder analysis of a crowd logistics platform in Belgium	2018	Buldeo Rai, H., Verlinde, S., Macharis, C.
40	Transport reduction by crowdsourced deliveries – a library case in Finland	2016	Paloheimo, H., Lettenmeier, M., Waris, H.
41	A new robotized vehicle for urban freight transport	2013	Dinale, A., Molfino, R.,

			Huang, P., Zoppi, M.
42	Evaluating the use of an urban consolidation centre and electric vehicles in central London	2011	Browne, M., Allen, J., Leonardi, J.
43	A methodology to evaluate the competitiveness of electric delivery trucks	2013	Davis, B.A., Figliozzi, M.A.
44	Drone delivery: Factors affecting the public's attitude and intention to adopt	2018	Yoo, W., Yu, E., Jung, J.
45	Parcel delivery in an urban environment using Unmanned Aerial Systems: A vision paper	2017	Anbaroğlu, B.
46	Delivery by drone: An evaluation of unmanned aerial vehicle technology in reducing CO2 emissions in the delivery service industry	2017	Goodchild, A., Toy, J.
47	Parametric analysis of technology and policy tradeoffs for conventional and electric light-duty vehicles	2012	Barter, G.E., Reichmuth, D., Westbrook, J., (...), Guzman, K.D., Edwards, D.M.
48	The economic and operational value of using drones to transport vaccines	2016	Haidari, L.A., Brown, S.T., Ferguson, M., (...), Connor, D.L., Lee, B.Y.
49	Acceptability of collection and delivery points from consumers' perspective: A qualitative case study of Christchurch city	2017	Kedia, A., Kusumastuti, D., Nicholson, A.
50	The Rise of Crowd Logistics: A New Way to Co-Create Logistics Value	2017	Carbone, V., Rouquet, A., Roussat, C.
51	An economic and technological analysis of the key factors affecting the competitiveness of electric commercial vehicles: A case study from the USA market	2013	Feng, W., Figliozzi, M.
52	Towards E(lectric)-urban freight: First promising steps in the electric vehicle revolution	2013	Van Duin, J.H.R., Tavasszy, L.A., Quak, H.J.
53	How battery electric vehicles can contribute to sustainable urban logistics: A real-world application in Lisbon, Portugal	2016	Duarte, G., Rolim, C., Baptista, P.
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