POLITECNICO DI MILANO

School of Industrial and Information Engineering

Master of Science in

Management Engineering

REVERSE LOGISTICS IN B2C E-COMMERCE: A MODEL TO ASSESS RETURN COSTS

Graduation thesis of:

Elena Temperelli
ID 913329

Claudio Venosta
ID 916223

Supervisor:
Prof. Riccardo Mangiaracina, Politecnico di Milano

Co-supervisors:
Prof.ssa Angela Tumino, Politecnico di Milano
Dott.ssa Arianna Seghezzi, Politecnico di Milano
Dott.ssa Chiara Siragusa, Politecnico di Milano

December 2020
Academic year 2019-2020

Table of contents

List of figures

List of tables

List of graphs

(this page intentionally left blank)

(this page intentionally left blank)

ABSTRACT

Over the last years, e-commerce B2c has been expanding tremendously as a purchasing strategy: in this setting reverse logistics, namely the process of returning items from end-users, plays a pivotal role since it directly relates to customer experience and so e-merchants bottom line. Over time researchers have placed stronger focus on forward logistics, reverse logistics counterpart, whereas very little attention is paid to this latter being considered as an afterthought rather than the so-called “New normal”.

This dissertation is willing to fill the gap by studying the process of reverse logistics from a cost assessment point of view considering two peculiar phases of the e-commerce process – collection and transportation of returns, two actors – logistics service providers and e-customers, and different return methodologies – traditional home pick-up and parcel lockers.

Via a time-constrained clustering algorithm, this thesis has found that the variables whose influence is the greatest in driving down return unitary costs are the ones affecting drop density and the total number of packages to be handled, whereas mixed configurations, where more than one return methodologies are employed in the same mission, exhibit the highest levels of efficiency.

The novelty of this work is twofold: from an academic perspective, the model can be considered as a first attempt to analytically study reverse logistics cost structure and its determinants, while from a managerial point of view, the algorithm developed could help practitioners, logistics service providers above all, in understanding weaknesses and set up actions for improvements accordingly.

ESTRATTO

Negli ultimi anni, l'e-commerce B2c si è sviluppato enormemente come strategia di acquisto: in questo ambito la reverse logistics, ossia il processo di reso dei prodotti da parte dei consumatori, gioca un ruolo centrale poiché strettamente legata all'esperienza di acquisto e quindi al profitto dei venditori. L'attenzione dei ricercatori è per lo più focalizzata sulla forward logistics, la controparte della logistica di ritorno, poiché quest'ultima è spesso considerata secondaria e non il cosiddetto "New normal".

La presente dissertazione vuole colmare questo vuoto studiando il processo di reso da un punto di vista del calcolo dei costi considerando due fasi del processo e-commerce – raccolta e trasporto, due attori – corrieri e consumatori, e differenti modalità di reso – reso tradizionale via corriere presso un indirizzo definito dal cliente e parcel locker.

Attraverso un algoritmo di clustering vincolato al tempo, gli autori hanno scoperto che le variabili più impattanti nella riduzione del costo unitario del reso sono quelle che influenzano la densità di consegna e il numero totale di pacchi da gestire, e che le configurazioni miste, dove molteplici metodologie di reso sono utilizzate nello stesso tour, mostrano i più alti livelli di efficienza.

L'originalità di questo lavoro è duplice: dal punto di vista accademico, il modello può essere ritenuto un primo tentativo di studiare analiticamente la struttura dei costi della reverse logistics e i suoi determinanti, mentre da un punto di vista manageriale, l'algoritmo potrebbe aiutare le aziende, fornitori di servizi di logistica in particolare, nell'individuare debolezze nei processi e predisporre azioni migliorative.

(this page intentionally left blank)

(this page intentionally left blank)

EXECUTIVE SUMMARY

I. Purpose of the study

This dissertation aims at investigating the topic of reverse logistics in e-commerce B2C by placing great emphasis on the features beneath returning items procedures. The importance of the e-commerce B2C sector is well captured by the increasing trend of its revenues as presented for the Italian scenario by Osservatorio eCommerce B2c (2020): in 2015 sales accounted for 16663 mln € while in 2019 they reached 31583 mln €, showing a 17% yearly average increase achieved in these past five years (it should be specified that this 31,6 billion € includes both products (57,4%) and services (42,6%)). Also, a second remarkable indicator is the online shopping penetration rate, namely the ratio between online consumptions on total ones: in 2019 it averaged for the 7,3%, more in the specific it is 6% for products while 11% for services (Osservatorio eCommerce B2c(2020)), reflecting a 82,5% increase compared to 2015. On a global scale, statista (2020) forecasted a continuous and significant e-commerce growth with 3299.5 billion US$ revenues for 2024, +71% compared to 2019, considering also Covid-19 pandemic boost which is forcing and enhancing online purchases. However, some barriers still differentiate and favor offline traditional brick and mortar retailing to online one, especially the lack of physical interaction with the product. This evidence is at the basis of return decisions, as presented by Zhenleong & Zaiqiu (2010): wrong fit of products, unmatching features with the description provided online, lower quality than expected. In the light of the topic this dissertation would like to address, numbers show that the product return rate (percentage of products returned over the total items bought) is much higher in the online channel, 30% as for Saleh (s.d.), than in the offline one (9%). Focusing on the Italian scenario, product return rates in e-commerce accounts for 5% for general goods, 15% for electronics and over 40% for fashion, as presented by Kulach (2018)[1].

Since e-commerce sales rate is growing, online return rate is expected to increase too. As a matter of fact, Orendorff (2019) reported that "in the U.S. alone, Statista estimates return deliveries will cost $550 billion by 2020, 75.2% more than four years prior". Because of this, reverse logistics, to be intended as the set of processes that moves physical products from final customers back to the retailers, is no longer to be considered as an afterthought. It should not be managed as an additional service offered by retailers to clients but as the "New Normal", because it directly affects customer experience and so companies' bottom line. In this regard, it could be claimed that reverse logistics in B2C e-commerce is worth to be addressed as a main topic for this master thesis dissertation.

[1] https://www.webinterpret.com/au/blog/ecommerce-italy-definitive-guide/#:~:text=In%20terms%20of%20return%20rates,to%20offer%20easy%20returns%20solutions

II. Notes on the extant knowledge

This dissertation places great emphasis on how reverse logistics in B2c e-commerce works, considering the different ways to return products currently available as well as the interplay between the different actors encompassed by this process.

Taking this perspective, the objective of the literature review is to systematize the existing peer-reviewed resources dealing with the process of reverse logistics, net of closed-loop supply chain and return policy sphere. The searching process performed on Scopus and Web of Science has led to 35 articles, which have then been widely examined in order to identify relevant patterns in the reverse logistics field, if any. In this regard, following the approach by Perego and colleagues (2011), the 35 resulting papers have been firstly classified according to standard information namely title, authors, source, year (referring to the year of online publication), country (country of the main author which refers to the country where the scholar's university is placed), industry (sector addressed in the paper if any) and research method used: the main takeaways of the searching process will be now disclosed.

To begin with, selected resources are quite broad in nature ranging from marketing to computer science pointing out how many facets can be described in the selected field. Years of online publication of the articles, then, are in line with expectations: most of the academic studies are recent (21 papers out of 35 have been published in 2016-2019), thus following the current e-commerce volumes rise. From a country perspective, China and USA are the main contributors in the field of reverse logistics: arguably the presence of e-commerce giants as Alibaba and Amazon, as well as the penetration of internet retailing in those countries are the determinants of this pattern. From an industry point of view, scholars are usually not in favor of any sector in particular, probably due to the willingness to provide generalizable contribution to the current academic knowledge. In this regard, more focus was expected on the most return-inclined sector, namely the fashion one, where return rates are above the average. Interestingly, the reverse logistic process in B2C e-commerce is usually debated as a side topic of the more general forward logistic field: it might be assumed that academia is willing to provide an overall picture of the e-commerce sector which encompasses reverse but also forward logistics. Arguably, scholars implicitly consider forward logistics in B2C e-commerce very similar to reverse one, so at assuming forward logistics studies as good proxies of reverse logistics ones.

Coming to the different ways to return products in e-commerce B2C, the literature identifies three different options to return unwanted items back to the point of origin from a consumer perspective, namely traditional (home pick-up), collection points (both attended, and unattended) or else cross-channel, the option which encompasses the possibility to buy goods online and return them to the merchants' physical store. Although not widely investigated from an academic point of view, last-mile delivery innovative options (e.g., reception boxes, drones, trunks, underground, robots and smart key deliveries as well as crowdsourcing option) can be implemented also in reverse logistics.

A further step carried out in the literature review has been to systematize the papers/articles found by considering which phases of the process of reverse logistic were described within each piece of literature. Following the approach of De Araùjo et al. (2017), the process of B2C reverse logistic can be synthetized in the phases of pre-receipt, collection, transportation, processing of returns and shipment to final destination, in which customers, logistic service providers and merchants, the actors involved in a typical e-customer journey as for Vakulenko et al. (2019), carry out peculiar activities. By considering this units of analysis, the literature proves to be quite scarce in insightful contributions: in most of the cases collection and transportation are the only process phases described in detail by scholars, whereas very little attention is placed on return processing and shipment to the final destination.

As an additional contribution of the literature analysis, authors have mapped the process of reverse logistics in relation to existent return methodologies. Besides expanding the knowledge of this e-commerce retailing facet with all the interactions between players, phases and locations, the modular shape of the maps can be used as starting point to ground models and schema which could improve even further reverse logistics understanding and so procedures. Undoubtedly, this might also be applied to the other side of reverse logistics, namely forward logistics/last-mile delivery.

Grounded on these findings and restricting the unit of analysis to the different ways to return products in B2C e-commerce, the following formal gaps this dissertation has uncovered could be formulated as follows:

- lack of models for assessing cost (monetary and environmental) of returning items in B2C e-commerce
- incomplete state-of-art description of the methods e-commerce clients might use in returning items back to merchants and comparison/integration with last mile-delivery
- no considerations on the usage of cutting-edge ways to return goods in reverse logistics
- holistic description of the return management process absence

III. Research questions and methodology used

Among the formal gaps derived from the literature review, this dissertation will revolve specifically around the first one: lack of models for reverse logistics (monetary) cost assessment. The determinants of this choice can be traced back to:

- the chance to link cost assessment to a broad array of different topics as profit maximization (i.e. efficiency enhancement), sustainability (by means of traffic and pollution reductions) and complex logistics and distribution decisions (i.e. how to schedule and organize forward/reverse missions to fulfil customers' requests);
- the possibility to provide results from both an academic and a practitioner perspective, thus fulfilling the formal requirements of the master thesis typology, a dissertation, candidates have chosen;
- authors' willingness to solve an engineering problem which requires not only problem setting skills, as in the definition of the theoretical framework, but also problem solving and analytical ones in coding the model and interpreting the results.

The literature gap is translated in the following research questions, this dissertation will try to answer:

RQ1: *Which are the elements that impact the most in the cost of returning an item?*
RQ2: *To what extent the cost of returning an item differs from one return methodology to another?*

To answer the research questions addressed, candidates have chosen to deploy a modelling and simulation approach: through modelling it has been possible to represent a real and complex system – e-commerce B2C reverse logistic process from customer's place to courier's first hub - without any physical interactions, while simulation comes handy in testing the model developed and analyzing different scenarios. In this exercise, quality and availability of input data play a pivotal role, indeed the higher the precision of input data, the greater the value of the results. Different sources - both primary (interviews, websites, personal experiences) and secondary (literature reviews, reports) - have been employed with the objective of simulating real-world alike scenarios. From a practical point of view, then, authors have chosen R as modelling tool: its statistical, simulation and graphical capabilities are useful not only in the development phase but also in output creation, analysis and discussion of the results. Figure 1 represents the architecture of the model designed.

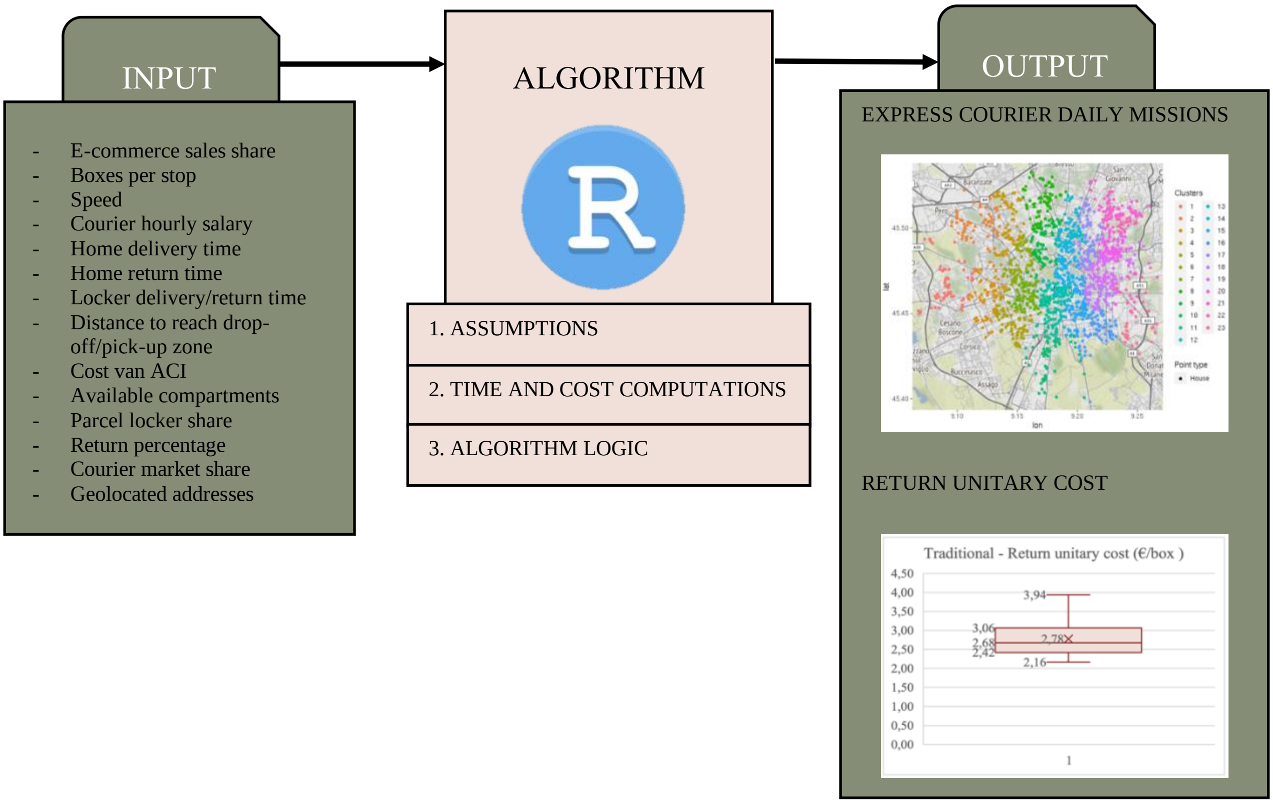


Figure 1: Model architecture (the output is specific to one selected scenario)

Coming to the key features of the algorithm developed, the main idea is to divide an area, in the case of this master thesis the municipality of Milan, via a time-constrained-clustering method, where each cluster points out a tour/mission a single express courier van performs daily in managing e-commerce customers' requests, regardless of the type – deliveries or returns. The k-means clustering approach is applied to a set of addresses within the city of Milan which are net of the daily e-commerce requests, courier market shares and the average number of order (boxes per stop) each address might account for. To overcome k-means heterogeneity outcomes, then, addition/subtraction of datapoints takes place thus getting homogeneous 8 hours, standard work shift, saturated clusters. Different input variables have been plugged into the algorithm to let R generating the optimal number of clusters to satisfy the demand, namely van average speed, unitary operation time and distance outside the delivery area (from drop-off/pick-up area to first couriers' hub). It should be also noted that the model is dynamic in nature, meaning that depending on the customers' requests (e.g. e-commerce sales) and the relative market share one express courier has in respect to its competitors, a corresponding number of clusters is activated.

The algorithm has been tested on three scenarios:

- ➢ SCENARIO 1 (TRADITIONAL) → customer requests' (both deliveries and returns) are managed in home locations, the traditional parcel handling methodology in this dissertation, meaning that express courier van travels each day within the municipality to either drop-off or pick-up packages at clients' place.

- SCENARIO 2 (EXCLUSIVE) → a share of the daily e-commerce demand (14%) is managed by mean of parcel lockers with exclusive tours (vans which collect just parcels at parcel locker locations), whereas the remaining requests (86%) are managed in the traditional way, home pick-up/drop-off.
- SCENARIO 3 (MIXED) → clusters identify express courier van daily tours, which encompass both home locations and parcel locker locations, meaning that in one tour a single van could visit both parcel locker and home locations. It is worth noticing that this latter scenario is the most realistic one: willingly to increase as much as possible efficiency, logistic service providers schedule mission in a mixed fashion.

The representative variable used to analyze results will be "**return unitary cost**", a sort of summary variable which encompasses all the elements essential to handle return requests in e-commerce B2C from customer location/parcel locker to courier's first hub.

IV. Main findings

The main findings of this dissertation should be read in the light of the input data employed. In this regard, it should be noticed that the reliability of input data, retrieved from both primary and secondary sources, has been validated by an express-courier-senior-manager candidates had the chance to interview in October 2020. In this regard, the following table (Table 1) shows the data used to run the algorithm:

Number	Input variable	Value
1	E-commerce sales share	27 %
2	Boxes per stop	1.23 boxes/stop
3	Speed	10.21 km/h
4	Courier hourly salary	20 €/h
5	Home delivery time	1.5 minutes
6	Home return time	2 minutes
7	Locker delivery/return time	0.75 minutes
8	Distance to reach drop-off/pick up zone	15 km (one way)
9	Cost van ACI	1.6 €/km
10	Available compartments	20 compartments
11	Parcel locker share	14 %
12	Return percentage	10 %
13	Courier market share	12.5 %
14	Geolocated addresses	Longitude and latitude

Table 1: List of input variables with values

The outcomes of this dissertation take the form of precise and thorough answers to the research questions addressed as follows.

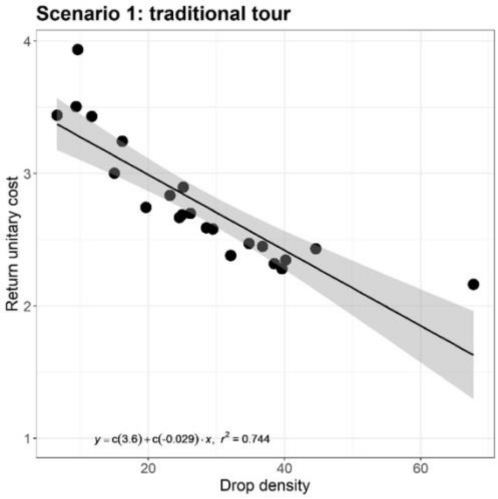
RQ1: Which are the elements that impact the most in the cost of returning an item?

As far as RQ1 is concerned, the answer could be found in the sensitivity analysis run on the input variables which affect the summary "return unitary cost". To accomplish this task, the effects on the summary variable caused by the same variations among input (considering their benchmark value as reference starting point) have been investigated, thus obtaining comparable results as per the following Table 2 where TRADITIONAL scenario sensitivity analysis is shown.

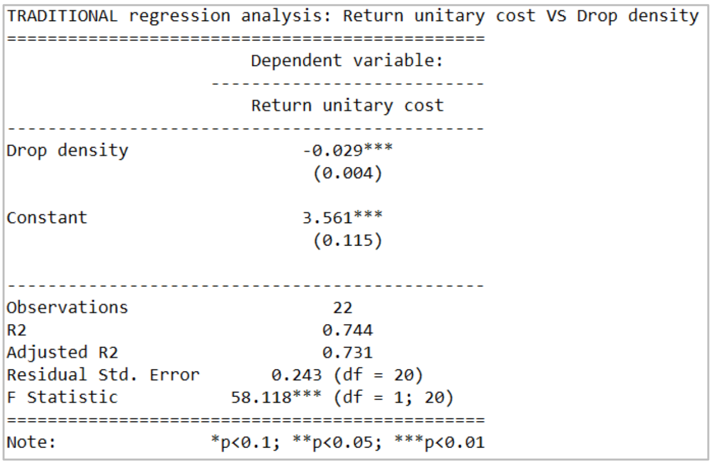
	Variables							
	Speed	Courier market share	E-commerce sales share	Cost van ACI	Home boxes per stop	Home return unitary time	Home delivery unitary time	Return percentage
Delta % Variables	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost
-75%		63%	63%	-26%		-21%	-12%	0%
-50%		28%	28%	-17%		-15%	-10%	-1%
-25%	39%	9%	9%	-9%		-7%	-4%	-1%
0%	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
25%	-16%	-6%	-6%	9%	-6%	5%	2%	0%
50%	-26%	-11%		17%	-11%	13%	9%	-1%
75%	-32%	-14%		26%	-11%	19%	13%	0%
100%	-36%	-17%		34%	-15%	25%	19%	-1%

Table 2: Impact of input variables variations on the return unitary cost

Considering the main takeaways of this what-if type of analysis applied to scenario 1, the variables which show the greatest impact on the summary variable "return unitary cost" regardless of the sign are **market share courier** and **e-commerce sales share** (+63% in return unitary cost for a 75% drop in the input variable). Although these two elements are different by nature and dependency, being "market share courier share" connected to the strategic ability of an express courier firm to gain larger market shares and sales e-commerce linked to the overall demand of e-commerce requests in the area under investigation, the effects they cause on the summary variable is the same. The determinant of this pattern has to be found in the relationship between these two inputs and drop density. Drop density, defined as the number of packages to be managed in a drop-off/pick-up zone divided by the surface of this latter, is statistically significant in predicting the return unitary cost, as authors have tested via simulation (see Graph 1 and Figure 2). Above all, economies of scale and scope phenomena play a pivotal role in explaining the abovementioned figures.



Graph 1: Drop density VS Return unitary cost in the traditional scenario



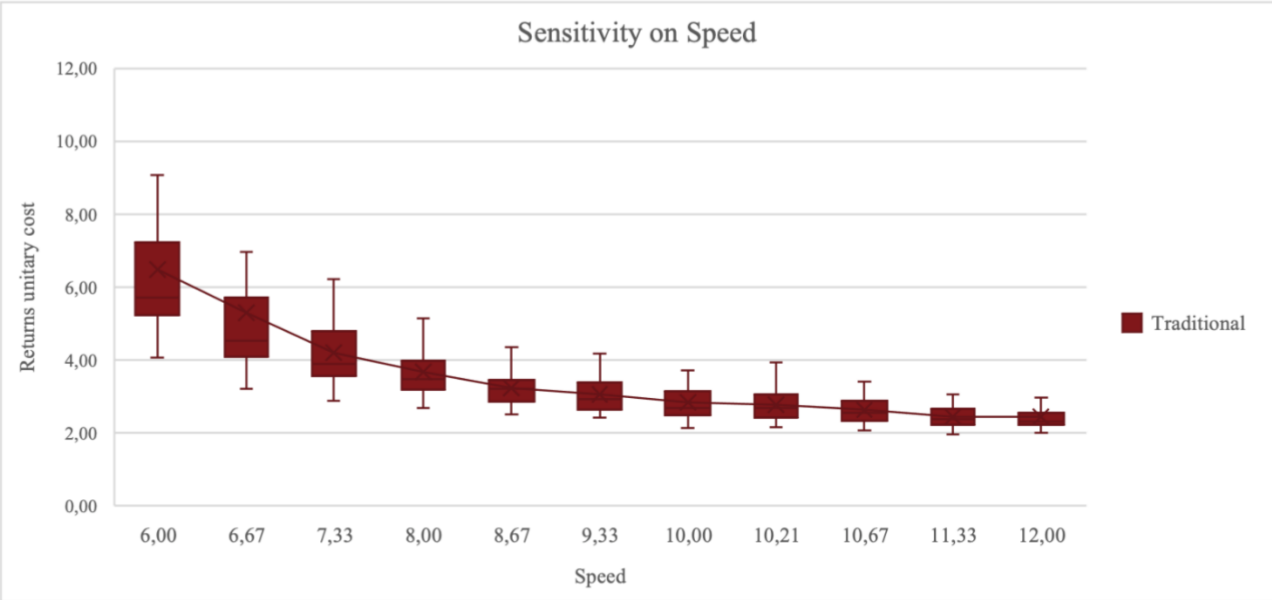
TRADITIONAL regression analysis: Return unitary cost VS Drop density

	Dependent variable:
	Return unitary cost
Drop density	-0.029***
	(0.004)
Constant	3.561***
	(0.115)
Observations	22
R2	0.744
Adjusted R2	0.731
Residual Std. Error	0.243 (df = 20)
F Statistic	58.118*** (df = 1; 20)
Note:	*p<0.1; **p<0.05; ***p<0.01

Figure 2: Output of the regression analysis for Drop density VS Return unitary cost in the traditional scenario

The third variable by effects magnitude is **speed**: if this latter is decreased by a 25%, +39% in return unitary cost is expected. Regardless of R limitations in generating results at any delta variation levels for this variable, it could be claimed that the average speed a van can assume during an 8 hours shift is the variable whose relationships with the return unitary cost is the greatest, indeed significant variations in the summary variable are achieved for both speed drop (-25% in speed is worth +39% in return unitary cost) and rise (+100% in speed causes -36% in return unitary cost). The determinants of this strong interaction can be found in the way speed relates to "travel time" and "boxes per tour". In particular, speed affects travel time in a negative way, thus the higher the average speed the lower the incidence of travel time over operation time (on the total time constrained to 8 hours) and so the ability to handle more packages within one single tour, and vice versa. To support this statement, authors have tested that the number of boxes within a tour is inversely proportional to cost of a returned box and the effect is statistically significant, as for the drop density. Therefore, the joint effect of "speed-boxes per tour" and "speed-travel time" relationships makes van speed the input variable whose role is the most effective one in modifying "return unitary cost".

It is worth noticing that the effect of speed on return unitary cost is not constant, but it assumes the following pattern (Graph 2):



Graph 2: Sensitivity on Speed in the traditional scenario

The decreasing tendency is due to the relationships "speed-boxes per tour", which implies that for high level of boxes per tour a lower number of tours needs to be activated overall by each single express courier company to fulfill the demand, whereas the asymptote is caused by fixed components (i.e. fixed distance to reach the drop-off/pick-up area) which has to be beared in any case.

Cost van ACI, the cost per km ascribed to the use of the vehicle to perform deliveries-pick-ups, provides milder variations on the return unitary cost: this variable is used as a multiplicative coefficient, with no links on other variables. Its direct relationship with the km travelled implies that effects caused by cost van ACI on the return unitary cost are symmetric, meaning that a -25% variation in its reference value causes a -9 % in the summary variable, whereas a +25% variations is worth a +9%. As noticeable, a drop/rise in the cost per van does not yield the same percentage in the return unitary cost, because this latter comprehends not only vehicle operations costs but also labor ones.

Coming to the number of **boxes per stop**, interestingly by doubling the number of boxes within a single location, the return unitary cost decreases by just 16 %. This takeaway could be traced back to the way the analysis is framed: by modifying each variable at a time in the what-if analysis, the level of demand will not change, thus higher level of boxes per stop implies less addresses to be visited in a single tour, higher boxes per tour but also larger surface covered in a single tour. Being drop density defined as number of boxes divided by the surface of the tour itself, the ratio will be not strongly affected because both numerator and denominator increase. This is to say that the single effect of different levels of boxes per single stop is not pivotal in changing drop density value and drive costs, differently from higher demand levels generated by variations in both market share courier and e-commerce sales share.

As far as both **home return unitary time** and **home delivery unitary time** is concerned, the consequences they could produce on the summary variable "return unitary cost" are milder than the previous ones, since these two elements solely impact the operation time, which accounts for one third of the total time of 8 hours (at benchmark level).

As the least representative input variable, **return percentage** has to be described: this element does not impact in a meaningful way the summary variable "return unitary cost", therefore the model supports the line of reasoning expressed by the expert manager candidates have the chance to talk with, who states that from a logistic service provider point of view, the one this dissertation follows, the direction of the flow (return/delivery) does not affect costs.

As a final remark, this piece of analysis holds even in the case of the other two selected scenarios (EXCLUSIVE and MIXED), with mild variations ascribed to the different return/delivery methodologies (e.g. parcel lockers) used to satisfy the demand.

Considering the other two scenarios, two additional input variables have to be investigated: **locker unitary time** and **available compartments**. Locker unitary time follows the same pattern of home delivery/return unitary time: however, considering the relative weight of parcel locker boxes (14 %) on the total boxes to be managed daily, the effects on the summary variable are less visible, while available compartments – the number of compartments that can be used within a single locker location – by construction are not very meaningful.

RQ2: To what extent the cost of returning an item differs from one return methodology to another?

To answer this second research question, the comprehensive summary variable, "return unitary cost", identified by authors comes handy, indeed by considering the same input variables, the three selected scenarios can be easily compared one to each other.

In particular, "return unitary cost" is worth **2.78 €/unit** in scenario 1 TRADITIONAL (baseline), **2.82 €/unit** in scenario 2 EXCLUSIVE (considering both traditional and parcel locker tours) and **2.50 €/unit** in scenario 3 MIXED.

Bearing in mind the input variables used as well as the perspective considered in the model (e.g. the cost of one single returned parcel is assessed from customers' place/parcel locker location to logistic service provider's first hub), the fundamental insight coming from these figures is that the **least**

expensive scenario is the mixed one. Although the expert manager interviewed by candidates has already claimed that mixed configurations (e.g. different delivery/return methodologies are employed in the same courier tour) are the most frequent ones employed by logistic service providers in managing customers' requests (regardless of the type, both returns and deliveries), the novelty of this master thesis lies in the capability to test via a mathematical modelling and simulation approach that mixed configurations are truly the most efficient ones in dealing with returns.

The determinant of this finding must be traced back to the role of parcel locker as **flow consolidator**, indeed by using parcel locker as return/delivery methodology, the number of boxes manageable within a single tour could be increased by large, so at reducing the number of missions (and so vans/clusters) to be activated in order to fulfil customer requests. As shown below in Table 3, by increasing the parcel locker share from the benchmark value of 0.14, the number of clusters identified by the algorithm decreases consistently with a tremendous cost reduction from a logistic service provider perspective, which will need a lower number of vans to manage the same number of customer orders. The same concepts can be applied to other CDPs (i.e. service points, bars, newsagents, supermarkets …) which could work as well as flow consolidators.

Parcel locker share	Number of clusters
0.14	20
0.2	19
0.3	17
0.4	16
0.5	14
0.75	6
0.995	1

Table 3: How the number of clusters vary changing the parcel locker share

V. Implications and limitations

The current work is intended to develop extant knowledge on the topic of reverse logistics procedures in B2C e-commerce from both a theoretical and a managerial point of view.

Despite candidates' willingness to provide a complete study, the following limitations have to be highlighted:

- *input data quality:* e-commerce sector is ever-changing thus the input variable used could differ from time to time. By increasing the quality of input data gathering in terms of timeliness, the outcome will be enhanced.
- *geographical boundaries and drop density:* the model has been tested solely on the municipality of Milan to manage both time requirements and complexity. Further improvements could consider multiple drop-off/pick-up areas to be tested. In addition, input variables could be paired to a specific zone by linking the input variables to its population and drop density.
- *volume constraints, time windows, deliveries/returns failure rates, overtime:* the model does not make use of these latter elements to keep the degree of complexity under control.
- *return methodologies:* the model makes use of two return/delivery methodologies, home delivery/pick-up and parcel lockers, given its strong diffusion among customers. Future studies could benefit from the modular nature of the algorithm developed, thus studying more return methods.
- *focus on environmental consumption:* despite authors' choice to focus on the monetary perspective of reverse logistics in B2C e-commerce, future inquiries could address the environmental side of the topic.

From an academic perspective, it could be claimed that this dissertation represents the first attempt to investigate in an analytical way which are the variables whom effect is the greatest in determining the return unitary cost across different scenarios and the determinants beneath their different relationships with the summary variable "return unitary cost", bearing in mind the link between last mile and return reverse logistics. Plus, it has been studied the setting who could drive down more consistently costs, namely the mixed configuration where different delivery/return methodologies are integrated within one single express courier tour.

Considering the managerial perspective, the dynamic, scalable and modular model developed could help practitioners, express couriers above all, to gain efficiencies and so drive down costs, because weaknesses and criticalities could be easily spotted by mapping the as-is situation, while simulation could serve as a road map for future improvements.

(this page intentionally left blank)

(this page intentionally left blank)

1. INTRODUCTION

1.1 What e-commerce is

E-commerce, Electronic Commerce, is defined as the activity of buying or selling products or services online, thanks to an electronic network, the internet.
According to some authors, e-commerce birth can be traced back to 1994 when a guy from Philadelphia went shopping for a compact audio disk making the "first retail transaction on the Internet using a readily available version of powerful data encryption software designed to guarantee privacy", as appeared on an article on The New York Times written by the journalist Lewis (1994). Some other authors collocate it when Jeff Bezos, in 1994, founded Amazon.com and started selling books online overcoming all the physical possible geographical constraints, reaching worldwide customers. From that moment on, several others e-commerce websites arose thanks to the increasing development of internet connectivity, as for other e-commerce giants like Alibaba and eBay, that changed the whole retail industry as it was known before.
Nowadays, there are different typologies of e-commerce according to who are the actors involved in the transaction. If the transaction is between businesses, it will be called e-commerce B2B, Business-to-Business. Whereas, if the actors are businesses and consumers, it will be defined as e-commerce B2c, Business-to-Customers, the branch this dissertation will address.

1.1.1 E-commerce vs traditional retail

Since its first development, e-commerce became a game changer in the retail industry and rapidly influenced customers' behaviors. The benefits achievable by using an e-commerce business, rather than a traditional one, are perceived both by sellers and buyers. As highlighted by Khan (2016), the buyers will have:

- An increase in comfort and accessibility, since it is possible to purchase 24/7 and from whatever location provided with internet connectivity;
- A reduction in transaction costs;
- A quick and continuous access to information as concern products prices, availabilities and features;
- The possibility to switch to other companies;
- Accessibility to worldwide retailers.

The seller, on the other side, by having an online business will achieve:

- Higher revenues because of potential worldwide customers;
- Lower operation and maintenance costs;

- Increase customer loyalty and retention;
- Development of customer and supplier relationships;
- Higher speed of the selling process;
- Improvement in internal and external communication;
- Development of the company image and brand.

In order to have a complete and fair overview of the differences between e-commerce and traditional retail, the focus should be placed also on the other side of the coin, so not only on the benefits coming from online selling but on possible drawbacks and problems too. According to Raquel Serrano[2] (2019), some disadvantages are:

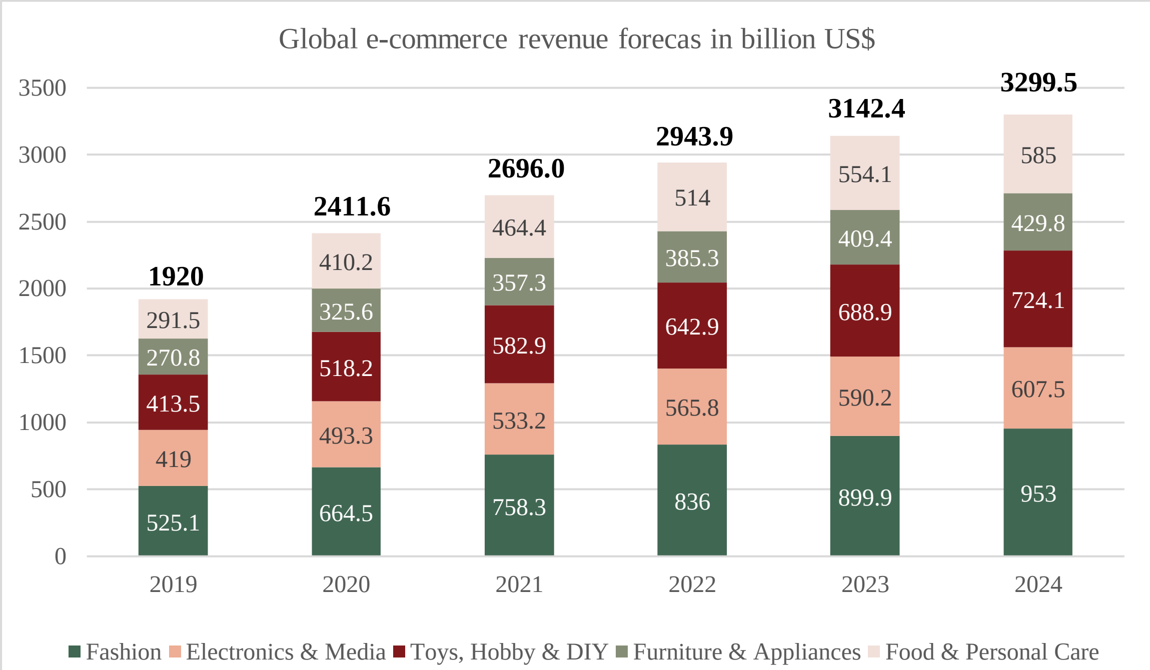
- Physical interaction with products is not possible, so perceptions may be misinterpreted;
- Face-to-face relationships are absent, customer is relying only on descriptions and feedbacks;
- Insecurity in payments, mostly for those e-businesses who are not well-known, implies that the payment system has to be safe and transparent in order to gain customer trust;
- Possibility of having delivery problem due to logistic issues;
- Connection problem may cause failure in the purchasing process.

By analyzing and evaluating the trade-off between advantages and disadvantages, both buyers and sellers started exploiting the online channel as an alternative to the traditional brick-and-mortar retailing. New fully e-commerce businesses grew up, while traditional retailers decided to join the e-commerce world with an omnichannel business model. Indeed, over the years traditional brick-and-mortar retailers understood the importance of selling products in different channels in order to increase the number of potential customers, to give more visibility to their products and so to follow market trends. They started developing their own websites to direct sell their brand items or else exploiting third parties' platforms like marketplaces. Such business models can be labelled as multi-channel strategies: different sales channels independent each other are offered to customers. Later on, it was understood the additional benefits laying in the integration of these different channels, and therefore customers have been given the chance of buying items online and exploiting some services offered by physical stores, like in-store return or maintenance operations. So, there was the shift from multi-channel to omni-channel strategy, which is the integration of physical (like offline brick-and-mortar stores) with online digital channels to offer a unified customer experience.

[2] https://enebfaculty.com/2019/05/14/e-commerce-vs-traditional-commerce/

1.1.2 Trends in e-commerce

Global ecommerce revenues, according to Statista Digital Market Outlook (2020), are expected to grow until US$ 3299,5 billion by 2024, also taking into consideration in Graph 3 the increase of the last months due to Covid-19 pandemic:



Graph 3: Global e-commerce revenue forecast in billion US$.
Source: statista (2020)

The trends pushing towards this expected growth, following research presented in the eCommerce Report (2020) by Statista, are:

- *Mobile commerce:* customers are spending more time connected to their mobile devices which leads to a higher exploitation of mobile commerce, where this means doing online shopping with a mobile device, like a smartphone. Moreover, since companies understood this powerful trend, they are investing always more in mobile customer experience, by optimizing searches and by reducing the number of clicks leading to purchases. Also, websites have been improved in their mobile versions and applications are developed to guarantee a better customer purchase experience.
- *Marketplaces and SEO*: marketplaces are offering to merchants a high level of expertise in their infrastructures for what concerns product presentation, search engine optimization (SEO), payments and customer service. Moreover, they offer to customers a broad range for the same product allowing them to easily individualize the one that better fits their needs in terms of quality and price. For example, a person looking for a lamp on Amazon marketplace has the possibility to access a list of lamps coming from different brands. The marketplace also provides him/her

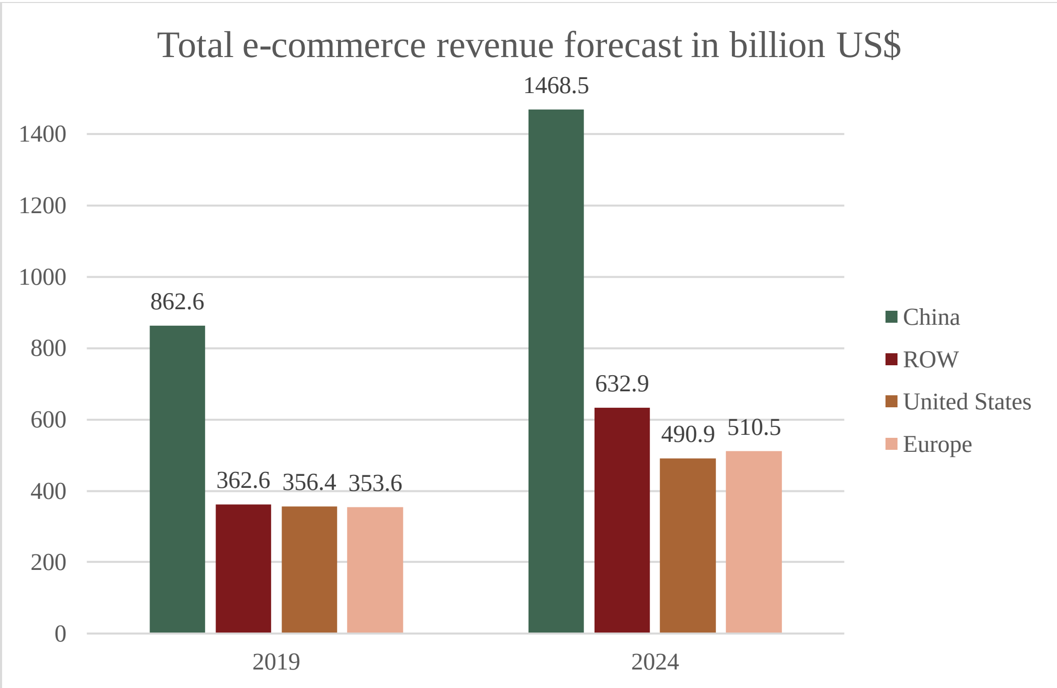
with some useful functions like filters on physical features (colors, material, dimensions), prices, feedbacks of previous customers that already experimented the product, and on other evaluation criteria. In this way, thanks to the possibility of using filters and comparing products from different manufacturers, the potential buyer can make a more accurate and faster selection of what he/she would like to buy.

- *Simplification of checkout and payments:* the abandoned virtual cart rates are diminishing over time thanks to the current simple checkout and payment process. From the registration on the e-commerce website until the check-out, the client is facilitated in personal information entry, by sharing data coming from other personal accounts already existing like Facebook or Google, and in payment instrument choice, by having the possibility of selecting several payments methods like PayPal, different prepaid cards, Apple Pay, Amazon Pay, Credit Coupon, Gift Cards and many others.
- *Delivery optimization:* this challenge is fundamental for electronic commerce, since it is directly and strongly impacting on customer satisfaction. In order to have an efficient product and service delivery, retailers are offering a wider gamma of delivery/return manners, involving not only traditional logistic companies but also exploiting new innovation technologies. As a matter of fact, retailers are offering collection delivery points, click & collect (buy online and delivery/return offline), same-day deliveries and even some revolutionary drone deliveries appeared in the market.
- *Loyalty and memberships programs:* price, product features and quality are no longer the only differentiating factors in the market driving the choice of a specific item, due to the strong competition characterizing worldwide e-commerce. Because of this, retailers had to find new competitive strategies: here is the role of loyalty and memberships programs. Willingly at increasing customer engagement, purchase frequency and basket size, their goal is to build strong and loyal relationships with customers. Membership programs offer customers several advantages like customized newsletters, dedicated discounts, exclusive products or else favorable delivery policies among the others. It is worth mentioning Amazon Prime, the paid subscription service provided by Amazon, which offers to customers free and 1-day deliveries for many items but also the access at discounted prices to digital products like Video, Music, Readings.
- *Voice Commerce:* voice assistants, also known as chatbot, like Siri or Alexa, are becoming a new way used for the interaction between customers and merchants. This technology allows to make much faster and easier purchases exploiting vocal and pattern recognition.
- *Sustainability:* in the last years new and strict regulations were made to keep under control carbon emissions in every kind of businesses, due to the global climate change and global warming emergencies. For this reason, full transparency and focus on environmental footprints are

mandatory nowadays, making companies invest in several sustainable initiatives. This is true both for the traditional brick-and-mortar retail and for the e-commerce reality. Online merchants are boosting different sustainable initiatives, mostly for what concerns logistics and transportation using renewable energy for powering their plants and warehouses and choosing low emissions vehicles for transportation.

1.1.3 E-commerce in numbers

In this paragraph the reader will be provided with key figures concerning major markets for e-commerce and main related segments.
Relying on the analysis carried out by statista (2020), the three major e-commerce markets, according to revenues of 2019, are China, with revenues of US$ 862,6 billion, US (Osservatorio eCommerce B2c, 2020) with revenues of US$ 356,4. billion and Europe with revenues of US$ 353,6 billion. In Graph 4 it can be noticed that these figures are expected to grow consistently up to 2024: e-commerce global revenues are forecasted to top US$ 3102,8 billion by 2024 (+10% compared to 2019).



Graph 4: Total e-commerce revenue forecast in billion US$. (ROW = Rest Of The World.)
Source: statista (2020)

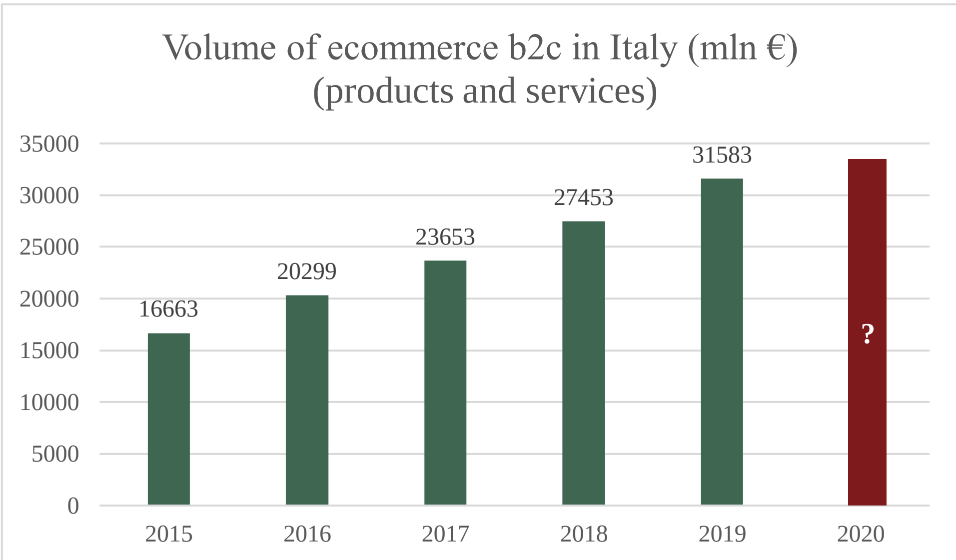
To describe e-commerce markets, it should be mentioned that online sales channel touches different segments, as it was already presented in Graph 3: fashion, electronics and media, toys hobbies and DIY, furniture and appliances, food and personal care among the others.

Also, there are different typologies of players:

- *Marketplaces*: like Amazon, Alibaba and Zalando. These businesses are running mainly online selling items produced by other brands in the vast majority of the cases. It is worth noting that recently Amazon changed its business model by opening some physical shops: this tendency may be observed in the future also for other marketplaces.
- *Online retailers:* like BestBuy, Tesco and Walmart. These players are both physical and online resellers of other brand's products, in line with an omnichannel strategy.
- *Direct sellers:* like Zara, Apple and Ikea. This typology of actors is made by brands that are selling their products directly, with no intermediaries, online as exclusive or alternative channel.

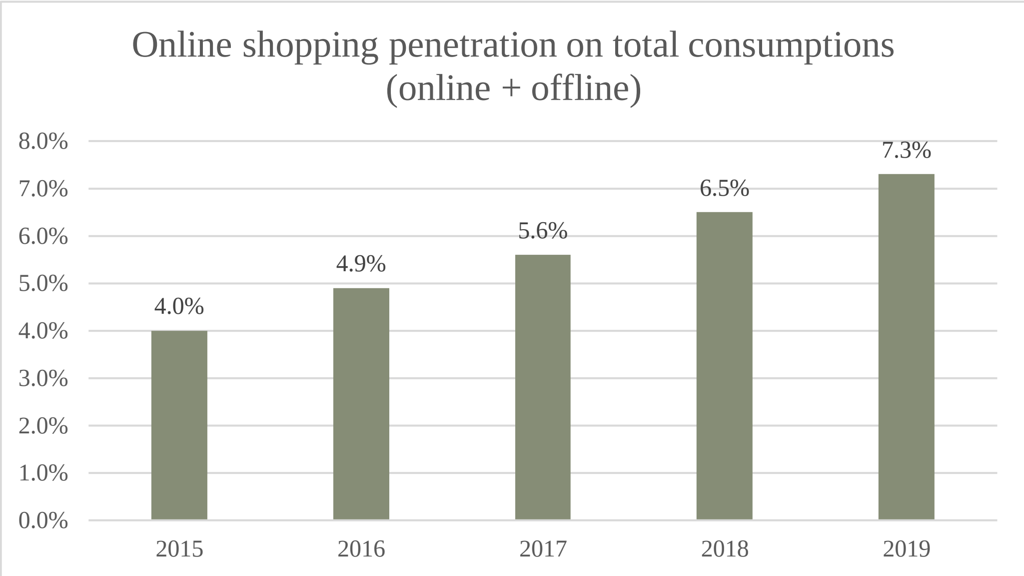
1.1.3.1 State of art of e-commerce in Italy

Until this point, the reader is provided with a general worldwide overview. But what about Italy? Relying on the analysis carried out by Osservatorio eCommerce B2c of Politecnico di Milano (2020), the total volume of online shopping for e-commerce B2c in Italy accounted for 31583 mln € in 2019, showing a 15% increase compared to 2018 (see Graph 5) (it should be specified that this 31,6 billion € includes both products (57,4%) and services (42,7%)). This positive trend is in line with the worldwide e-commerce revenues growth already presented.



Graph 5: Volume of ecommerce B2c in Italy (mln€)
Source: Osservatorio eCommerce B2c (2020)

The biggest part of the total volume was represented by the tourism industry. The other driving branches that can be considered mature markets for e-commerce were electronics and fashion. Furthermore, new emerging industries were furniture and food and grocery. In order to understand how e-commerce is really spreading among Italian consumers the focus has to be placed on the e-commerce penetration rate, defined as the percentage of online purchases over the total purchases, both online and offline. This index, equal to 7,3% in 2019 (see Graph 6) (more in the specific it is 6% for products while 11% for services) (Osservatorio eCommerce B2c, 2020) showed that the online channel was not so mature yet, mostly if making comparison with other countries like US or China where it is even three times higher.



Graph 6: Online shopping penetration on total consumptions (online + offline)
Source: Osservatorio eCommerce B2c (2020)

Of course, as well as the volume, also the penetration rate varies according to the industry: for example, for the tourism it is 36% while for grocery 1% (Osservatorio eCommerce B2c, 2020). This relevant gap can be explained by the different categories of products purchased and the barriers that prevent or push customers from/to online purchases. For example, groceries are today very well spread in terms of locations so for people it is easy to stop and buy food. Instead, buying a vacation package becomes more difficult in terms of accessibility for the customer because travel agencies are not widely spread, pushing customers towards online booking. Eventually, the penetration rate for a specific product category is a result of the trade-off evaluation of those benefits and problems coming from online purchasing, as described in Paragraph 1.1.1.

1.1.3.2 Impact of Covid-19 pandemic on e-commerce in Italy

An important game changer in the picture of e-commerce was the Covid-19 pandemic. It is important to highlight how this situation that affected worldwide population impacted on both customers and sellers. Describing the Italian scenario, starting from the end of February 2020, some high-risk regions for number of infections were locked down. After some days, because of the spread of the virus and a fast worsening in numbers of people infected, the lock down was extended to all the country. Government forced people to stay home, plus commercial and productive activities not necessary for essential goods were stopped. Due to this situation, online shopping skyrocketed. For example, many omnichannel retailers which were forced to stop their brick and mortar stores activities kept on working just online (e.g. Decathlon). Looking at the figures resulting from a study conducted by Casaleggio Associati (2020), in March 2020 there has been a +60% in web traffic, in particular +250% related to great distribution websites. Indeed, customer needs were mainly oriented towards food and groceries, entertainment and insurance, whose revenues increased by 21%. For those retailers whose revenues grew in a consistent way, they might have faced situations like traffic congestions solved by the installation of queuing systems for their websites, limitations in order frequency and daily orders accepted per customer, warehouse management difficulties, slowing down in order release or else investing in omni channel integration strategies. Differently, concerning other markets like events, tourism, fashion and luxury, revenues dropped by 54%. In this difficult scenario, these retailers had to find some new strategies to keep relationship with customers like, for instance, offering online experiences or switching their offering towards more digital contents and services. In example, a make-up retailer started offering to the public live streaming events to keep the relationship on and further to sustain business continuity. Furthermore, it is worth noticing that Covid-19 pandemic impacted on e-commerce not only for those companies that were already running their business online as just pointed out: it worked as a driver to break barriers both in the eyes of sellers and buyers, pushing brick-and-mortar retailers to sell their product online and convincing more traditional buyers to discover the e-commerce reality.

1.2 Reverse logistics in e-commerce B2c

Logistics is one of the key pillars allowing an e-commerce company to run its business properly. The Council of Supply Chain Management Professionals stated that “Logistics Management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements.”. In this direction, all the activities characterizing the movement of resources in the whole supply chain that is “a set of entities (organizations and individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer” (Mentzer et al., 2011), can be classified in two different flows. The flow consisting in transforming raw materials into a finished product and in delivering it to the final user, the forward logistics, and the flow called reverse logistics, which is formally defined by the Reverse Logistics Executive Council as "a specialized segment of logistics focusing on the movement and management of products and resources after the sale and after delivery to the customer".

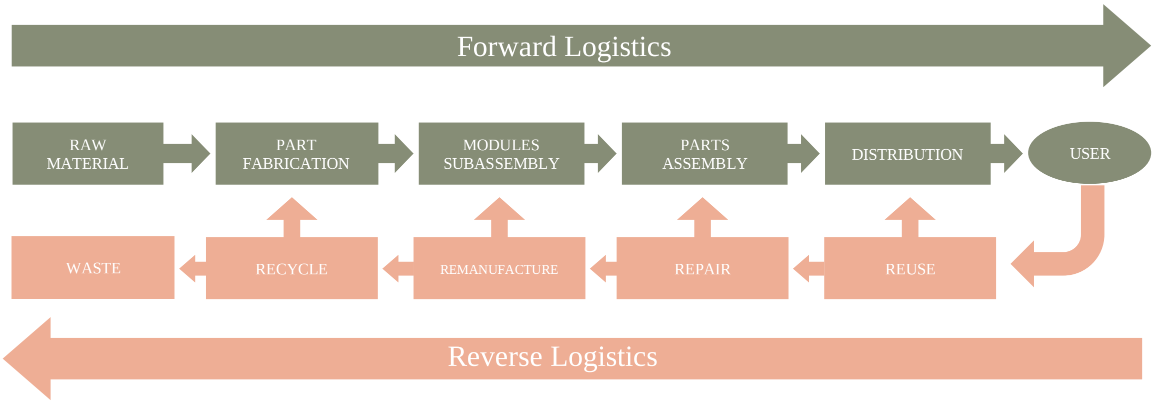


Figure 3: Forward and Reverse Logistic process

Coming to the possible stages of the reverse logistics flow presented in Figure 3 according to Chiranjib & Walid (2018) they are:

- Reuse: when the product is simply put back in the inventories and is ready to be distributed again;
- Repair: when the product can acquire again its original properties with some maintenance operations;
- Remanufacture: when the product needs to go back again into some production activities;
- Recycle: when the parts and the materials of the products are reused for other parts fabrication;
- Scrap: when none of the previously mentioned activities can be done.

These activities, from reuse to recycle as listed above, imply incremental time and costs to be performed.

In the light of this dissertation, which revolves around e-commerce field, forward logistics includes all those operations necessary to deliver purchased goods to customers, so the transportation of raw materials and subassembly is disregarded. Forward logistics also includes the management of last-mile delivery, the very last step in delivering goods to final customers. Then, returns reverse logistics in e-commerce, main investigation topic of this master thesis, is when a customer returns an unsatisfying product back to the supplier/seller. Returns management (reverse logistics) for e-commerce is based on the existence of precise return policies (Paragraph 1.4), specific return processes (Paragraph 1.3), several return methodologies (Paragraph 1.6) and is characterized by different product return rates according to the typology of goods (Paragraph 1.5). It should be noted that returning items is possible for offline purchases too: in particular customers have this chance only if the original conditions are guaranteed and together with the sales receipt. Clients can either change the returned product with a different version, like a smaller or bigger size or a different color or else receive a credit coupon back. As soon as e-commerce was born, online sellers felt the surge to offer this service to customers not to be less attractive than traditional retailers.

After this introduction on reverse logistics in e-commerce, it is worth understanding the reasons behind returns. To investigate them, several researches were conducted, among the others, it should be pointed out the analysis of Zhenleong & Zaiqiu (2010) which classifies the reasons in:

- *Customer's subjective judgment:* like for example no reasons rejections, ignorance or intentional over-purchasing;
- *Product's fault:* like inferior quality, incompatible matching, unsuitable size, damaged product, lack of components, product differences from advertisement;
- *Logistic Distribution issues:* like products damaged during loading/unloading or transportation, delayed deliveries, wrong delivery because of distribution errors.

Now, to understand the relevance of reverse logistics flow for e-commerce, product returns rate will be defined, and related key figures will be shown.

Product return rates is the percentage of products returned over the total products ordered. It can be computed both for online and offline shopping: a big difference can be noticed between these two different scenarios. In particular, this indicator accounts for the 30% in case of products ordered online while only for the 9% regarding brick-and-mortar store purchases according to Saleh (s.d.), therefore having strong logistics capabilities becomes fundamental and strategical in running e-commerce activities and in having a high service level towards customers. Focusing on the Italian scenario, product return rates in e-commerce accounts for 5% for general goods, 15% for electronics and over 40% for fashion, as presented by Kulach (2018)[3].

Furthermore, this phenomenon is growing over time in a relevant way and consequently also the costs related to the management of return logistics. As a matter of fact, Orendorff (2019) wrote "In the U.S. alone, Statista estimates return deliveries will cost $550 billion by 2020, 75.2% *more* than four years prior.".

Because of the incidence of the figures provided, returns management, synonym with reverse logistics in this dissertation, is no longer to be considered as an afterthought. It is no more an additional service offered by retailers, but it has to be tackled as the "New Normal", being a strategic aspect to be managed efficiently with a twofold implication concerning customer satisfaction and overall company's profitability. Therefore, this thesis will aim at investigating the field of reverse logistics in ecommerce B2c providing the reader with structured knowledge about return methodologies and processes.

[3] https://www.webinterpret.com/au/blog/ecommerce-italy-definitive-guide/#:~:text=In%20terms%20of%20return%20rates,to%20offer%20easy%20returns%20solutions

1.3 The process of returns reverse logistics

This paragraph aims at explaining how making a return works for physical products bought online, describing the return process step by step.

The starting point for the process is the decision of sending back the item to the seller/supplier/e-tailer (e-tailers stands for retailers using internet to sell their products). The customer could face two different scenarios. The first scenario is having already received the return label with the item: in this case he/she will fill all the fields required, and this means providing information about order ID and date of the order, item code for the returned products and reason behind the return. In case the label is not provided yet, second scenario, the client has to follow online instructions on the e-commerce website and print himself the return label.

Then, he/she will either take the product to a predetermined location, like a collection delivery point (postal office, UPS Access Point™, parcel lockers…), call a courier to schedule the home pick-up or else take the item to a retailer physical shop, if any. After these steps, except for the in-store return, in order to take items from houses or CDPs to retailer hubs, the intervention of a third party, logistic service providers, is needed. They are business entities managing transportation of goods and warehouse operations, that organize delivery/pick-up tours relying on optimization algorithms. These algorithms allow to have an efficient exploitation of resources in terms of time saturation in the courier work shift and in terms of volume of the van, ensuring the minimization of distances travelled within a delivery/pick-up tour. Logistic service providers can be in charge not only of the transportation but also of quality checking activities, the following step a returned product has to go through. This phase consists in a careful screening of the products to check for its compliance.

If the outcome of the quality check is positive, the item is sent back to inventories in order to be sold again and the client will be refunded, otherwise, if the outcome is negative, recycle or disposal activities will take place. In this second alternative, the customer receives either a partial, or a zero-value refund or the item is sent back at client's expenses.

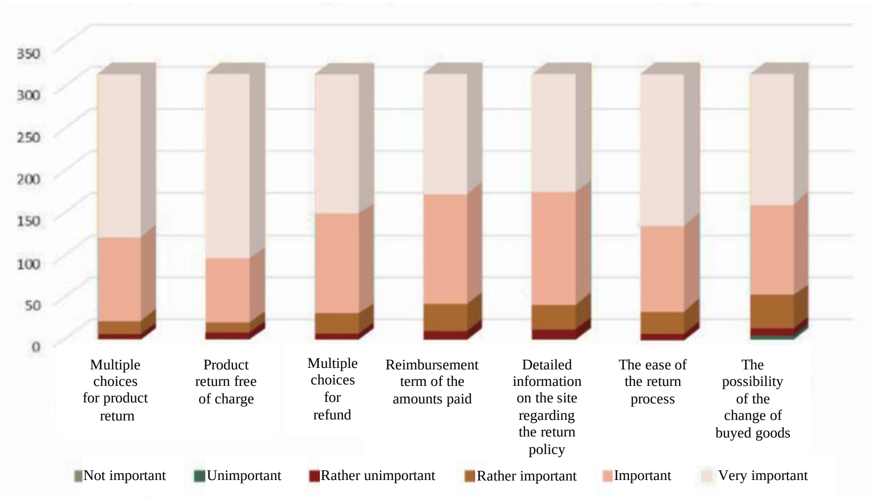
1.4 Return policies

Return policies are defined as all the rules that characterize a return process; in particular following the approach of Albastroiu et al. (2016) the key aspects related to return policies are:

- Multiple choices for product return (i.e. home pick-up, parcel locker…);
- Product return fee;
- Multiple choices for refund (i.e. cash back, credit coupon, voucher…);
- Reimbursement term of the amounts paid (i.e. refund back on the bank account within 5 days…);
- The possibility of changing purchased goods (instead of receiving the refund).

Returns management and related policies have been existing since offline commerce started. Indeed, brick-and-mortar stores had to offer this service to customers in compliance with regulations. To keep up with traditional retailing, e-tailers were forced to offer the same service. In online shopping, however, considering the inability of customer to touch and feel the physical product, the sellers may use policy in order to protect consumers against the risk of product misfit: as a consequence, policies strongly affect customer purchase behaviors. In addition, it was noticed over the years that return policies are a fundamental driver that affect customer's choice of buying online.

In particular, having convenient return policy (i.e. many return possibilities available, free return and at least 15 days available to make the return request) became a competitive lever for online businesses. As a matter of fact, a survey presented in a conference paper in 2016 entitled "Approaches regarding the return policy of online retailers", from Albastroiu et al. (2016), investigated several clients' attitudes regarding different aspects of the policy. The output of the survey relates to the assessment of the main drivers that are considered important in evaluating a return policy, as presented in Graph 7:

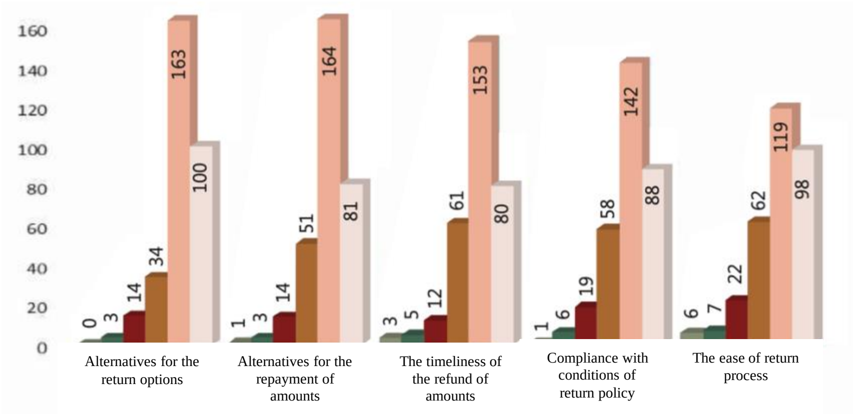


Graph 7: Importance of returning policy of e-commerce shops in buying process

Source: Albastroiu et al. (2016)

Among the most relevant aspects there are product return free of charge, multiple choices for product return and ease of the return process.

The second finding shows the interplay between the level of satisfaction perceived by consumers and return policy features, as presented in Graph 8: the most influencing ones are the number of alternatives available for returning the item and for receiving the repayments and the timeliness of the refund.



Graph 8: Satisfaction degree regarding return policy

Source: Albastroiu et al. (2016)

In addition, an e-commerce study carried out in 2018 by Dotcom Distribution demonstrated that 90% of customers highly value free returns when making online purchases and 62% of customers would buy again from a brand offering free returns/exchanges (MH&L, 2018). This implies that the right policy in return management can increase sales volumes since it is directly linked to the satisfaction felt by the customer when purchasing online.

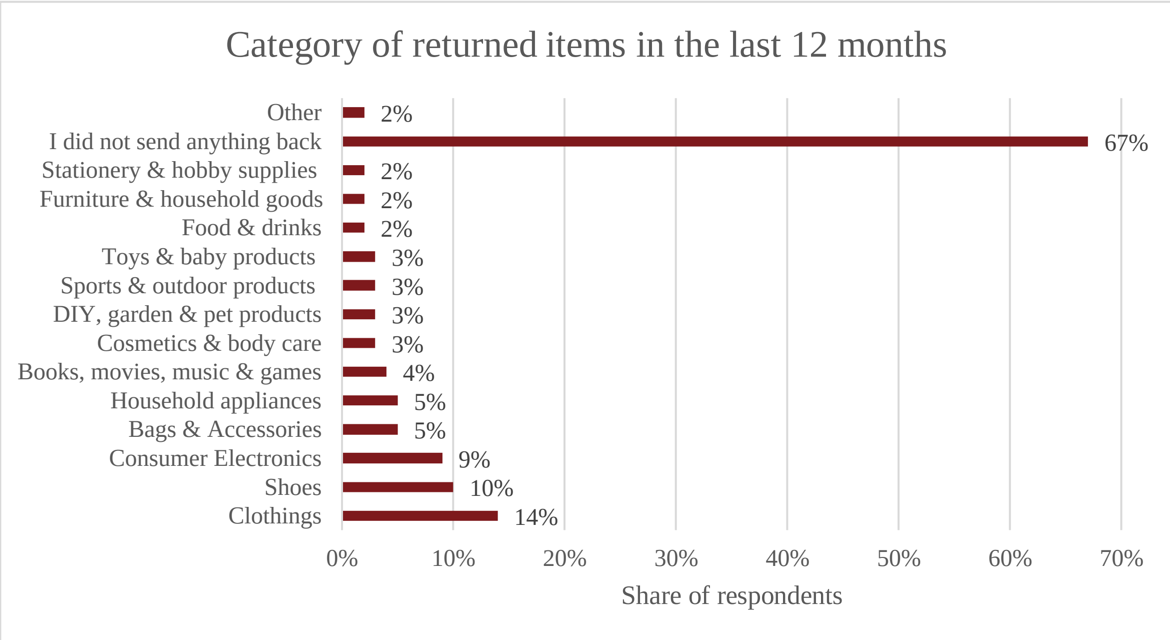
Unfortunately, adopting the seller point of view, not only benefits are coming from lenient return policies. It is true that they increase the conversion rate and will likely push sales, but also generate extra costs. Consider a customer willing to buy a dress on the official website of the brand and consider he/she is not sure about the right size that best suits him/her. Reading the return policy, the customer realizes that he/she can benefit from free return, therefore he/she will order different sizes of the same dress with the aim of finding the right one. The remaining ones will be sent back to the seller free of charge. Despite being very convenient for the buyer, this will lead to an increase in costs for the seller who will have to handle all these returns shipped back to its warehouses.

Aiming at preventing returns, e-tailers are also investing consistently in innovative solutions. The first enabling strategy to reach this goal was to provide better description of products together with advanced feedback systems. When analyzing a product, customers can rely on the feedbacks released by people that already experimented that specific product. In the past, these feedbacks encompassed only written description, then it was given the possibility of enriching these pieces of information with media files, like photo or video, in order to show how the product performs in reality, validating the image of the item that the seller wants to spread. More in detail, in several fashion websites, these media are further enriched with precise information about the body shape of the people wearing these fashion items. This typology of contents allows a soon-to-be buyer understanding which the real fitting of the product guiding him/her in purchasing the right size and thus diminishing the possibility

of returning items. Of course, nothing comes for free: these feedbacks provided by customers are, in some situations, “paid back” by retailers with fidelity points or other kind of benefits.
In addition to feedback systems, advanced and innovative technologies are being exploited by sellers. This is the case of AI/VR/AR, Artificial Intelligence/Virtual Reality/Augmented Reality. AI is the ability to acquire and apply knowledge and skills as exhibited by machines or software, VR means a computer-generated simulation of a three-dimensional image or environment which people can interact with by using special electronic equipment and, at last, AR is when the interactive experience of a real-world environment is enhanced by computer-generated perceptual information. These technologies make the online shopping experience the most similar to the offline one, in a way to overcome barriers represented by the absence of physical interaction with products. For instance, some retailers are developing tools to simulate the strategic fit of a specific fashion item according to the personal feature of a client, also proposing possible matches with other products. To provide the reader with a real application of these technologies the case of Nike will be presented as highlighted by Alvarez (2019). Nike developed an app called Nike Fit that, exploiting augmented reality (AR), is able to individualize the right size for the specific shoes the client wants to buy, considering possible differences in terms of shoes that run slightly small and vice versa, only by framing customers feet; this technology clearly increases the right fitting of purchased shoes and can reduce the number of returned products.
Nevertheless, it should be noted the risk linked to e-commerce returns: opportunistic behaviors of clients who exploit lenient return policies. It may happen that clients order goods just to show off and then return them back to the retailer (i.e., consider a customer who buys a camera just before a trip and right after the event he/she performs a return request). In the long run, this specific kind of behavior can be unsustainable for sellers, which started to introduce countermeasures, as the example of Amazon shows. Amazon in the last years, according to Formica (2018), decided to close those accounts whose return activities will result unusual or not properly justified.

1.5 Which typology of goods are mostly returned?

As already presented before, e-commerce is today well spread in all markets and whatever kind of product or service can be sold and purchased online. So, also product returns are spread across all the possible categories with product return rate which varies according to the industry. This diversity is justified by the different features and the expectations related to products, as an example there are more uncertainties in the purchase of a dress compared to the ones related to a food product. When considering returns for non-physical products it has to be noted that there will not be any physical reverse logistic activity: it will consist only in online information exchange and financial transactions for the refunds. This typology of returns is outside the research boundaries of this master thesis. Focusing on physical product returns, investigation topic of this dissertation, Alexander Kunst (2020) conducted a survey to investigate the typology of returns of online purchases by category in Italy. The survey addressed 2099 respondents between 18 and 64 years with this question "Which of these kinds of articles have you sent back after an online order in the past 12 months?". The outcome of the research, available in Graph 9, shows that the mostly returned items belong to clothing category, shoes category and to consumer electronics.



Graph 9: Category of returned items in the last 12 months.

Interviews conducted from 8 Aug to 29 Aug 2019 and from 20 Feb to 31 Mar 2020

Source: Kunst (2020)

1.6 Different ways to return products

As anticipated in the previous paragraph, giving customers several different possibilities to make returns is a competitive advantage directly affecting in a positive way customer satisfaction, and therefore increasing online purchases rate. This paragraph aims at deepening all the existing possibilities to return an item to the retailer, giving the points of view both of the clients and of the 3PL, Third-party logistics, which are businesses managing transportation, distribution, warehousing and fulfillment services.

- *Traditional home pick-up:* the customer calls the courier to schedule the pick-up. This typology is considered traditional since when return management was born it was the only available alternative. Considering this process from the 3PL side, it works similarly to home delivery, with the only difference that the box is not dropped-off but picked-up. Since volumes and flows for returns are not that high to justify dedicated tours, the transportation of returns is managed together with deliveries in the same tour. The mean of transport used is usually a van and therefore the environmental sustainability of the solution is linked to the emissions of the truck employed: in home pick-up/delivery tours there are many customers to be visited so the emissions due to the van travel are quite significant. From a customer's point of view, the effort is to be at home in the predetermined time window in order to deliver the box to the courier, while the constraints are represented by the working hours and the availability of the courier. Gradually, with the development of innovative technologies, new scenarios came available, starting from the highly populated areas with advanced infrastructural services.

- *Collection & delivery points (CDP):* logistics service providers put at customer disposition collection & delivery points. These hubs, that are mainly located in strategical corners easy to be reached by people and that work as intermediary consolidation points for the deliveries and returns flows, can be classified in attended or unattended:
  - *Attended CDP:* attended means that the collection & delivery point is managed by humans, typically it is either directly owned by the 3PL (couriers hub, postal offices…) or it is a commercial activity that signed agreements with 3PL to run this service (i.e. commercial activities like bars, newsagent and supermarkets that serve as UPS Access Point™). Concerning non-professional CDPs like bars and supermarkets, becoming a CDP could be an attractive lever to increase the number of visiting people that can be converted in new customers. In the eyes of the 3PL the use of attended CDP consistently increases the saturation of the courier tour, since the travel distance, if this scenario is compared with home delivery/pick-up, is significantly lower and the carbon emissions too. The increase in saturation of tours and the optimization of the travel distance of the 3PL are at the expenses of the customers, who have to take the boxes to these CDPs. But the customers are willing to make this effort for the advantages coming from this solution, like the possibility of managing these delivery/pick-up operations in the most suitable moment for them and the possibility of integrating the stop to the CDP with their habitual trips.
  - *Unattended CDP:* unattended stands for a hub not controlled by anyone in person as for the case of parcel lockers. Thanks to the diffusion of automated systems, smart lockers (= parcel lockers) started being available in strategical locations like universities, petrol, railway or subway stations. The implications for the 3PL are the same as the ones of attended CDP, concerning increase in saturation and optimization of travel distance. 3PL can also benefit from the automation itself that prevents the operators to deal with congestions in the activities of delivery/pick-up. Alongside with the benefits coming from the use of CDPs, automatic operations resulting in less congestions can benefit final clients too. Moreover, it is worth

noticing one additional positive factor: parcel lockers do not have any constraints in terms of opening hours since they are available 24/7. However, all the players using this methodology should respect some limitations in terms of weights and dimensions of boxes and the constraint of compartments availability.

Eventually, the use of CDP as above described represents a "win-win" solution for both 3PL and buyers. For all the types of CDPs, it is important to bear in mind that customers, compared to home delivery/pick-up, have an active role in terms of transportation and therefore the overall footprints linked to these methodologies are related to their choice of the mean of transport, that could be their own car, a public bus or else on foot.

- *In store return (Buy Online Return Physical - BORP):* nowadays it is a standard practice for major retailers (i.e. Decathlon, Mediaworld, Ikea) owning physical stores to give their customers the chance to buy online and pick-up the product in the shop. Such a paradigm applies in case of returns too: items purchased via online channel can be brought back to one of retailers' physical shop. In several cases, shops could manage on their own the returned products which has not to be shipped back to the central warehouse of the firm. In this way, sellers' physical shops act as a sort of collection delivery points enabling a cross-channel alternative. This solution is working well for the retailer since it will have clients back to its own shop, which could be pushed to buy directly the right version of the product instead of spending the refund in a different way. The implications for the 3PL are exactly the same as for the attended CDP concerning saturation and optimization of travel distance and emissions as well as constraints related to shops opening hours. The customer using this return typology will be free from waiting at home for the scheduled pick-up and, also, he/she will be given the possibility of finding the right version of the item in the same moment. Even with BORP methodology the customer is required to make the effort of reaching the shop, however it must be noted that sometimes it is not feasible because there are not sellers' shop in the nearby, so customer will likely switch to other return possibilities. Like it was for the CDP, the role of customers choosing in-store return becomes active in terms of transportation and affects the overall footprints generated.

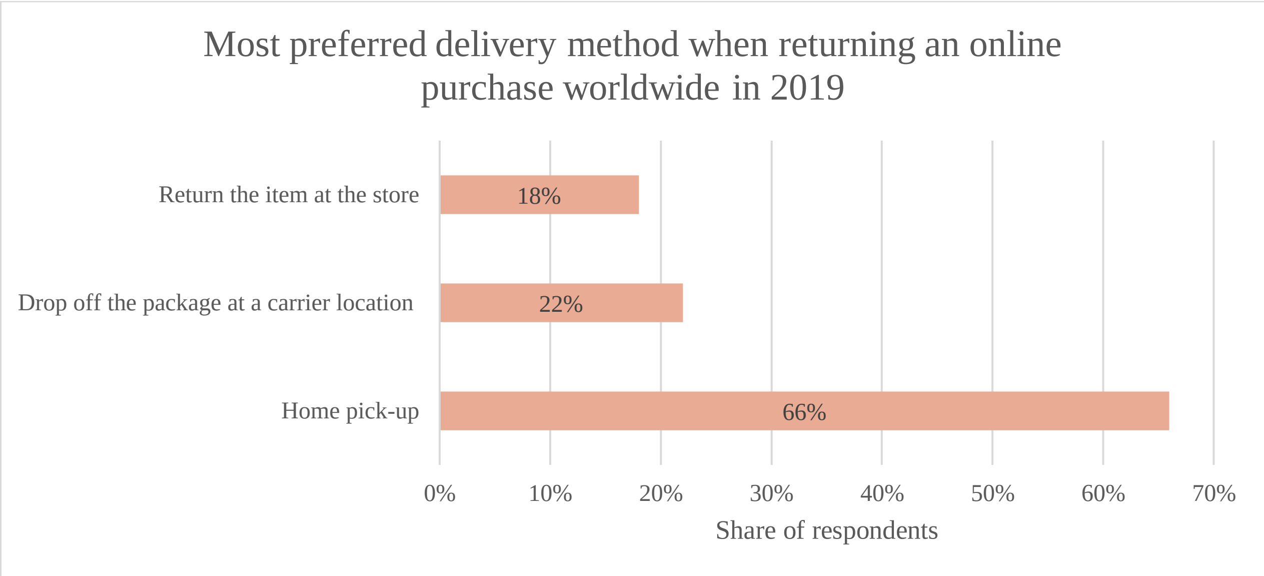
In Table 1 a qualitative evaluation of all the possible drivers that characterize the different return methodologies previously described is provided. Indeed, when making comparisons between these multiple return options, it is not only about taking into consideration those activities whose costs can be precisely assessed, like fuel consumption, courier salary or handling activities: differences and comparisons should be made by looking at more qualitative factors that can determine "hassle costs" both for customers and for 3PLs. These hassle costs are represented by efforts beared by actors (customers or 3PLs), related to some apparently for free activities considering one actor's point of view, that instead hide relevant efforts faced by the counterpart. The effort is represented by opportunity costs (i.e. consider a person who has to wait for the courier at home and cannot go to work and earn money), that can be linked to time consuming activities, negligible in the short term, which can become consistent in the long term (i.e. consider a person who has to queue 10 minutes at the postal office for a return, then, how much time he/she will spend waiting for returning products in the whole year? And which is the opportunity cost related to this activity?). In the rows of Table 4 the reader is provided with all those activities considered relevant to evaluate return methodology features, not only the ones that are tangible and intuitive (in green) but also more theoretical and not visible ones (in pink). For each return methodology, drivers are also assessed considering the two different points of view: 3PL and client.

	Traditional Home Pick-up		CDP attended		CDP unattended		In store return	
	3PL	Client	3PL	Client	3PL	Client	3PL	Client
Issuing the request	+	+		+		+		+
Printing the label (optional)		+		+		+		+
Preparing the box		+		+		+		
Waiting the courier		+						
Time spent queueing for the service			+ +	+ +	+	+	+ +	+ +
Travel (fuel and emissions)	+ +		+	+	+	+	+	+
Traffic congestion	++		+	+	+	+	+	+
Operations	++	+ +	++	+ +	+	+	++	+ +
Opening hour / Time window constraint	+	++	+	+			+	+
Volume/Weight constraint			+	+	++	++		
Availability of space constraint			+	+	++	++		
Failed pick-up	+	+						
Consolidation of flows			+		+		+	

Table 4: Qualitative analysis of different drivers according to the return method
(Based on authors' elaboration)

The choice of the return methodology from a customer perspective is either forced by the available options (i.e. set of agreements between merchants and logistic service providers), or by the location of physical store in case of in store return (i.e. somewhere there may not be retailers' shops nearby to perform in store return). If more return methodologies are feasible, the choice is the result of trade-off analysis just presented.

To understand which return method was more commonly chosen by customers, in September 2019 Bowes (2019) conducted a worldwide survey. In particular, 8031 online shoppers 18+ years old from six countries were surveyed. The output of the responses received is shown in Graph 10:



Graph 10: Most preferred delivery method when returning an online purchase worldwide in 2019. Source: Bowes (2019)

As presented in Graph 10, traditional home pick-up was the chosen return method by the 66% of the addressed shoppers, the 22% of them preferred the drop off at a carrier location and last, the 18% preferred the return at the shop.

Looking at the latest disruptive scenarios, not yet implemented in the field of reverse logistics but only in last mile delivery, there are other delivery methodologies and even other transportation modes, in the footsteps of the literature review presented by Mangiaracina et al. (2019).

As for the transportation modes, there are:

- *Drones:* they will become a future fully autonomous delivery system able to deliver packages to customers in less than 30 minutes from the purchase, with a safe and efficient transportation system (Amazon)[4]. Limitations of this transportation mode are in the dimensions and in the weights of goods;
- *Bikes:* they ensure a totally green and agile-in-traffic transportation service, but they are characterized by limitations in dimensions and weights of items handled;
- *Subway:* this mean of transport is fast and agile, not subjected to traffic congestions, especially advantageous in peak times for urban centers.

[4] https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011

Then, for the delivery methodologies there are also:

- *Smart Keys:* automated door key have been developed in the last years. This technology allows to lock and unlock the house door by using a code. This code, which has temporary duration, is communicated to the courier who will be able to open the door and store safely the box inside the customer house. Using smart keys eliminates fail deliveries and makes customers free of being at home during deliveries. This solution was discussed in terms of safety and privacy but the possibility of knowing the exact moment of delivery and the one-time-use digital key associated to the specific order mitigated these issues, alongside with video cameras to verify the right behavior of the courier when entering the house.
- *Trunks Delivery:* connected car can enable automatic lockers allowing courier to deliver packages in the trunk of consumers' personal car. This technology is quite expensive and works similarly to the smart key.
- *Reception Boxes:* personal mail boxes characterized by bigger dimensions, enabling so the reception of boxes. The courier could behave like for home delivery visiting several customer houses. The pros of this solution are that failed deliveries are totally eliminated and waiting time for the proof of delivery is null, moreover, the customer will be free from the constraint of being at home in the time of the delivery. Despite being not spread in Italy, this methodology finds large application in countries like New Zealand and Australia.

In addition, it is worth adding a solution that combines different transportation modes and represents an innovative delivery methodology:

- *Crowdsourcing*: it is spreading as a new solution for handling boxes. It relies on a business model that allows potentially everybody to become a flexible third-party non-professional carrier, in exchange of little revenues. The choice of the mean of transport is entrusted to the carrier and may include the use of personal car, bikes, public transport (i.e. subway) or else on foot.

Until today, these initiatives are confined only to last-mile delivery but could be integrated also in reverse logistics in the near future.

2. LITERATURE REVIEW

2.1 Introduction to literature review

To introduce this chapter, it is worth underlining what reverse logistics in e-commerce stands for. According to the definition given by the American Reverse Logistics Executive Committee, the term "reverse logistics" in e-commerce refers to "retrieving the value of the product or making it handled properly and the process of moving the product from the consumer to the source" (Li and Li, 2015). In internet retailing, a synonymous with e-commerce, then, five categories of returns can be found, namely consumer, marketing, asset, product and environmental returns, amongst which the first one stands out. Consumer returns relate to defects which may occur at product and/or delivery service level, buyers' remorse or customer dissatisfaction (Hjort et al., 2019).
In line with the abovementioned definition and classification, this literature review will revolve around reverse logistics in B2c e-commerce from a consumer return perspective.

To fathom the growing importance of Reverse logistics in B2c e-commerce, the following circumstances should be considered:

- *Online sales growth rate is unstoppable*: a higher percentage of sales via e-commerce results in a higher number of goods to be returned, other else being equal, and so the necessity of proper reverse logistics management models. E-commerce penetration is likely to increase in the short-term due to COVID-19 pandemic. (Mohsin, 2020).
- *Product returns are unavoidable*: handling customers' returns is an essential component of running an e-commerce store, indeed, as the internet lacks the physical interaction vital for assessing items, consumer returns will be always a part of e-commerce (Hjort et al., 2019). Online retailers should ensure not only the needs of the customers providing a seamless user experience, but also the needs of the company itself, knowing that product returns have an impact on the bottom-line (Robinson, 2014).
- *Lenient return policies:* e-merchants are trying to boost sales by allowing customers to return products free of charge, not only in case of malfunctioning or defects but also in case of wrong purchasing decisions. This paradigm on one hand is needed to keep up with traditional brick and mortar stores and increase sales, but on the other hand may increase returns volume (Robinson, 2014).
- *Operational and environmental cost considerations:* different ways to return products imply different monetary and environmental costs due to the different degree of involvement of the actors in the reverse logistics chain and the various configurations available. Finding the least

expensive and the most sustainable method to handle returns is therefore fundamental to streamline the logistic process and reduce its environmental impact. (Mohsin, 2020).

The importance of reverse logistics is well captured by Wang and Li (2014) who claim the following: "Reverse logistics for e-commerce is just like water for fish. It may be assumed that e-commerce cannot develop without the development of reverse logistics", and again, "the proper management of reverse logistics is an effective way to reduce operating costs, improve customer satisfaction and enhance the core competitiveness for the enterprises adopting the B2c e-commerce business model.". Therefore, a proper management of returns has to be considered a must-have, rather than a nice-to-have, due to its direct impact on people (customer value), planet (environmental consequences) and profit (i.e manufacturers, merchants and logistics service providers), the so-called triple bottom line.

In order to narrow the topic of reverse logistics in B2c e-commerce down, this dissertation places greater emphasis on the different options final clients have to return unwanted products back to the point of origin, considering all the players involved in the reverse chain as online retailers/manufacturers, logistics service providers and final consumers. Differences, pros, cons and flaws of the different options will be investigated to assess whether, why and how these vary. In such a fast-growing industry where e-commerce is, then, the innovativeness of the solutions adopted by the different stakeholders in dealing with the returns management cannot be disregarded, thus it will be used to further enrich the analysis. A strong focus is also placed on existing models which aim at quantifying the operations and logistics costs involved in returns management, indeed efficiency and effectiveness in the procedures may differ across returns options, industries and locations. For sure, the counterpart of the reverse process, namely forward logistics/last mile delivery, has to be considered as well, to assess whether and to what extent the two parts differ, being the two strictly related to B2c internet retailing as a whole.

2.2 Body

The following sections have been structured to study and systematize what researchers and scholars have already investigated about "reverse logistics in B2c e-commerce": this part is deemed fundamental to get a complete and certified overview of the topic under examination, discover gaps and develop research questions accordingly. To sum up, this chapter can be considered as the very backbone of this master thesis: the first step to get a better understanding of reverse logistics procedures and processes in B2c e-commerce.

2.2.1 Methodology

The literature review has been carried out on Scopus and Web of Science. The process which guided this literature review was to start working on Scopus searching for peer-reviewed papers and/or proceedings on the reverse logistics in B2c in e-commerce and then repeating the same procedure on Web of science, evaluating any differences in the final research output if any.
In order to carry out the searching process, a set of relevant keywords has been used: these latter have been combined together to find a match among the documents stored into Scopus (or Web of Science) database. Article title, abstract and documents keywords were the parts of the documents where the search engine looked for matches.
The keywords have been merged together by using Boolean operators (AND, OR); in addition, "*" symbol has been used to account for partial matching (e.g. if you type logistic*, the search engine finds matches that include "logistic" at the beginning of a word, so for instance "logistic", "logistics", "logistician", "logistical").

In the first step of the searching process, three different families of keywords have been plugged into Scopus search engine. These latter were the key elements of the topic under investigation, namely E-commerce B2c, reverse logistics, innovation.
In particular the clusters of keywords used have been:

- *E-retailers, ecommerce B2c, e-commerce B2c, online, e-tailers, e-business* to account for the "E-commerce B2c" dimension of the topic;
- *Reverse logistic*, reverse flow, returns management, return good*, product return** to account for the reverse side in e-commerce B2c;
- *Innovat*, new* to point out the innovation that lays in the different ways to return products.

The final form of the string used is the following one:
("e-retailers" OR "ecommerce B2c" OR "e-commerce B2c" OR "online" OR "e-tailers" OR "e-business") AND ("reverse logistic" OR "reverse flow" OR "returns management" OR "return good*" OR "product return*") AND ("innovat*" OR "new")*

The resulting number of papers totalled 64 units: among them, the ones related to different subject areas (2) have been taken out of this analysis. Then, an analysis based on the abstract has been performed: papers dealing with different disciplines (i.e. waste management, closed loop supply chain) have been excluded leading to 19 articles left. At the end, a content-level analysis has been used in order to select the papers in line with the scope of this dissertation. In this last step, the articles which did not highlight the logistics procedures of reverse logistics in e-commerce B2c have been ruled out: the sources left accounted for 4 papers. The low number of papers left was not sufficient to provide an exhaustive and complete backbone to rely on for this literature review, therefore research criteria have been changed.

In the second step of the searching process a reverse engineering approach has been used, indeed, the keywords which explicitly pointed out the different ways to return products have been combined with searching terms referring to the reverse logistic. For what concerns the different ways to return items, the classification provided by Mangiaracina and colleagues (2019) comes handy: the paper points out the innovative solutions to increase the efficiency of last mile delivery, namely reception boxes, parcel lockers, pick-up points, crowdsourcing logistics, drones, trunks, underground delivery and robots. Although Mangiaracina et al. (2019) refer to last mile delivery in their literature review, the abovementioned solutions, even not always implemented on a large scale, could be used in dealing with the reverse flow of e-commerce, being this latter similar to last-mile delivery from a pure operational perspective (basically instead of moving an item from A to B, the good has to be sent from B to A). In addition to these categories, the following terms have been included in the second research string: postal box, subway and metro, collection point as synonymous respectively with reception box, underground delivery and pick-up point, plus bike to point out the usual mean of transportation in crowdsourcing logistics and smart key, the trunk version of returns/deliveries applied to clients' houses.

The keywords used divided in clusters have been:

- *Reverse logistic*, reverse flow, returns management, return good*, product return** to look for the reverse logistics procedures;
- *Reception box*, parcel lockers, pick-up points, crowd*, drones, trunk, underground delivery, robots, postal box, subway, metro, collection points, bike, smart key,* the existing modes to handle deliveries in B2c e-commerce.

The final form of the string used is the following:

(("reverse logistic" OR "reverse flow" OR "returns management" OR "return good*" OR "product return*") AND ("reception box*" OR "parcel lockers" OR "pick-up points" OR "crowd*" OR "drones" OR "trunk" OR "underground" OR "robots" OR "postal box" OR "subway" OR "metro" OR "collection points" OR "bike" OR "smart key"))*

The output of the above mentioned second step accounted for 78 articles. As before, a first filter has been applied at a subject area level, leading to 49 sources left; studying the abstract then, just 9 articles proved to fulfil the requirements of this dissertation. At the end, the body of the remaining sources have been scanned looking for sources which could match the scope of the literature review: 2 sources, already selected in the first step of the searching process, has been kept.
The low number of papers dissatisfying the needs of completeness and precision of this work led to the third step of the procedure.

In the third step, the boundaries of the analysis have been broadened by including the traditional way to return products in B2c e-commerce as intended in this thesis, namely the home pick-up methodology. To fulfil this objective, two families of keywords have been plugged into the search engine:

- *E-retailers, ecommerce B2c, e-commerce B2c, online, e-tailers, e-business* to look for the "E-commerce B2c" part of the topic;
- *Reverse logistic**, *reverse flow, returns management, return good**, *product return** to consider the reverse logistics procedures in the e-commerce B2c.

The final form of the string employed is:
("e-retailers" OR "ecommerce B2c" OR "e-commerce B2c" OR "online" OR "e-tailers" OR "e-business") AND ("reverse logistic" OR "reverse flow" OR "returns management" OR "return good*" OR "product return*")*

In this third step, a higher number of papers has been found: 255. The filter based on subject area has then been applied, leading to 240 articles left, alongside with the scanning procedure based on the abstract. The resulting 88 papers have then been carefully read and analysed looking for the ones in line with the scope and boundaries of this dissertation, so a detailed analysis on the different procedures to return products in B2c e-commerce, excluding the topic of closed loop supply chain, B2B (business-to-business) market, waste management and return policies. Following this method, 35 papers have been kept: this number was considered thorough to study and systematize the topic under investigation. It should be noted that in this three-steps searching process, the authors have been forced to reconsider the terms referring to the innovativeness in B2c return methodologies by including the traditional way to handle returns, namely traditional home collection/pick-up, otherwise it would have not been possible to start any kind of fruitful analysis given the insufficient number of papers.

The same three-steps process has been carried out on Web of Science database; however, no additional pieces of literature have been found.
This research was performed in March-April 2020, therefore it reflects the state-of-art of reverse logistics in B2c e-commerce from a consumer perspective at that point in time.

2.3 Paper classification

Following the approach by Perego Alessandro and colleagues (2011), papers have been classified according to standard information namely title, authors, source, year (referring to the year of online publication), country (country of the main author which refers to the country where the scholar's university is placed), industry (sector addressed in the paper if any) and research method used. The output of the research is shown in Table 5:

Number	Title	Authors	Source	Year	Country	Industry	Research Method
1	Using taxis to collect citywide E-commerce reverse flows: a crowdsourcing solution	Chao Chen, Shenle Pan, Zhu Wang, Ray Y. Zhong	International Journal of Production Research	2016	China	not specified	mathematical model + simulation
2	Omnichannel retailers' return policy strategies in the presence of competition	Jin D., Caliskan-Demirag O., Chen F.Y., Huang M.	International Journal of Production Economics	2019	China	not specified	mathematical model
3	An exploratory study on the returns management process in an online retailer	de Araújo A.C., Matsuoka E.M., Ung J.E., Massote A., Sampaio M.	International Journal of Logistics Research and Applications	2017	Brazil	IT	case study
4	Reverse logistics challenges in e-commerce	Biswas C., Abdul-Kader W.	Proceedings of the International Conference on Industrial Engineering and Operations Management	2018	Canada	not specified	literature review
5	An Effective Strategy for Non-defective Reverse Logistics	Chang Q.-Q., Zheng H.-Z.	Proceedings of the International Conference on Information and Automation	2014	China	fashion + easily to be checked goods	mathematical model + simulation
6	A preliminary analysis of reverse logistics in B2C	Tang Z., Gu Z.	International Conference on Information Management, Innovation Management and Industrial Engineering	2010	China	not specified	survey + case study
7	Reverse logistics under E-commerce environment	Liu H.	International Conference on E-Product E-Service and E-Entertainment	2010	China	not specified	other
8	Managing internet product returns: A focus on effective service operations	Diane A. Mollenkopf, Elliot Rabinovich, Timothy M. Laseter, Kenneth K. Boyer	Decision sciences: A journal of the decision sciences institute	2007	USA	not specified	mathematical model

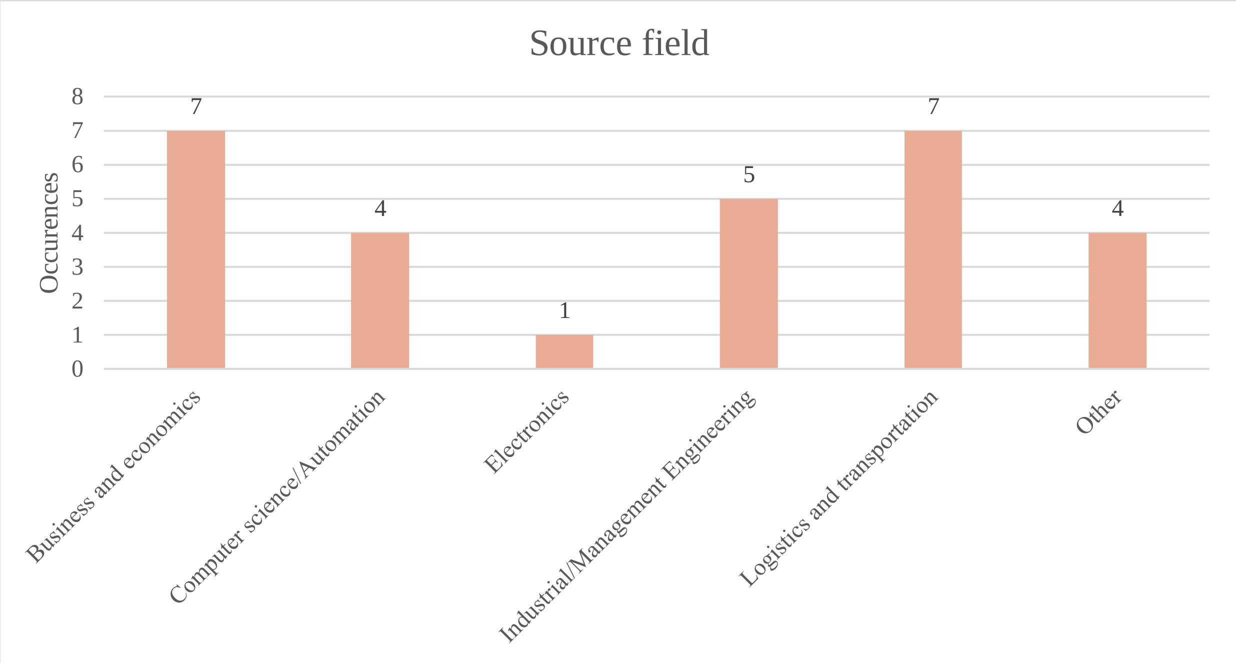
9	A study on returns logistics operating mode in E-business environment	Changli F., Lili X.	International Conference on Service Operations and Logistics, and Informatics	2006	China	not specified	literature review + case study
10	Returns Reverse Logistics Management Strategy in E-commerce B2C Market	Wang Qingjun; Li Yaofei	International Conference on Mechatronics, Control and Electronic Engineering	2014	China	not specified	other
11	Approaches regarding the return policy of online retailers	Vasiliu, Cristinel; Albastroiu, Irina; Dina, Razvan; Dina, Ioana	International Conference - New Trends in Sustainable Business and Consumption	2016	Romania	not specified	survey
12	Forward and reverse logistics network and route planning under the environment of low-carbon emissions: A case study of Shanghai fresh food E-commerce enterprises	Guo, Jianquan; Wang, Xinyue; Fan, Siyuan; Gen, Mitsuo	Computers & Industrial Engineering	2017	China	fresh food	mathematical model + simulation
13	Omnichannel retail operations with consumer returns and order cancellation	Zhang, Juzhi; Xu, Qingyun; He, Yi	Transportation Research Part E: Logistics and Transportation Review	2018	China	not specified	mathematical model
14	Return Strategies and Online Product Customization in a Dual-Channel Supply Chain	Zhang, Rong; Li, Jiatong; Huang, Zongsheng; Liu, Bin	Sustainability	2019	China	not specified	mathematical model
15	Investigating the influential factors of return channel loyalty in omni-channel retailing	Xu, Xun; Jackson, Jonathan E.	International Journal of Production Economics	2019	USA	not specified	survey
16	Reverse supply chain issues in Indian electronics industry: a case study	Agrawal S. Singh R.K. Murtaza Q.	Journal of Remanufacturing	2018	India	electronic s	case study
17	Typology of practices for managing consumer returns in internet retailing	Hjort K., Hellström D., Karlsson S., Oghazi P.	International Journal of Physical Distribution & Logistics Management	2019	Sweden	not specified	case study
18	The Collection-And-Delivery Points Implementation Process from the Courier, Express and Parcel Operator's Perspective	Zenezini, G., Lagorio, A., Pinto, R., Marco, A.D., Golini, R.	IFAC-PapersOnLine	2018	Italy	not specified	interview
19	B2c e-commerce logistics: The rise of collection-and-delivery points in the Netherlands	Weltevreden J.W.J.	International Journal of Retail & Distribution Management	2008	Netherland s	not specified	survey + interview
20	The "next day, free delivery" myth unravelled. Possibilities for sustainable last mile transport in an omnichannel environment	Rai, Heleen Buldeo; Verlinde, Sara; Macharis, Cathy	International Journal of Retail & Distribution Management	2018	Belgium	not specified	survey
21	Online retailers' return policy and prefactual thinking. An exploratory study of USA and China e-commerce markets	Yu, Yanan; Kim, Hye-Shin	Journal of Fashion Marketing and Management	2019	USA	fashion	content analysis
22	Environmental Impact of Last Mile Deliveries and Returns in Fashion E-Commerce: A Cross-Case Analysis of Six Retailers	Velazquez R., Chankov S.M.	International Conference on Industrial Engineering and Engineering Management	2019	Germany	fashion + furniture	case study
23	Service innovation in e-commerce last mile delivery: Mapping the e-customer journey	Yulia Vakulenko, Poja Shams, Daniel Hellström, Klas Hjort	Journal of Business Research	2019	Sweden	not specified	interview
24	What's in the parcel locker? Exploring customer value in e-commerce last mile delivery	Yulia Vakulenko, Daniel	Journal of Business Research	2017	Sweden	not specified	interview

		Hellström, Klas Hjort					
25	Acceptability of collection and delivery points from consumers' perspective: A qualitative case study of Christchurch city	Ashu Kedia, Diana Kusumastuti, Alan Nicholson	Case Studies on Transport Policy	2017	New Zealand	not specified	case study
26	Distribution systems in omni-channel retailing	Hübner A., Holzapfel A., Kuhn H.	Business Research	2016	Germany	not specified	interview
27	A Simulation Model Of Multi-Echelon Retail Inventory With Cross-Channel Product Returns	William A. Muir, Stanley E. Griffis, and Judith M. Whipple	Journal of Business Logistics	2019	USA	not specified	simulation
28	A Dynamic Strategy for Home Pick-Up Service with Uncertain Customer Requests and Its Implementation	Yu Wu, Bo Zeng, Siming Huang	Sustainability	2019	China	not specified	mathematical model + simulation
29	Online retail returns management. Integration within an omni-channel distribution context	Michael Bernon, John Cullen, Jonathan Gorst	International Journal of Physical Distribution & Logistics Management	2015	UK	not specified	other
30	A new location-inventory policy with reverse logistics applied to B2C e-markets of China	Ziping Wang, Dong-Qing Yao, Peiqing Huang	International Journal of Production Economics	2006	China, USA	electronic s	mathematical model + simulation
31	Comparative analysis of the carbon footprints of conventional and online retailing. A "last mile" perspective	Julia B. Edwards, Alan C. McKinnon, Sharon L. Cullinane	International Journal of Physical Distribution & Logistics Management	2010	UK	not specified	other
32	In-Store Pickup and Returns for a Dual Channel Retailer	Stephen Mahar and P. Daniel Wright	IEEE Transactions on Engineering Management	2017	USA	not specified	mathematical model + simulation
33	Returning Customers: The Hidden Strategic Opportunity of Returns Management	Felix Johannes Röllecke, Arnd Huchzermeier, David Schröder	California Management Review	2017	Germany	not specified	other
34	The Option Value of Returns: Theory and Empirical Evidence	Eric T. Anderson, Karsten Hansen, Duncan Simester	Marketing Science	2009	USA	fashion	mathematical model + simulation
35	Omnichannel fulfillment strategies: defining the concept and building an agenda for future inquiry	Daniel Taylor, Sebastian Brockhaus, A. Michael Knemeyer, Paul Murphy	The International Journal of Logistics Management	2019	USA	not specified	literature review

Table 5: Papers classification - title, authors, source, year, country, industry and research method (Based on authors' elaboration)

2.3.1 Source

Built upon the analysis of 35 papers, this literature review makes use of 28 different sources, which are divided in scientific journals (20) and proceedings of international conferences (8). The theme of reverse logistics is examined in a broad array of journals and international conference proceedings, which have been categorised by authors in the following fields as displayed in Graph 11: Business and Economics, Computer Science/Automation, Electronics, Industrial/Management Engineering, Logistics and Transportation and Other.



Graph 11: Source field categories
(Based on authors' elaboration)

The consistent number of sources categories underlines the relevance of the topic discussed within this master thesis, pointing out how many facets can be addressed in B2c e-commerce reverse logistics.

The source used in this dissertation are also reported by frequency in Table 6, alongside with the corresponding source field/category and type.

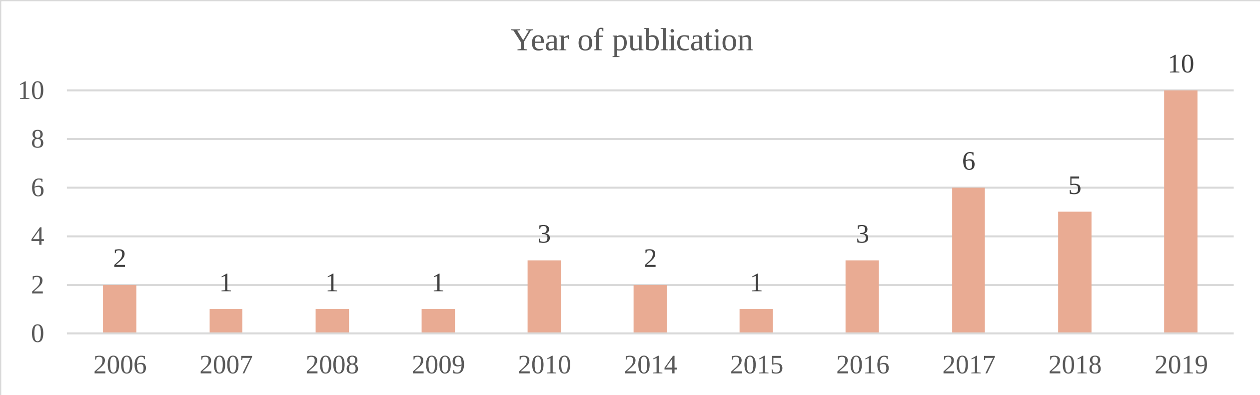
Source	Category	Type	Occurrences
International Journal of Physical Distribution & Logistics Management	Logistics and transportation	Scientific journal	3
International Journal of Production Economics	Business and economics	Scientific journal	3
International Journal of Retail & Distribution Management	Logistics and transportation	Scientific journal	2
Journal of Business Research	Business and economics	Scientific journal	2
Sustainability	Other	Scientific journal	2
Business Research	Business and economics	Scientific journal	1
California Management Review	Business and economics	Scientific journal	1
Case Studies on Transport Policy	Logistics and transportation	Scientific journal	1

Computers & Industrial Engineering	Computer science/Automation	Scientific journal	1
Decision sciences: A journal of the decision sciences institute	Other	Scientific journal	1
IEEE Transactions on Engineering Management	Industrial/Management Engineering	Scientific journal	1
IFAC-PapersOnLine	Computer science/Automation	Scientific journal	1
International Conference - New Trends in Sustainable Business and Consumption	Business and economics	Proceedings of international conference	1
International Conference on E-Product E-Service and E-Entertainment	Electronics	Proceedings of international conference	1
International Conference on Industrial Engineering and Engineering Management	Industrial/Management Engineering	Proceedings of international conference	1
International Conference on Information Management, Innovation Management and Industrial Engineering	Industrial/Management Engineering	Proceedings of international conference	1
International Conference on Mechatronics, Control and Electronic Engineering	Computer science/Automation	Proceedings of international conference	1
International Conference on Service Operations and Logistics, and Informatics	Other	Proceedings of international conference	1
International Journal of Logistics Research and Applications	Logistics and transportation	Scientific journal	1
International Journal of Production Research	Other	Scientific journal	1
Journal of Business Logistics	Logistics and transportation	Scientific journal	1
Journal of Fashion Marketing and Management	Business and economics	Scientific journal	1
Journal of Remanufacturing	Industrial/Management Engineering	Scientific journal	1
Marketing Science	Business and economics	Scientific journal	1
Proceedings of the International Conference on Industrial Engineering and Operations Management	Industrial/Management Engineering	Proceedings of international conference	1
Proceedings of the International Conference on Information and Automation	Computer science/Automation	Proceedings of international conference	1
The International Journal of Logistics Management	Logistics and transportation	Scientific journal	1
Transportation Research Part E: Logistics and Transportation Review	Logistics and transportation	Scientific journal	1

Table 6: Sources of the selected papers
(Based on authors' elaboration)

2.3.2 Year of online publication

As for the year of online publication of the articles/papers found, a trend is visible: the number of papers on different ways to return products has been increasing over time, as shown in the online-publication-year breakdown below (Graph 12):



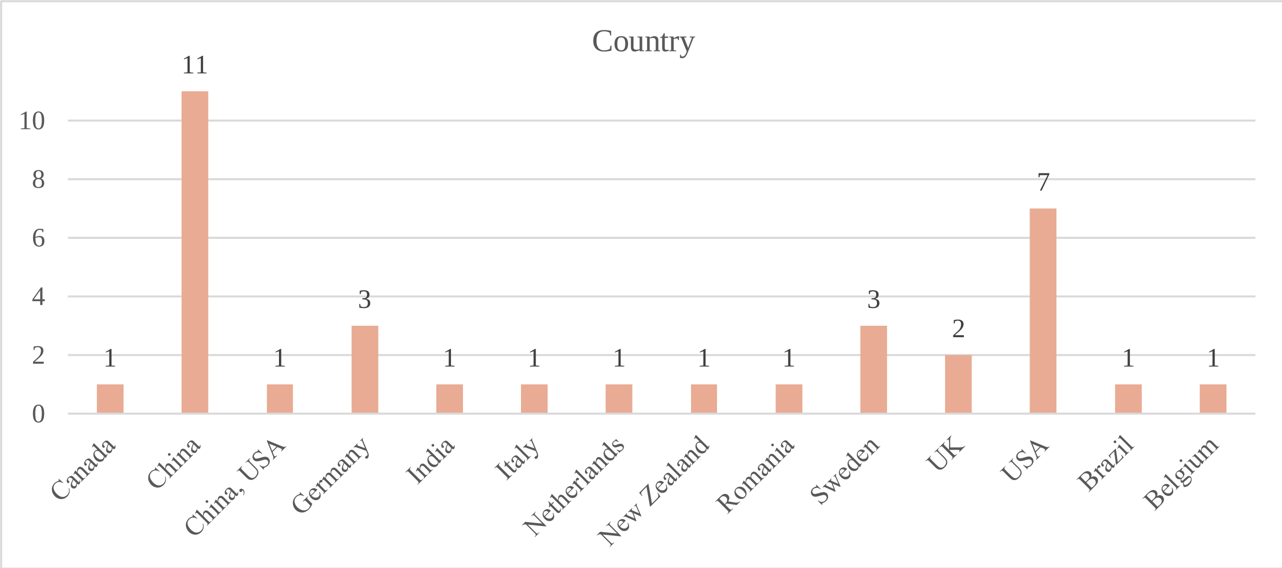
Graph 12: Years of the papers' online publication

It can be inferred that the higher percentage of online sales has led to a higher degree of attention among researchers, who are probably willing to provide frameworks, models and methods to handle returns in the most efficient and effective way for practitioners, in particular logistics service providers and e-tailers. Indeed, even if new technologies (i.e. augmented reality in the fashion sector) have the chance to reduce the number of returns, lenient return policies adopted by most of the e-tailers to keep up with traditional retailing are likely to increase the returns volume. To effectively handle these volumes, e-commerce cannot grow without the development of reverse logistics.

The goal of the article "Managing Internet Product Returns: A Focus on Effective Service Operations" by Mollenkopf et al. (2007) namely "inform managers' choices regarding investment in the returns management system as an element of service quality improvement and a potential means of improved profitability" could be intended as a justification of the above mentioned reasoning where a positive relationship between the number of academic writings and the share of online retailing sales is inferred. Indeed, it seems conceivable that the higher the penetration rate of e-commerce sales in B2c retailing, the higher the attention among researchers which could provide solid contributions to different stakeholders, logistic service providers and merchants/manufacturers.

2.3.3 Country

As stated before, in this literature review "country" refers to the country where the main researchers' university is settled. To account for the possibility that a scholar works for different institutions, the university under which the paper/article is officially registered in Scopus is recorded. In Graph 13, the country-level analysis is provided.



Graph 13: Countries of the selected papers

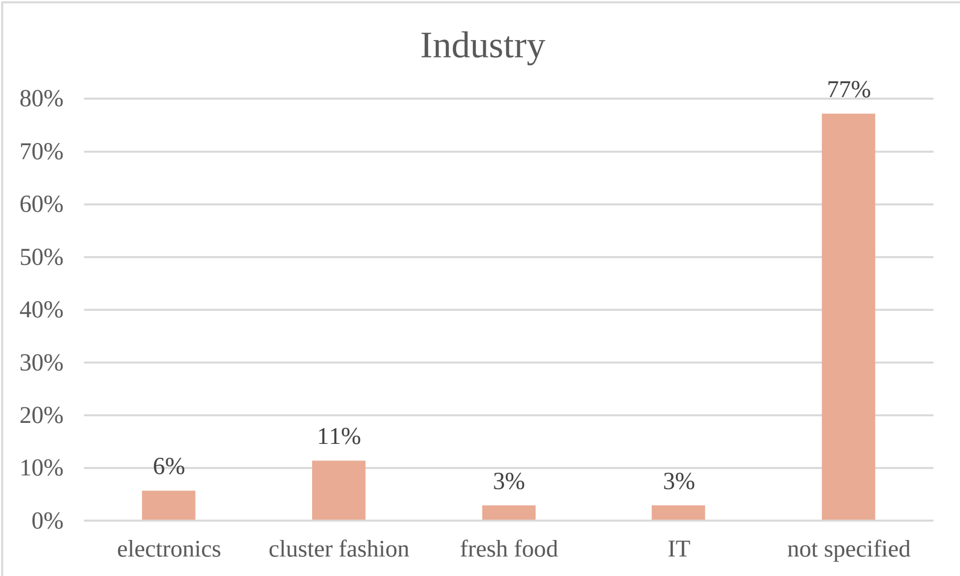
Two countries, namely China and USA, show the highest number of publications in this literature review (Graph 13): not surprisingly Chinese and American markets are also the focal ones in e-commerce retailing. In the latest publication called "Global Ecommerce Market Ranking 2019" (eshopworld, 2018), powered by the World Retail Congress, USA is considered the number one eCommerce market in 2018. Despite not being the first one by total revenues, the birthplace of internet retailing shows the highest level of revenues per shopper, great logistics infrastructure and high-demand for cross-borders purchases which places it at the very top of the ranking. Coming to the second place, Chinese market can be found: China is the largest market by revenue, by number of online shoppers and cross-border online shoppers.

The number of online publications could be biased by the number of universities and research centres per country, which are substantial in China and USA for demographic reasons and because of the strong presence of giant marketplaces, namely Alibaba and Amazon in China and USA respectively. Nevertheless, it could be assumed that the joint effect of size, number of universities/research centres, e-commerce sales figures and presence of multinational e-commerce companies results in a higher number of publications. Indeed, practitioners may push academia to develop even further the topic of e-commerce, and reverse logistics as a part of it, willingly to improve their triple bottom line (e.g. social, economic and environmental sustainability).

No relevant patterns are visible among the other countries since the number of online publications is too low to be significant and generalized.

2.3.4 Industry

Papers/articles were also classified on the basis of the industry/sector considered and described if any. It is worth noticing that in 77% of the cases the articles do not revolve around any sector specifically: this may be related to scholars' willingness to generalize results, concepts and ideas. However, among the remaining 23% of the papers, the fashion sector is the most cited in the list of articles found: by summing up the three clusters referring to fashion, namely *fashion*, *fashion + furniture* and *fashion + easy to be checked goods*, the occurrences total 11 % of the cases (Graph 14). This figure could be explained by the high return rates, even up to 40%[5], experienced by fashion sector in e-commerce B2c.



Graph 14: Industries mentioned in the selected papers

2.3.5 Research method

As regards the research methods, they have been either collected if clearly stated by the authors or, if not, inferred. For the sake of completeness, the reader is now provided with the list of methods used in the articles under investigation, alongside with a brief description. Later on, each class has been filled with the corresponding papers, underlying features, common traits and differences if any.

The list of methods used in the articles under investigation are:

- Empirical
    - Case study → it is used to describe a particular situation (case) in detail: this may entail a person, a business or a firm. Then key issues of the case are identified and

[5] https://blog.exekon.com/mercato-del-reso-industria-tessile

analysed using relevant theoretical concepts from the disciplines involved. Eventually, a course of action may be suggested for that particular case[6].

  - Survey/interview → it is a method of collecting information related to a specific topic from a sample of people. The goal of this method is usually to generalize the results to a larger population[7].
  - Content analysis → it is a research method used to determine the presence of certain words or concepts within texts. Researchers quantify and analyse the presence, meanings and relationships of such words and concepts, then make inferences about the messages within the texts, the writer(s), the audience, and even the culture and time of which these are a part[8].
- Conceptual
  - Literature review → it is a comprehensive summary of previous research on a particular topic. It involves reviewing articles, surveys, books and other relevant sources of information. This method is based on enumerating, describing, summarizing, evaluating and clarifying previous research in order to give the reader a clear and full understanding of the process under investigation[9].
- Analytical
  - Mathematical model → it is a method which describes real-world using mathematical concepts and language. The results of this method can then be used to provide insights about the original real problem.
  - Simulation → it is an attempt to duplicate features, appearance and characteristics of a real system. The goal is to imitate a real-world situation mathematically, study its properties and operating characteristics, draw conclusions, and make action decisions based on the results of the simulation.
- Other

In Table 7, the summary of the research methods adopted in the papers is shown.

[6]https://www.westernsydney.edu.au/__data/assets/pdf_file/0007/1082473/Case_Study_Purpose.pdf

[7]https://www.qualtrics.com/experience-management/research/survey-basics/

[8]http://www.umsl.edu/~wilmarthp/mrpc-web-resources/content-analysis.pdf

[9]https://guides.library.bloomu.edu/litreview

Research method	Occurrences	Percentage
empirical	17	39%
case study	7	
survey/interview	9	
content analysis	1	
conceptual	3	7%
literature review	3	
analytical	19	43%
mathematical model	11	
simulation	8	
other	5	11%

Table 7: Research method
(Based on authors' elaboration)

The occurrences of research methods exceed the papers/articles analysed (35), because it may happen that multiple methods are used within a single paper. As for the figures, it is worth noticing that empirical and analytical methodologies are the most common ones, while literature reviews are not widely employed as main research approach; nevertheless, these reviews are the backbone of each academic writing as in the case of this dissertation.

Within the empirical clusters of methodologies, surveys/interviews play a relevant role for a twofold reason: on the one side these are employed to better understand the behaviour of customers in relation to e-commerce and returns management, an expected pattern given the interplay between returns management and consumer purchase decisions (Weltevreden (2008), Vasiliu et al. (2016), Vakulenko and colleagues (2018 and 2019), Xu and Jackson (2019), Buldeo Rai et al. (2019)); on the other side interviews are used to collect information regarding reverse logistics from practitioners (Tang and Gu, 2010; Hübner et al., 2016 and Zenezini et al., 2018).
For what concerns case study methodology, scope and purpose differ among the selected papers. De Araújo and colleagues (2017) present the returns management process of an online retailer showing its evolution, analysing its performance and pointing its main shortcomings out to better understand the return management process. A similar approach is followed by Agrawal et al. (2018). Instead, Tang and Gu (2010) discusses the various modes to handle reverse logistics by considering the experiences of multinationals like FedEx and UPS, as for Feng and Xie (2006). Hjort (2019) and colleagues, instead, offer a broader overview of the practices of managing product returns in internet retailing by carrying out a multiple case study which involved e-commerce firms and logistics service providers as well. In the light of the scholars, the systematic approach used in the paper proves to give a valuable contribution to practitioners who are willing to improve their return process. A similar pattern can be found in Velazquez and Chankov (2019): in this paper, however, the core objective is

not the return process itself but the interplay between forward and reverse logistics with environmental considerations. Nevertheless, it sheds the lights on opportunities in operations management as for Hjort and colleagues (2019). Dealing with the different ways to return products in B2c e-commerce, in Kedia et al. (2017) acceptability of collection and delivery points is analysed and described with a qualitative case study. Despite focusing not only on reverse logistics but also on the forward ones, the paper is the only one in this group of sources that considers and describes deeply one specific mode to handle returned items through the case study methodology. Within the empirical group of papers, it could be added the article by Yu and Kim (2019), who studied the differences between American and Chinese e-commerce markets via a content analysis of eight international online fashion retailers. Even if the core of the paper was placed on the interplay between consumers' purchase decision and return policies, thus exceeding the boundaries of this master thesis, the authors makes use of this source due to the detailed description of how the return process differs among countries and firms.

The second family of papers is labelled as conceptual, where literature reviews- 3 in this analysis- can be placed. These latter can be further split in two classes: Biswas and Abdul-Kader (2018) and Feng and Xie (2006) give a snapshot of the return process in B2c e-commerce. The first one is relevant because it emphasizes the role of Internet of things in returns management, whereas the second one proposes and compares different return modes considering all the stakeholders involved in the process, namely logistic service providers, e-tailers (and manufacturers) and final clients. The second class within this category refers to Taylor and colleagues (2019), which provide a great contribution to academic study by reviewing all the literature connected to omnichannel strategy, the strategy linked to in-store return, one of the return methodologies currently available.

The third cluster of research method is the analytical one where mathematical modelling and simulation can be placed. All in all, 11 papers are based on a mathematical modelling approach, 8 on simulation, however it should be noted that the two methodologies are combined together in 7 articles/papers. In the latter case, the array of solutions proposed is quite broad: Chen and colleagues (2017) and Chang & Zheng (2014) suggest models to reduce the cost and the negative externalities (i.e. pollution, traffic jams) of reverse logistics in B2c e-commerce relying on crowdsourcing paradigm on one side and outsourcing of reverse logistics operations on the other. In Wu et al. (2019) a dynamic strategy is implemented to reduce the travel distance of vehicles performing home pick-up services in case of both scheduled and unscheduled requests. Furthermore, a trait d'union of mathematical modelling and simulation papers revolves around the concept of logistics network: throughout the years, scholars have analysed how and where to set the nodes (i.e distribution centres)

within the network (i.e. drop off/pick up zone) to speed up processes and reduce costs in internet retailing. Such a concept can be recognized in Guo and colleagues (2017) who provides a network which integrates reverse and forward logistics for a fresh food e-commerce. Similar to this, in Wang (2007) a model to set the location of checking sites and the inventory replenishment policy is recognized. Even insightful from a methodological perspective, it is worth noticing that such a paper relies on the presence of third checking sites (3CS), physical sites where customers had to bring unwanted items. Once the product was verified, a label was given to the customer who then could arrange the pick-up with the courier. Nowadays, there are no instances of the use of such a way to handle returns: the procedure is complex and could not face the surge of e-commerce sales. The concept of network is investigated also in Mahar and Wright (2017): revolving around the omnichannel strategy, the article looks for the optimal set of stores that should be set up to handle efficiently in-store pickups and online returns. Finally, this literature review takes into account Anderson (2009) and colleagues who develop a model of a consumer's decision to purchase and return an item. In this case, even if the paper deals with return policy and its implication on the level of sales, it has been included in the analysis because of the methodological perspective deployed.
Among the remaining sources, two of them propose mathematical models shedding the light on the omnichannel retailing strategy: Jin and colleagues (2020) investigate the retailers' strategic decision on the adoption of an omnichannel strategy (BORP policy in the text which stands for Buy Online and Return-to-Physical store), whereas Zhang et al. (2018) try to identify the condition under which the retailer benefits from the omnichannel retailing strategy. Via a simulation study, also Muir and colleagues (2019) analyse omnichannel strategy focusing on the combination of return processing structure, centralized and decentralized, and returns channel policy, same-channel and cross-channel. Mollenkopf and colleagues (2007) instead, develop a model in the service returns offering area, providing evidence of the impact of returns management system on customer purchasing intentions. Lastly, Zhang et al. (2019) propose a model to account for return strategies and online customization.

It should be underlined the lack of papers/articles on reverse logistics cost assessment: no instances on how much is the reverse logistics processes have been found in the existing body of literature, as well as an up-to-date description on the different ways to return products with peculiarities, differences and flaws. The counterpart of reverse logistics in e-commerce, namely last mile delivery/forward logistics, benefits from a much broader attention among scholars and researchers.

2.3.6 Core vs ancillary

A brief summary of each paper is provided in Table 8 alongside with an overall evaluation of the content for the scope of this work. Concerning this last point, if the focus of the paper was solely on the "different ways to return products in B2c e-commerce" with a description of the return process, the article has been recorded as "core", while if the above mentioned topic was not the focal one in the paper, the article has been classified as "ancillary" (e.g. in some papers the theme of reverse logistics in e-commerce was just a part of the overall process of online sales, which includes among the others the processes of forward logistics/last-mile delivery and consideration about return policies). For instance, source number 6 (Table 8) "A preliminary analysis of reverse logistics in B2c" is marked as core, because it discusses the various methodologies to handle reverse logistic flows relying on the operation mode and the experience of multinationals. As an example of ancillary paper instead, "Acceptability of collection and delivery points from consumers' perspective: A qualitative case study of Christchurch city" (source number 25 in Table 8) comes handy, indeed authors describes collection and delivery points considering them as a mean of handling both forward and reverse flows. Among the selected papers, 12 out of 35 (34 %) can be classified as core, while 23 out of 35 (66 %) can be considered ancillary. In this second cluster of papers, the topic of reverse logistics is studied alongside with other themes, namely forward logistics, omnichannel retailing, return policy, cause analysis and corrective measures analysis, which can be even combined together.
The following table (Table 8) summarizes this content-based analysis:

Number	Title	Summary	Core/Ancillary	Ancillary Category
1	Using taxis to collect citywide E-commerce reverse flows: a crowdsourcing solution	An innovative proposal of using taxis, collection points and crowdsourcing paradigm to collect return goods in e-commerce with a real data simulation from a large city in China.	core	
2	Omnichannel retailers' return policy strategies in the presence of competition	Study of an omnichannel strategy that enables consumers to buy online and return to the physical store. The paper is based on a duopoly competition model where different decisions of both retailers and consumers are compared and evaluated.	ancillary	omnichannel retailing
3	An exploratory study on the returns management process in an online retailer	Case study on the process of return management of the largest online retailer of the Brazilian market by means of interviews and on-site visits.	core	
4	Reverse logistics challenges in e-commerce	Preliminary research paper that summarises and analyses the challenges in reverse logistics and provides directional approach to solve these challenges.	core	

5	An Effective Strategy for Non-defective Reverse Logistics	Paper that presents a new strategy to reduce the waste on non-defective reverse logistics. It leverages on customer's order and position to combine reverse and forward logistics to cut transportation expenses.	core	
6	A preliminary analysis of reverse logistics in B2C	Summary of the reasons for reverse logistics in e-commerce and discussion of the various modes to handle returned goods deployed by multinationals.	core	
7	Reverse logistics under E-commerce environment	Paper which analyses the factors of reverse logistics and provides suggestions on how to circumvent and revolve reverse logistics problems.	ancillary	cause analysis + corrective measures analysis
8	Managing internet product returns: A focus on effective service operations	Development of a model to study the impact of returns management system upon customer loyalty intentions based on data from a survey of customers of 5 different internet retailers.	ancillary	return policy
9	A study on returns logistics operating mode in E-business environment	It proposes and compares four models of returns logistics operating system; it discusses practical implementing strategies of returns logistics to provide valuable approaches of return logistics operation for online retailers.	core	
10	Returns Reverse Logistics Management Strategy in E-commerce B2C Market	It describes the features, the modes, the management strategies and the barriers of reverse logistics. An example of returning reverse logistics is also provided.	core	
11	Approaches regarding the return policy of online retailers	It aims at studying the attitude of young educated people on different aspects of the return policy in the e-commerce environment.	ancillary	return policy
12	Forward and reverse logistics network and route planning under the environment of low-carbon emissions: A case study of Shanghai fresh food E-commerce enterprises	It proposes a network and route planning model of a two-stage forward/reverse logistics for fresh food e-commerce enterprises under the environment of low-carbon emission. The validity of the model is tested with the study of the fresh food e-commerce enterprises of Shanghai.	ancillary	forward logistics
13	Omnichannel retail operations with consumer returns and order cancellation	Analytical study on an online retailer's omnichannel operations where optimal pricing and inventory decisions are derived under the online-only strategy and the omnichannel strategy. The conditions under which a retailer benefits from the omnichannel retailing strategy are identified too.	ancillary	omnichannel retailing
14	Return Strategies and Online Product Customization in a Dual-Channel Supply Chain	The paper investigates the return strategies in a dual-channel supply chain composed of a manufacturer and a retailer and the conditions for the manufacturer to open online customization channels.	ancillary	return policy
15	Investigating the influential factors of return channel loyalty in omni-channel retailing	Empirical analysis via surveys about the influential factors on customers' return channel loyalty.	ancillary	return policy + omnichannel retailing
16	Reverse supply chain issues in Indian electronics industry: a case study	The study aims at exploring the key strategic issues and challenges faced by the electronics industry in managing	core	

		reverse supply chain through the analysis of an Indian electronics company.		
17	Typology of practices for managing consumer returns in internet retailing	The paper explores, describes and categorises practices of managing product returns empirically in internet retailing.	core	
18	The Collection-And-Delivery Points Implementation Process from the Courier, Express and Parcel Operator's Perspective	The work aims at understanding the enablers and barriers to the spread of collection and delivery points mode of delivery via interviews to couriers with a focus on the Italian market.	ancillary	forward logistics
19	B2c e-commerce logistics: The rise of collection-and-delivery points in the Netherlands	The paper empirically studies the uptake of collection-and-delivery points in the Netherlands and its consequences for retailers, shopping centres and mobility.	ancillary	forward logistics
20	The "next day, free delivery" myth unravelled Possibilities for sustainable last mile transport in an omnichannel environment	The paper aims at exploring to which extent consumers are willing to adopt last mile options that are more sustainable and how these options should be composed to remain attractive.	ancillary	forward logistics + omnichannel retailing
21	Online retailers' return policy and prefactual thinking: an exploratory study of USA and China e-commerce markets	The study examines how return policies from online fashion retailers in different countries (USA, China and Western Europe) support consumer need for uncertainty avoidance and lower negative prefactual thinking in China and USA.	ancillary	return policy
22	Environmental Impact of Last Mile Deliveries and Returns in Fashion E-Commerce: A Cross-Case Analysis of Six Retailers	The paper studies the environmental impact of fashion e-commerce last mile deliveries and returns, identifying improvement opportunities and deriving initial recommendations for greener practices via a cross-case analysis on six retailers.	ancillary	forward logistics
23	Service innovation in e-commerce last mile delivery: Mapping the e-customer journey	This study provides insights on how service innovation affects e-customer behaviour and presents a basic map of the e-customer journey. It is built on focus group interviews and a usability test that incorporates an innovative technology in the delivery service.	ancillary	forward logistics
24	What's in the parcel locker? Exploring customer value in e-commerce last mile delivery	It explores customer value in relation to parcel lockers following a focus group design. It provides insights on customer value in relation to parcel locker.	ancillary	forward logistics
25	Acceptability of collection and delivery points from consumers’ perspective: A qualitative case study of Christchurch city	The paper studies New Zealanders' acceptance of collection and delivery points and their online shopping behaviour by means of focus groups, using Christchurch as a case study.	ancillary	forward logistics
26	Distribution systems in omni-channel retailing	Through interviews and market data research, the paper aims at understanding where online orders should be fulfilled, how delivery and return processes can be organized, and which context-specific omnichannel distribution systems exist.	ancillary	omnichannel retailing
27	A Simulation Model Of Multi-Echelon Retail Inventory With Cross-Channel Product Returns	The paper explores the relationship between a retailer's product returns processing structure and multi-echelon inventory system performance under cross-channel and same channel product	ancillary	omnichannel retailing

		returns policies with nonstationary demand.		
28	A Dynamic Strategy for Home Pick-Up Service with Uncertain Customer Requests and Its Implementation	A home service problem is studied in this paper, where a capacitated vehicle collects customers' parcels in one pick-up tour. The aim is to understand how to guide vehicles to visit customers in an efficient way minimizing the vehicle's total expected travel distance.	core	
29	Online retail returns management: integration within an omni-channel distribution context	Given the rapid growth of omni-channel retailing, the paper explores its impact on consumer retail returns experienced through online sales and the emergent returns management strategies in relation to network configuration and returns management processes.	core	
30	A new location-inventory policy with reverse logistics applied to B2C e-markets of China	The paper considers a supply chain with one supplier, one B2c firm and multiple DCs to jointly study its location and inventory policy when product returns are considered: a new location-inventory policy based on B2c electronic markets in China is proposed and illustrated.	core	
31	Comparative analysis of the carbon footprints of conventional and online retailing: A "last mile" perspective	The article focuses on the carbon intensity of last mile deliveries and personal shopping trips in both conventional and online retailing.	ancillary	forward logistics
32	In-Store Pickup and Returns for a Dual Channel Retailer	Development of a model for analytically evaluating the cost and the value of providing in-store pick up and return options in multi-echelon retail/e-tail organizations. The model determines the optimal subset of a retailer/e-tailer's stores that should be set up to handle in-store pickups and online returns.	ancillary	omnichannel retailing
33	Returning Customers: The Hidden Strategic Opportunity of Returns Management	The article distinguishes among different types of returns management programs and discusses the managerial misunderstanding that reduces their effectiveness. It also presents a framework allowing retailers to boost sales, reduce returns and increase profitability.	ancillary	return policy + corrective measures analysis
34	The Option Value of Returns: Theory and Empirical Evidence	Development of a structural model of a consumer's decision to purchase and return an item. The model gives the company the chance to measure the consumers’ value of the return options and balance costs and benefits of different return policies.	ancillary	return policy
35	Omnichannel fulfilment strategies: defining the concept and building an agenda for future inquiry	It provides a snapshot of the current state of omnichannel fulfilment research via a systematic literature review in order to identify omnichannel fulfilment strategies and to establish an agenda for future inquiry.	ancillary	omnichannel retailing

Table 8: Papers' summaries and classification core VS ancillary
(Based on authors’ elaboration)

Despite the lower incidence of core-papers among the ones selected, it is worth mentioning the innovative mathematical model approach followed by Chen and colleagues (2017) in paper number 1. The author proposes an innovative model to collect e-commerce reverse flows by means of a network of taxis and CDPs (i.e. collection and delivery points) leveraging on crowdsourcing and physical internet paradigm. The proposal developed delivers returned items and passengers in an integrated way relying on the constant flows of taxis in the city and their extra-capacity. Negative social, environmental and economic impacts could thus be reduced. Paper number 5 proves to be insightful and innovative as well: Chang and Zheng (2014) present an effective strategy of non-defective reverse logistics. The author develops a model where sellers can choose another consumer's delivery address as client's return address to reduce the distance of non-defective return transportation. In such a case, integrity checking process is delegated to third-party logistic service provider (= outsourcing of quality check).

As shown by these two instances, logistic service providers play a fundamental role in managing reverse logistic flows, since e-tailers are not used to manage internally last mile and reverse logistics. Such a behaviour is expected: in most of the case, it would not be cost-efficient for a seller to manage internally its transportation, mainly for a matter of missing economies of scale and experience effects. The low incidence of "core" papers dealing with the return methods in e-commerce B2c, although undesirable, is a relevant subject matter for discussion in this literature review. This finding is in line with Hjort et al. (2019), who claim that "literature on return management (i.e. reverse logistics) is still underdeveloped". So far, scholars have widely discussed optimization methods and models in the last-mile delivery trying to study and propose solutions to improve efficiency and lessen the negative externalities of e-commerce (i.e. pollution and congestions): a way lower number of sources quantifies and suggests new frameworks which considers forward and reverse logistics at the same time, or solely the latter one.

2.3.7 Different ways to return products in B2c e-commerce

To further analyse and systematize the sources collected, the different methodologies to return products mentioned in the selected literature have been counted: results are shown in Table 9. These are: home pick up (the traditional way to handle return in e-commerce in this literature review, in line with the approach of Seghezzi et al. (2020), who consider as traditional "by van, with no appointment – home delivery"), collection points, also known as CDPs – collection and delivery points, divided into unattended (parcel lockers) and attended (bars, supermarkets, kiosks, service points, newsagents), cross-channel and postal office.

		Collection point				
Return method	**Home pick-up**	**Attended**	**Unattended**	**Cross-channel**	**Postal office**	**Total**
Occurrences	22	5	13	19	12	71
Percentage	31%	7%	18%	27%	17%	

Table 9: Different ways to return products with occurrences and percentages

Despite being studied, yet not being widely adopted as last mile delivery means of transportation and delivery, drones, trunks, reception boxes, underground deliveries and robots, as recorded again in Mangiaracina et al. (2019), are not found among the selected papers.

The total number of return methods exceeds the number of articles analysed, since it may happen that different return ways are discussed within a single paper. As reported in the Table 9, home pick-up way-of-return shows the highest number of occurrences, while cross-channel accounts for the 27% of the cases. Unsurprisingly, cross-channel methodology is a matter of discussion among researchers due to the rise of omnichannel strategy in B2c retailing. As reported by Jin and colleagues (2020), more and more traditional brick-and-mortar sellers are expanding their businesses in the online channel, whereas e-tailers have already opened physical stores to offer the highest possible service level. As a consequence, "the ability to offer a seamless return process can differentiate a retailer from the competition. This suggests that whether the BORP (i.e. Buy-Online, Return-to-Physical store) policy is offered can be a competitive strategy for retailers." (Jin and colleagues, 2020).

In addition to this classification, two noteworthy themes are recorded, namely crowdsourcing and outsourcing of returns management. Starting from the first one, the paradigm of crowdsourcing is widely studied in literature and it is even currently adopted in big cities: food delivery by means of bike is just an instance of the diffusion of such a model in the real world. Notwithstanding the relevance of the topic, only one article proposes a solution which integrates crowdsourcing into reverse logistics in e-commerce B2c. The second theme is the outsourcing of returns management, recorded in 5 papers, to logistics service providers, the link between manufacturers/producers/sellers and final customers in e-commerce. With the term outsourcing, this literature review means delegating to a third party the phase of quality check, the one which aims at verifying the compliance of the item to be returned. As suggested by Chang and Zheng (2014), if integrity checking activity is transferred to logistic service providers, transportation distance will be shortened: 3PLs would keep the returned items at stock, ready to be shipped to another customer's address. However, it is worth noticing that this approach works under specific conditions like simple and inexpensive items, whose quality can be easily assessed by couriers' operators and high population density area, whose products demand is consistent.

2.3.8 The process

The ultimate step carried out in this literature review has been to systematize the papers/articles found by considering which phases of the process of reverse logistic were described within each piece of literature. To begin with, the phases of reverse logistics in e-Commerce have to be introduced. In the list of 35 papers analysed, De Araújo et al. (2017) report the contribution of Stock and Mulki (2009) who identified five main steps in the reverse logistics process:

1. Pre-receipt: providing authorisation, labelling and other process elements to consumers who are willing to return an item;
2. Receiving: unloading and distributing product returns to processing centres;
3. Processing: activities like data entry and issuing customer refund;
4. Sortation: inspection and routing of returns to a disposition point;
5. Disposition: putting the item back to stock or temporary storage, repackaging, repairing, refurbishing or remanufacturing;

but they recall also Bernon, Rossi, and Cullen (2011) which presented a framework made by six process stages: "customer return request, return logistics, processing and sortation, inventory control, repair and refurbishment and final disposition". Plus, Biswas & Abdul-Kader (2018) report the four main steps of reverse logistics, namely gatekeeping (entry), collection, sorting and disposal as defined by most authors in academic literature. Alongside with these secondary sources, websites of e-commerce merchants, as Amazon[10], Zalando[11] and Yoox[12], have been taken into account to come up with a framework that could fit the current reverse logistics process. In line with these considerations, the authors propose the following phases to depict the reverse logistics process in B2c e-commerce:

- Phase 0 → Pre receipt
- Phase 1 → Collection
    - I. Initial travel
    - II. Drop-off/pick-up activities
- Phase 2 → Transportation
- Phase 3 → Processing of returns

[10] https://www.amazon.it/gp/help/customer/display.html?nodeId=GNW5VKFXMF72FFMR

[11] https://www.zalando.it/aiuto/Reso-e-Rimborso/Come-effettuare-un-reso.html

[12]http://help.yoox.com/system/selfservice.controller?CONFIGURATION=1093&PARTITION_ID=1&CMD=BROWSE_TOPIC&TOPIC_ID=1023

- Phase 4 → Shipment to final destination

Phase 0 refers to the very beginning of the process, where customers who are willing to give something back get in touch with the e-tailer and ask for a return. As reported by Biswas & Abdul-Kader (2018), “a customer once decides to return the products bought online, will inform the e-retailer online”, and again Feng & Xie (2006) state the following: “the customer submits a request for returning goods by phone or on website. Based on relevant prescriptions and results of an online assessment, the retailer decides whether the request should be approved or not”

Phase 1 can be considered the most impactful one from both a monetary and environmental cost perspective, since most of the physical operations related to return management happens at this stage. This phase has been divided into two parts: on the one side the initial travel, the trip different actors in the process have to bear (i.e. explaining this part of the return process, Chen and colleagues (2017) note that “customers, who are also known as flow generators will drop off the returned goods at the nearby shop”) , on the other side drop-off/pick-up activities, the manual procedures entailed by the process itself (i.e. scanning barcodes, filling documents). Phase 2, instead, is called transportation: in this part returned items are shipped from the drop-off/pick-up zone to the processing facilities. According to Chen and colleagues (2017) transportation starts from the shops, to be intended as CDPs, and ends with distribution centres, either controlled by e-tailers or logistic service operators, where processing/checking activities take place (Phase 3 processing of returns). Hübner et al. (2016), considering this part of the return process, describe return processing location, those hubs “specialized in processing returns, mainly used when return handling processes become too work-intensive and DC capacities are scarce”. The last part is “shipment to final destination” (Phase 4), where returned items are either brought back to stock or re-send to consumers in case of negative response of checking activities. Still Hübner et al. (2016), talking about cross-channel return management, describe the situation where “returns can be processed and reworked directly at the store and added to the stores’ inventory afterwards”.

It should be noticed that in phase 2-transportation-the dimension related to the location is also taken into account to show where goods are sent after the collection phase.

The phases have then been combined with the players involved in reverse logistics. As for the phases of reverse logistics in B2c e-commerce, the papers were further analysed looking for references regarding the different actors. Vakulenko et al. (2019) provide a valuable contribution in this sense, depicting an example of an E-customer journey, where 3 distinct actors can be found, namely e-retailers and logistics service providers, besides customers; a similar approach can be found in Chang & Zheng (2014) and in Tang & Gu (2010). These latter sources pinpoint also the chance that a manufacturer/retailer could manage on its own transportation and distribution processes: for a matter of missing economies of scale and experiences effects, it is not common for a firm to follow this approach, thus the need to be supported by specialized logistics service operators. In this instance, even though the logistic service provider will be in the boundaries of the online retailing firm, the number of actors in the process would not change.

Feng and Xie (2006), differently from the abovementioned pieces of literature, distinguish between four different players in returns reverse logistics: online merchant (online retailer/e-tailer), manufacturers, 3rd party provider and customer. Notwithstanding this last classification, this literature review makes use of the first approach, thus the players considered in the process are customers, which buy items online and may ask for returns, online merchants who are in charge of selling items online and manage customer requests and logistic service providers, the actors in charge of managing transportation and distribution. Since online merchants could be both pure-selling operators and manufactures, the first framework with three players, namely online merchants (e-tailers/online retailers), logistics service providers (logistics service operators/3PL), is preferred to the second one, and thus it will be adopted.

The link between actors and phases is well displayed by Hjort et al. (2019), who provide a description of the return process combining phases with actors. Alongside with customer, LSP (logistic service provider) and retailer, the paper considers also service points as players of the process. In the light of this dissertation, however, service points are like attended CDPs (collection and delivery points, as bars, newsagents and supermarkets), thus not being physical actors of the process but means of returning items back.

In the light of process phases and actors classification, the 35 papers under investigation have been carefully scanned: for each paper the different ways of return products have been plugged into the table considering the above mentioned five phases and the three actors involved. As mentioned before, the number of ways recorded exceeds the number of papers analysed because it may happen that one article/paper deals with more than one method to handle returns. The activities players have to carry out in the process have been divided into active, if a physical movement was needed (e.g travel from the depot to the pick-up zone for a logistic service provider), and passive if not. Finally, the accuracy of the description was recorded too: it has be assigned “1” if the description of the activity performed by every single actor in the process was well-specified (e.g. the text clearly states that a customer travel by bike in an not-exclusive tour to reach the nearest parcel locker and return an item), “2” if deducible, “3” if unknown and “no” if not necessary for that specific phase (e.g. considering the home pick up no initial travel has to be performed by consumers, since the pick-up happens in his/her doorstep).

In Table 10 is reported the output of the underlying researching process.

		LOGISTIC PROCESS DRILL DOWN																									
		Phase 0 = PRE RECEIPT				Phase 1= COLLECTION								Phase 2= TRANSPORTATION					Phase 3 = PROCESSING OF RETURNS				PHASE 4 = SHIPMENT TO FINAL DESTINATION				
						Initial travel				Drop Off--> Pick Up																	
Number	Return methodology	Customer	Retailer	LSP	Innovation (Yes/no)	Customer	Retailer	LSP	Innovation (Yes/no)	Customer	Retailer	LSP	Innovation (Yes/no)	Location (Retailer/LSP)	Customer	Retailer	LSP	Innovation (Yes/no)	Customer	Retailer	LSP	Innovation (Yes/no)	Location (Retailer/LSP)	Customer	Retailer	LSP	Innovation (Yes/no)
1	CDP-attended	passive 2	passive 2	no	no	active 1	no	active 1	yes	passive 1	no	passive 1	yes	3	no	no	active 1	yes	no	3	3	3	3	no	3	3	3
2	cross-channel	passive 2	passive 2	no	no	active 1	no	3	yes	passive 1	passive 1	3	yes	3	no	3	3	no	no	3	3	3	3	no	3	3	3
	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
3	home pick-up	passive 1	passive 1	no	no	passive 2	active 1	no	no	passive 2	passive 1	no	no	retailer 1	no	active 1	no	yes	no	passive 1	no	no	retailer 1	no	active 1	3	3
	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	lsp 1	no	no	active 2	no	no	no	passive 1	yes	retailer 1	no	passive 1	active 1	no
4	postal office	passive 1	passive 1	no	no	active 2	no	active 2	yes	passive 1	no	passive 2	yes	retailer 2	no	no	active 2	no	no	passive 2	no	no	retailer 2	no	passive 2	no	no
	cross-channel	passive 1	passive 1	no	no	active 2	no	active 2	yes	passive 2	passive 1	passive 2	yes	retailer 2	no	no	active 2	no	no	passive 2	no	no	retailer 2	no	passive 2	no	no
5	home pick-up	passive 1	passive 1	passive 2	no	passive 1	no	active 2	no	passive 1	no	passive 1	no	lsp 1	no	no	active 1	no	no	passive 1	passive 1	yes	3	no	3	3	3
6	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	retailer 1	no	no	active 1	no	no	3	3	3	3	no	3	3	3
7	home pick-up	passive 1	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 1	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
8	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	3	3	3	no	3	3	3	3	no	3	3	3
	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
9	postal office	passive 1	passive 1	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	retailer 1	no	no	active 2	no	no	passive 1	no	no	3	no	3	3	3
	home pick-up	passive 1	passive 1	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	retailer 1	no	no	active 1	no	no	passive 1	no	no	3	no	3	3	3
	CDP-attended	passive 1	passive 1	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	lsp 2	no	no	active 2	no	no	no	passive 2	no	3	no	3	3	3
10	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
11	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	cross-channel	passive 2	passive 2	no	no	active 2	no	3	yes	passive 2	passive 2	3	yes	3	no	3	3	no	no	3	3	no	3	no	3	3	3
	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
12	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
13	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
14	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
15	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	retailer 1	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	cross-channel	passive 2	passive 2	no	no	active 2	no	3	yes	passive 2	passive 2	3	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
16	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	retailer 2	no	no	active 2	no	no	passive 2	no	no	3	no	3	3	3
17	home pick-up	passive 2	passive 2	no	no	passive 1	active 1	no	no	passive 1	passive 1	no	no	retailer 1	no	active 1	no	yes	no	passive 1	no	no	retailer 1	no	active 1	3	3
	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	no	retailer 1	no	no	active 1	no	no	passive 1	no	no	retailer 1	no	active 1	3	3
	cross-channel	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	passive 2	passive 2	yes	retailer 1	no	no	active 1	yes	no	passive 1	no	no	retailer 1	no	active 1	3	3
18	CDP-unattended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
19	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
20	CDP-unattended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	cross-channel	passive 2	passive 2	no	no	active 2	no	3	yes	passive 2	passive 2	3	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3

		LOGISTIC PROCESS DRILL DOWN																									
		Phase 0 = PRE RECEIPT				Phase 1= COLLECTION								Phase 2= TRANSPORTATION					Phase 3 = PROCESSING OF RETURNS				PHASE 4 = SHIPMENT TO FINAL DESTINATION				
						Initial travel				Drop Off--> Pick Up																	
Number	Return methodology	Customer	Retailer	LSP	Innovation (Yes/no)	Customer	Retailer	LSP	Innovation (Yes/no)	Customer	Retailer	LSP	Innovation (Yes/no)	Location (Retailer/LSP)	Customer	Retailer	LSP	Innovation (Yes/no)	Customer	Retailer	LSP	Innovation (Yes/no)	Location (Retailer/LSP)	Customer	Retailer	LSP	Innovation (Yes/no)
21	postal office	passive 1	passive 1	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	home pick-up	passive 1	passive 1	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	CDP-attended	passive 1	passive 1	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	cross-channel	passive 1	passive 1	no	no	active 2	no	3	yes	passive 2	passive 2	3	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
22	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
23	CDP-unattended	passive 1	passive 1	no	no	active 1	no	no	yes	passive 1	no	no	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
24	CDP-unattended	passive 2	passive 2	no	no	active 2	no	no	yes	passive 2	no	no	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
25	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	3	no	3	3	3	3	no	3	3	3
	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	3	no	3	3	3	3	no	3	3	3
26	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	retailer 1	no	no	active 2	no	no	passive 1	no	no	retailer 1	no	active 1	3	no
	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	retailer 1	no	no	active 2	no	no	passive 1	no	no	retailer 1	no	active 1	3	no
	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	lsp 1	no	no	active 2	no	no	no	passive 1	yes	retailer 1	no	3	active 2	no
	cross-channel	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	passive 2	passive 2	yes	retailer 1	no	no	active 2	no	no	passive 1	no	no	retailer 1	no	active 1	3	no
	cross-channel	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	passive 2	passive 2	yes	retailer 1	no	no	active 2	no	no	passive 1	no	no	retailer 1	no	active 1	3	no
	cross-channel	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	passive 2	passive 2	yes	lsp 1	no	no	active 2	no	no	no	passive 1	yes	retailer 1	no	3	active 2	no
	cross-channel	passive 2	passive 2	no	no	active 2	no	no	yes	passive 2	passive 1	no	yes	no	no	no	no	no	no	passive 1	no	no	no	no	no	no	no
27	cross-channel	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	passive 2	passive 2	yes	retailer 1	no	no	active 2	no	no	passive 2	no	no	3	no	3	3	3
28	home pick-up	passive 2	passive 2	passive 2	no	passive 1	no	active 1	no	passive 1	no	passive 1	no	lsp 1	no	no	active 1	no	no	3	3	3	3	no	3	3	3
29	cross-channel	passive 2	passive 2	no	no	active 2	no	no	yes	passive 2	passive 1	no	yes	no	no	no	no	no	no	passive 1	no	no	retailer 1	no	active 1	no	no
	cross-channel	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	passive 1	passive 2	yes	3	no	no	active 2	no	no	3	3	3	retailer 1	no	active 1	no	no
	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	retailer 1	no	active 1	no	no
	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	retailer 1	no	active 1	no	no
30	home pick-up	passive 1	no	passive 2	yes	passive 2	no	active 2	no	passive 2	no	passive 2	no	retailer 1	no	no	active 2	no	no	3	3	3	3	no	3	3	3
31	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	cross-channel	passive 2	passive 2	no	no	active 2	no	3	yes	passive 2	passive 2	3	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
	postal office	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
32	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	retailer 2	no	no	active 2	no	no	passive 2	no	no	3	no	3	3	3
	cross-channel	passive 2	passive 2	no	no	active 2	no	no	yes	passive 2	passive 2	no	yes	no	no	no	no	no	no	passive 2	no	no	3	no	3	3	3
33	home pick-up	passive 2	passive 2	passive 2	no	passive 2	no	active 2	no	passive 2	no	passive 2	no	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	CDP-unattended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
	CDP-attended	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3
34	cross-channel	passive 2	passive 2	no	no	active 2	no	3	yes	passive 2	passive 2	3	yes	3	no	3	3	3	no	3	3	3	3	no	3	3	3
	postal office	passive 1	passive 1	no	no	active 2	no	active 2	yes	passive 2	no	passive 2	yes	3	no	no	active 2	3	no	3	3	3	3	no	3	3	3
35	cross-channel	passive 2	passive 2	no	no	active 2	no	no	yes	passive 2	passive 2	no	yes	no	no	no	no	no	no	passive 2	no	no	3	no	3	3	3
	cross-channel	passive 2	passive 2	no	no	active 2	no	active 2	yes	passive 2	passive 2	passive 2	yes	3	no	no	active 2	no	no	3	3	3	3	no	3	3	3

Table 10: Expansion of the logistic process in all the papers

Coming to the findings of this last step of the literature review, the main takeaways phase by phase are:

- *Phase 0* is always either well explained or deducible (most of the cases). Since the focus of this dissertation is on the logistic processes, the pre-receipt phase proves not to be so insightful: it is assumed that every time someone seeks to return an item, the reverse logistic process starts. Nevertheless, for a matter of completeness it is worth adding also this part of the process.
- *Phase 1* is either well explained or deducible: just in few instances the role of each actor is unknown. Such a phase can be considered as the discriminating factor of each return way.
- *Phase 2*: in 61% of the cases this phase is not described in a complete way, a pattern that can be found also in the following stages. Plus, it should be noted that the location where the returned item is sent to is unknown in the vast majority of the papers.
- *Phase 3:* processing of returns is missing in 66% of the instances.
- *Phase 4:* the trend of not specifying the phase goes on steadily: in 75% of the occurrences, "shipment to final destination" is completely unknown.

It should be pointed out that the majority of papers studies and develops frameworks belonging to phase 1. Indeed, the collection phase could be handled in very different ways (i.e. via home pick-up service, parcel lockers among the others), thus increasing the possibilities to provide relevant contribution to practitioners, which could choose the modes that fit the most their business models. Eventually, logistic service providers could improve tremendously the efficiency of their operations, while merchants could choose the modes that better satisfy customers' needs. Very little attention is paid to other parts of the process from an academic perspective: probably it is not feasible to carry out this process (i.e. companies could not disclose data and information on their processes for the sake of confidentiality).

2.3.9 Process mapping

To provide the reader with a visual overview of the process showing phases and actors and to allow an easier comparison, the different ways to return goods presented in the introduction alongside with the considerations of Section 2.3.8 have been graphically mapped for the sake of completeness via *app.diagram.net*, an online diagram software for making flowcharts, process diagrams, org charts, UML, ER and network diagrams.

Legend

- In the columns of the charts the five phases are shown (pre-receipt, collection, transportation, processing of returns and shipment to final destination), while actors have been placed row-wise.
- The colours refer to the different locations where players operate:

I. green for customers' house (for the sake of simplicity, as customer's location, this literature review reports just houses. However, location could also be working places, since e-commerce goods could be shipped in whichever location);

II. orange in the e-tailers part to consider their operating locations, namely shop (to account for the omnichannel strategy), DC (distribution centre) and WH (warehouse);

III. violet for logistics service providers' DC (distribution centre);

IV. blue specifies the "other location" that could be used in the process of returning an item, namely attended and unattended collection points (parcel lockers, postal office, bars, newsagent, supermarkets …) which are not directly controlled by the aforementioned three players of the process.

- Solid lines represent the physical flow of the good within the network, which moves from one location to another, whereas dotted lines point the information flows out.
- Continuous-lines rectangular shapes refer to physical activities (i.e. customers who have to prepare the box or 3PL operator who has to locate and reach client's place), while dotted-lines shapes relates to non-physical ones (i.e. customer who places a return request, client who receives a return label, a warning, a refund).
- Four small clip-arts placed on the boundaries of activity shapes complete the maps:

I. boxes stand for returning items ready to pass through the reverse logistic flow;

II. clocks point concurrent activities out;

III. triangles are the usual representation of distribution centres;

IV. shirts denote checking activities put in place in the process.

- Shaded areas have then been introduced to show the parts of the process that do not have a direct reference in the literature: these sections have been inferred by considering additional sources like reports and merchants' website as for the phases of the process, earlier in this chapter.

The personal experience of the authors in returning an item comes handy too to complete the frameworks, because in the last years they had the chance to test themselves what returning an item means and how it works.

Maps

Below the graphical representation of the maps developed alongside with a brief qualification of the different methods to handle returning items is provided.

1. HOME PICK-UP

1.1. Non - exclusive home pick up tour

➔ *baseline scenario in the light of dissertation. Non-exclusive means that 3PLs, professional firms, arrange tour with both deliveries and pick-ups*

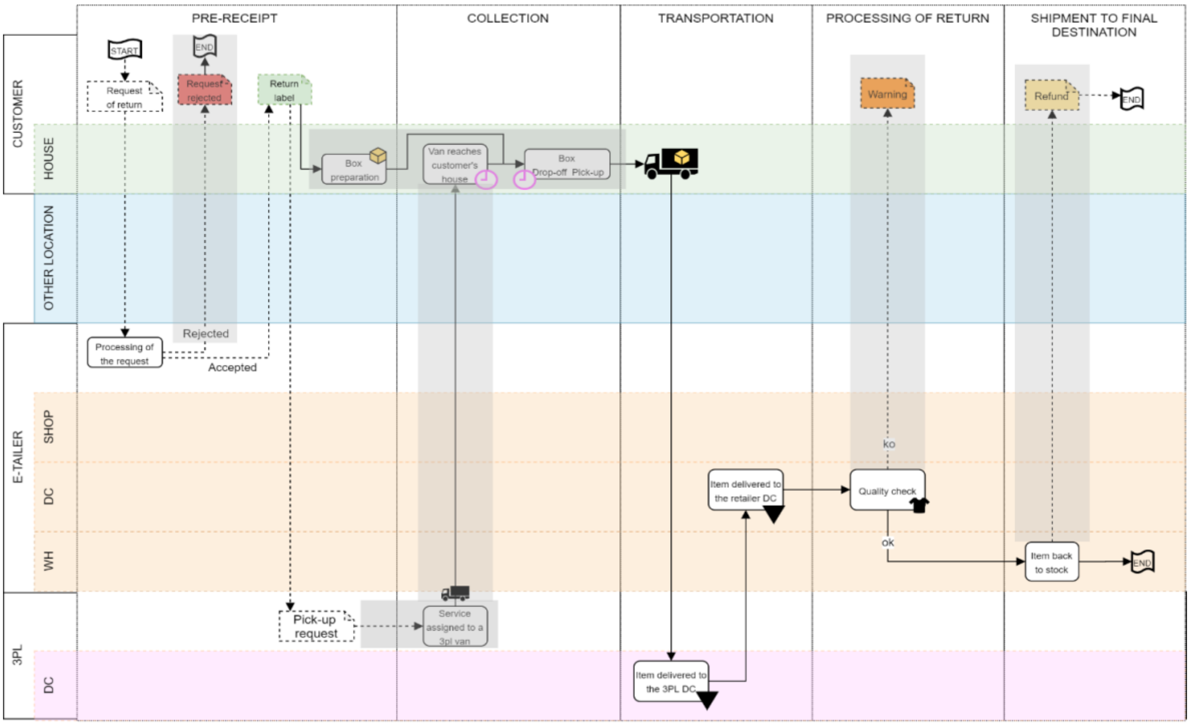


Figure 4: Mapping of non-exclusive home pick-up tour

1.2. Non – exclusive home pick up tour managed by the retailer

➔ *compared to the baseline scenario, in this case just two players are present, since retailers manage on their own both deliveries and returns*

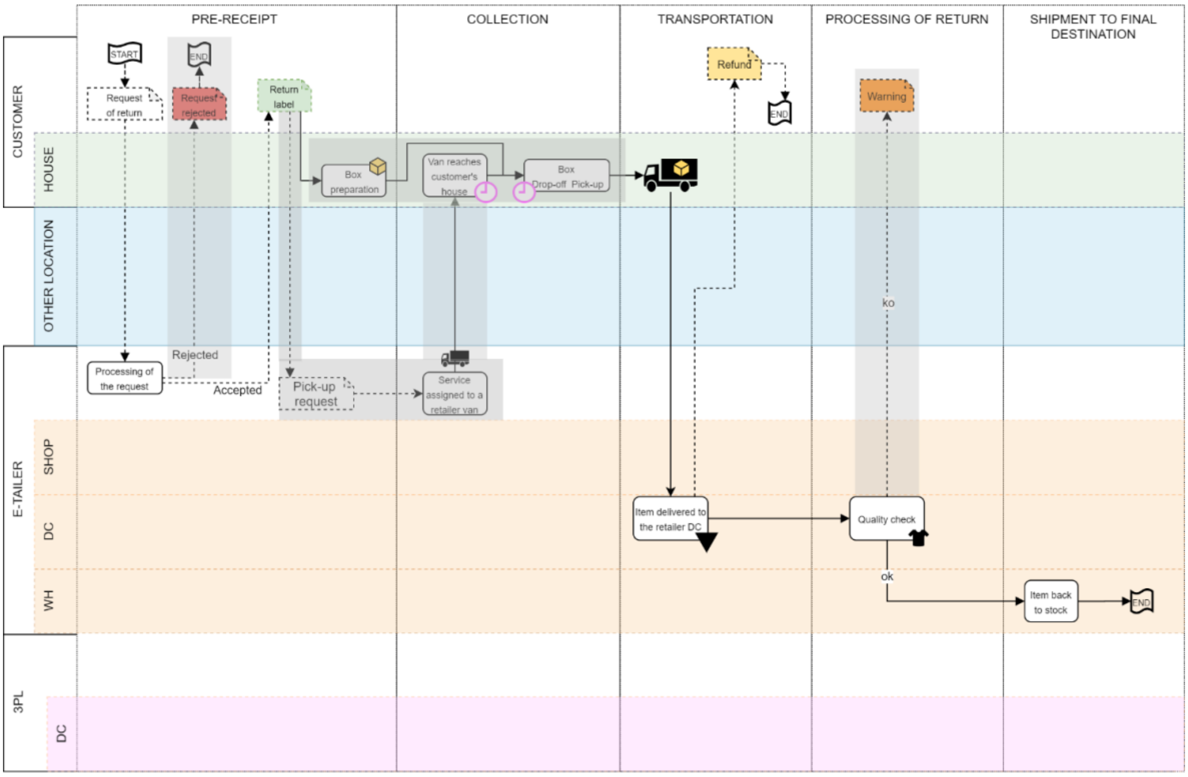


Figure 5: Mapping of non-exclusive home pick up tour managed by the retailer

2. CDP

2.1. Unattended

➔ *returns managed by means of unmanned/automatic collection and delivery points, namely parcel lockers*

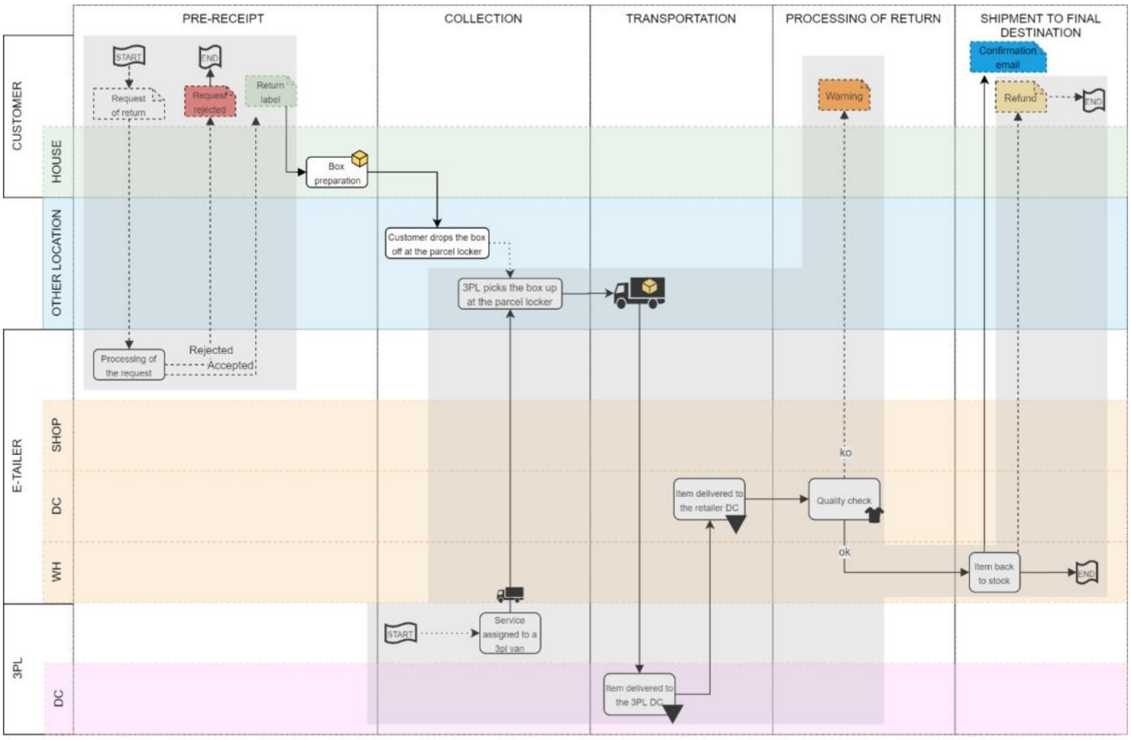


Figure 6: Mapping of unatteded CDP

2.2. Attended

➔ *returns managed by means of manned/supervised collection and delivery points, as bars, supermarkets, service points*

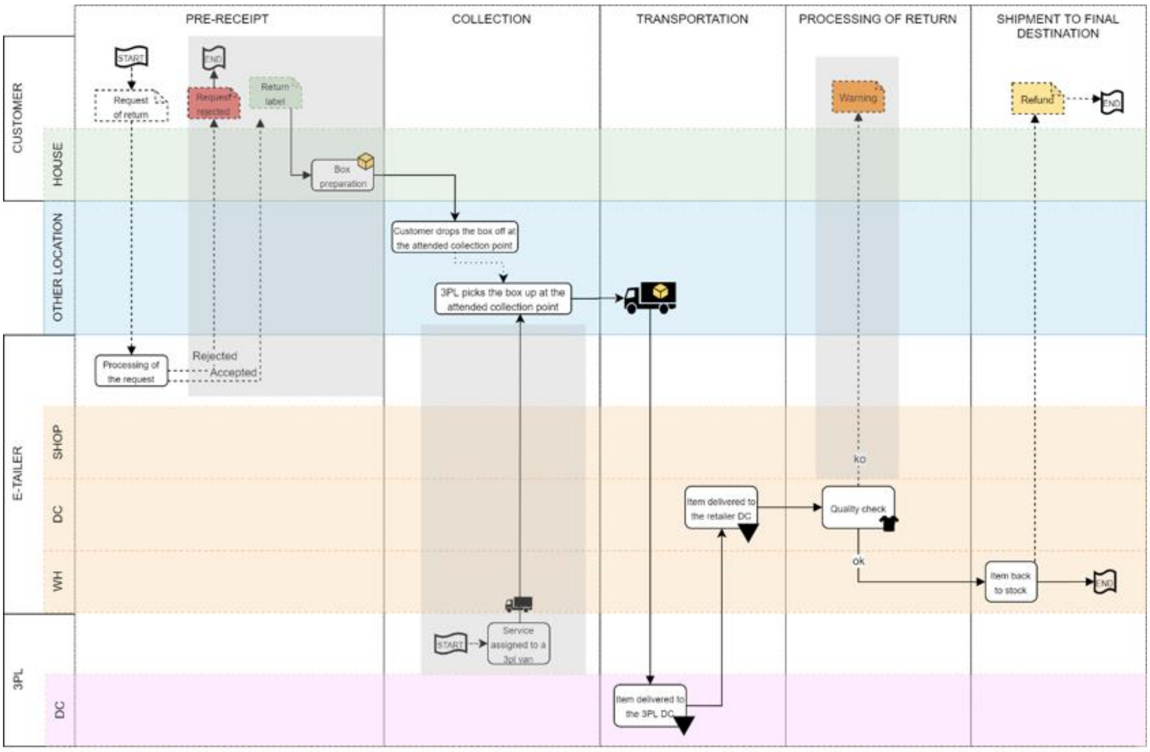


Figure 7: Mapping of attended CDP

2.3. Postal office

➔ *returns are brought by customers to postal offices. It differs from the others collection and delivery points because the personnel are professional*

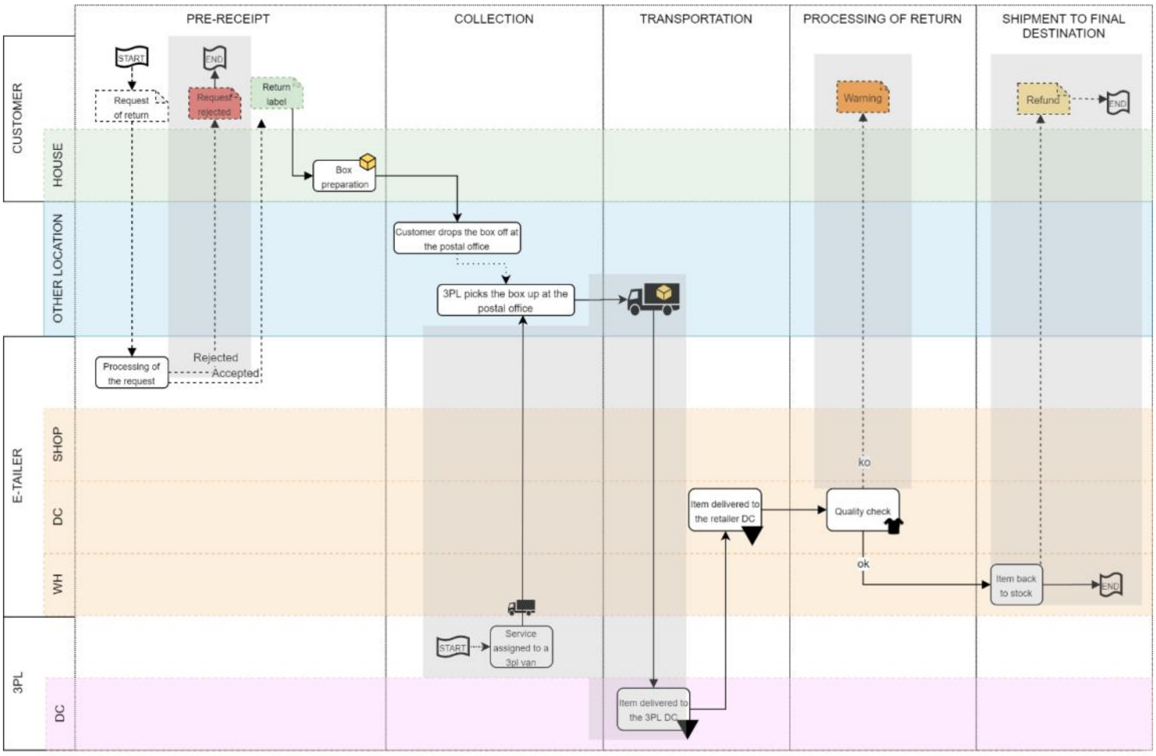


Figure 8: Mapping of postal office

3. CROSS-CHANNEL (omnichannel retailing)

3.1. Cross-Channel with quality check at the shop

➔ *quality checking activities are carried out in e-tailer's shop*

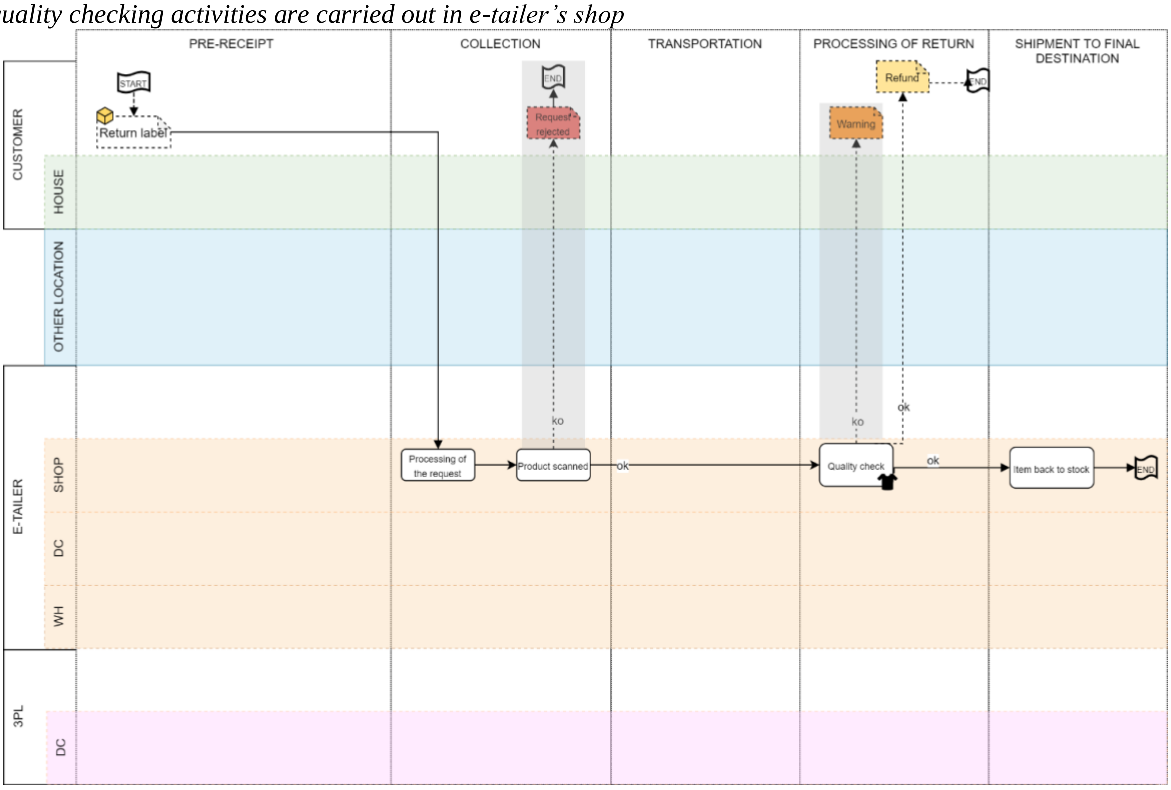


Figure 9: Mapping of Cross-Channel with quality check at the shop

3.2. Cross-Channel with quality check at retailer's DC and refund at the shop

➔ *shop assistants are entitled to give credit to customer in store. The product is sent back to a returns DC for processing*

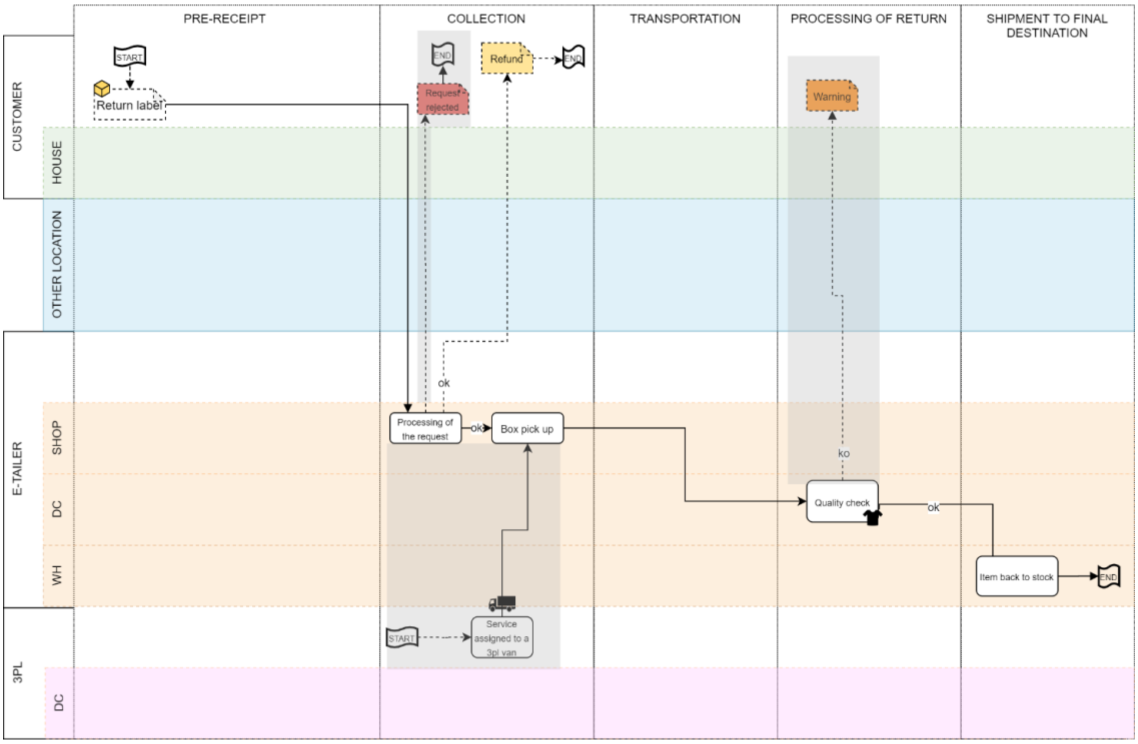


Figure 10: Mapping of Cross-Channel with quality check at the retailer's DC and refund at the shop

3.3. Cross-Channel with quality check at retailer's DC and refund after quality check

➔ *shop assistants are not entitled to give credit to customer in store. The product is sent to a returns DC for processing. Credit, if applicable, is legitimated afterwards.*

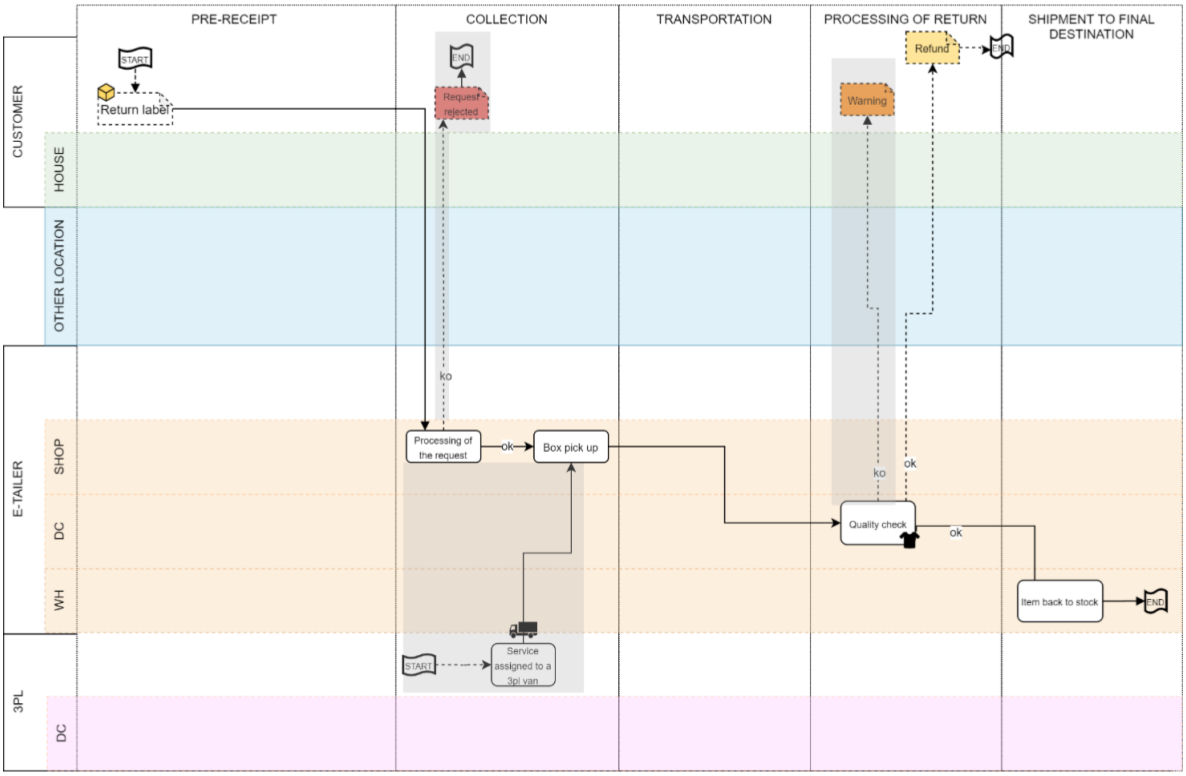


Figure 11: Mapping of Cross-Channel with quality check at retailer's DC and refund after quality check

4. OUTSOURCING (quality checking activities)

4.1. Outsourcing of quality checking activities, e-tailer in the acceptance phase, home pick-up

➔ *sellers approve customer request and delegate checking activities to external service providers*

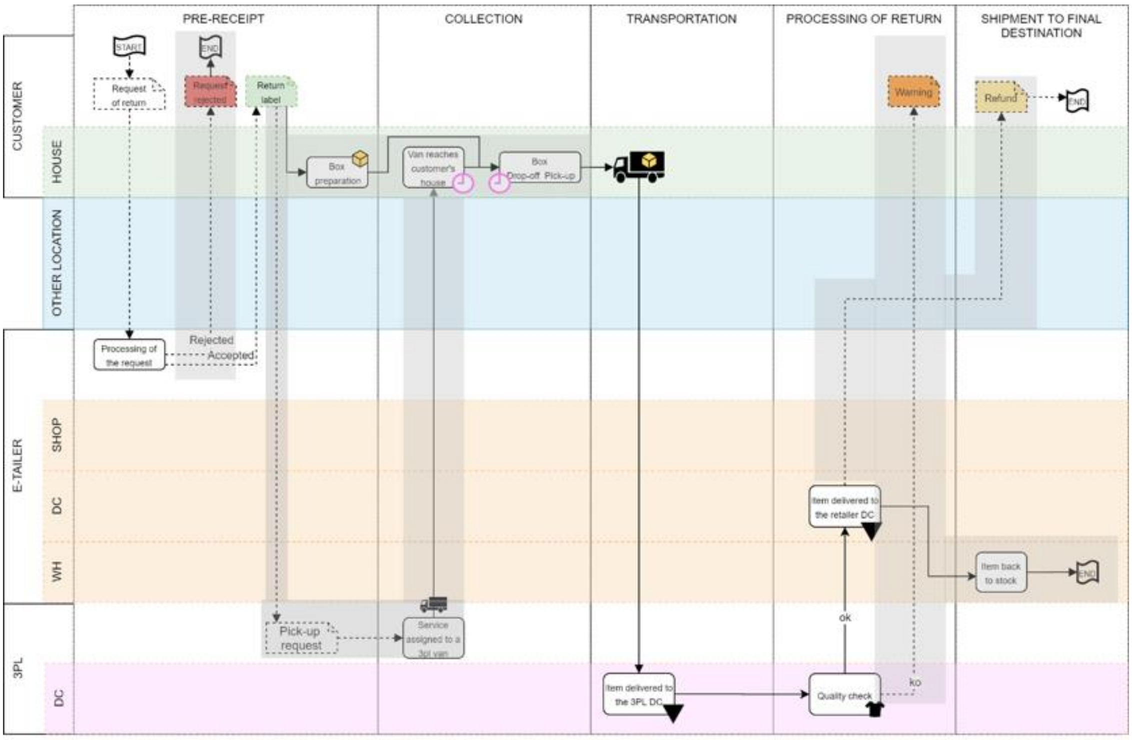


Figure 12: Mapping of outsourcing of quality checking activities, e-tailer in the acceptance phase, home pick-up

4.2. Outsourcing of quality checking activities, 3PL in the acceptance phase, home pick-up

➔ *customers looking for returning goods have to directly relate with 3PL, who will decide whether it is permitted according to the criterions defined by e-commerce enterprises.*

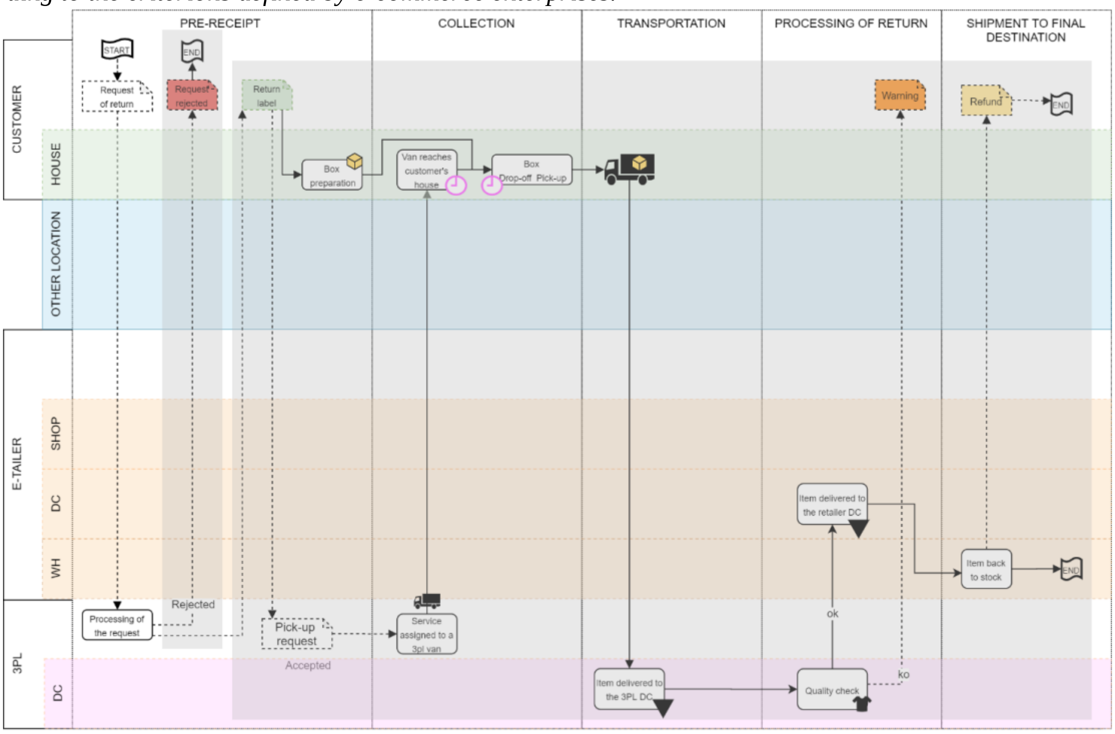


Figure 13: Mapping of outsourcing of quality checking activities, 3PL in the acceptance phase, home pick-up

4.3. Outsourcing of quality checking activities, cross-channel

➔ *return processing locations are managed by service providers. This applies when return handling processes become too work-intensive and retailer capacity is scarce*

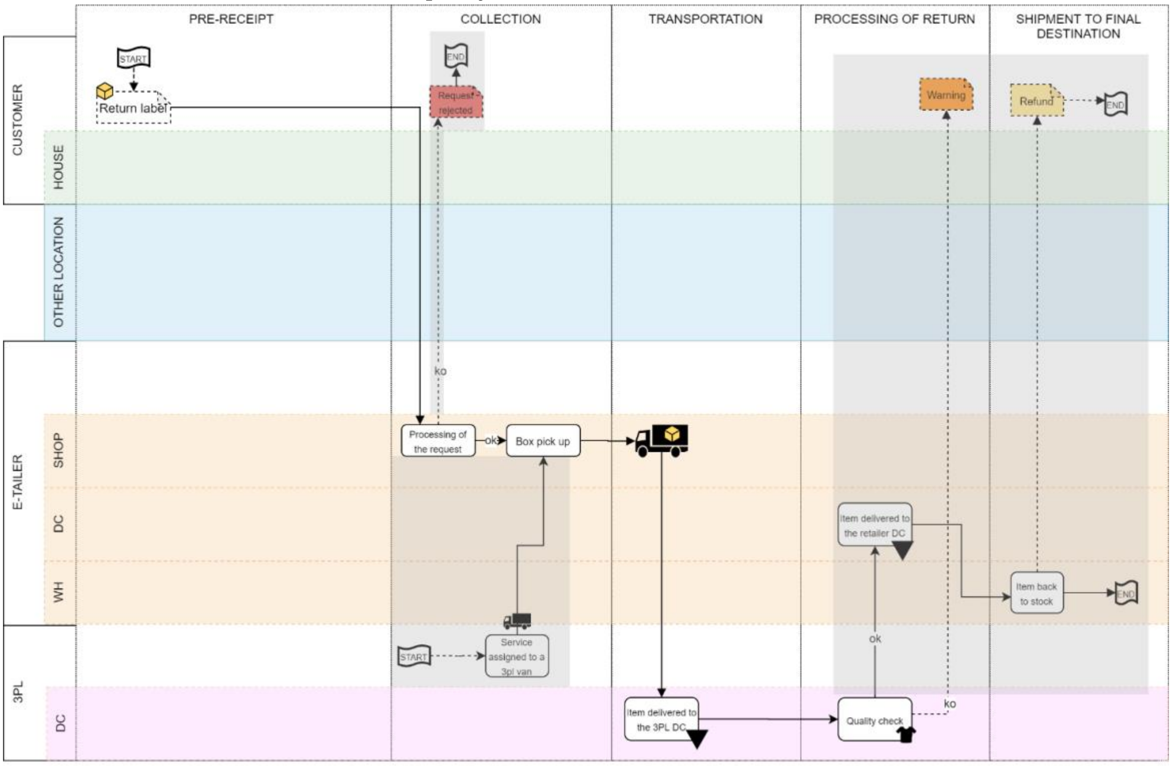


Figure 14: Outsourcing of quality checking activities, cross-channel

5. CROWDSOURCING + ATTENDED

5.1. Crowdsourced innovative transportation, attended

➔ *citywide returned goods collection, using a shops-based collection network and taxis as transportation means*

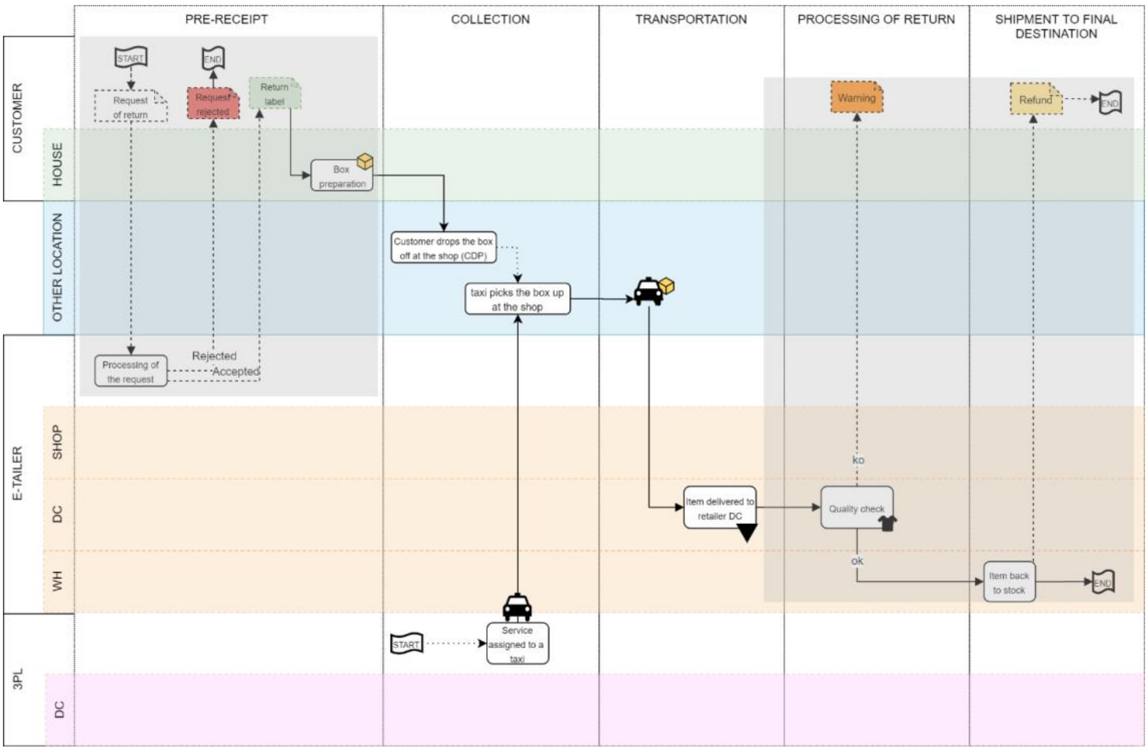


Figure 15: Crowdsourced innovative transportation, attended

2.4 Conclusion and gaps

This literature review provides the basis for this dissertation: it gives an overview of the existing academic literature on reverse logistics B2c in e-commerce with a special focus on the return logistics processes, it sheds light on research gaps which will result in the research questions this work would answer and discuss. Following a common approach to many literature reviews, standard information of the 35 selected articles have been recorded. Source, year of online publication and country figures have been in line with expectations. In particular, sources are quite broad, from economics and engineering to computer science, business and marketing journals as the e-commerce field would have suggested ex-ante. Year of online publication shows an increasing trend which could be explained by the surge of e-commerce in the last years, while the country where researchers' university is placed seems to be linked to e-commerce volumes, as inferable by China and USA cases. For what concerns the industry, in most of the cases the scholars do not mention any sector in particular: generalization willingness could explain this pattern. Nevertheless, fashion sector often deserves attention among scholars, probably due to the high incidence of return in such a field. Coming to the research methods under which the papers can be labelled, empirical and analytical methodologies are the most used ones, although no one stands over the others. The classification core versus ancillary, then, was thought to expand a "content-based" evaluation: it is noteworthy that just in one third of the cases reverse logistics is discussed as the central theme of the article. It may be due to the wish to provide a complete snapshot of the B2c e-commerce, which embeds both last mile delivery and reverse logistics.

Within the different purposes of each paper, in the analytical cluster of articles a lack of cost considerations and quantification is visible. Differently from the wide and broad literature on last mile delivery, there is no proof of researchers who have tried to assess which is the cost (both in monetary and environmental sense) of returning an item: the first gap this literature review recognized. As far as the different ways to return products is concerned, the literature is quite scarce. There is neither a detailed and complete description of the available modes to return unwanted items back to the origins (second gap) nor cutting-edge solutions (i.e. drones, subways …) are discussed (third gap). Finally, following the last unit of analysis on the phases of the process, it is worth mentioning that most of the papers does not consider what happens after the collection (fourth gap), which could derive from the impossibility to provide generalized contributions and/or insightful results. Based on this analysis, authors' understanding is that returns management literature in B2c e-commerce (except from marketing consideration on return policy and its impact on consumers' purchase behaviours and decisions) is underdeveloped compared to the broad literature on last-mile delivery. It could be due to the lower volumes of goods and thus profits at stake in reverse logistics on the one hand, but also to the assumption that what occurs in a process (forward) have to hold in its counterpart (reverse) on the other.

To conclude, the noteworthy gaps this literature review has spotted are:

1. Models for assessing the cost (monetary and environmental) of returning items in B2c e-commerce
2. Current state-of-art description of the methods consumers have to return items and comparison/integration with last-mile delivery
3. Use of innovative ways to return good in reverse logistics
4. Holistic description of the return management process

It should be pointed out the great contribution this literature review is providing to readers with Section 2.3.9 process mapping: the detailed maps of the different ways to return products in B2c e-commerce grounded on peer-reviewed academic papers and secondary sources analysis. Besides expanding the knowledge of this e-commerce retailing facet with all the interactions between players, phases and locations, the modular shape of the maps can be used as starting points to ground models and schema which could improve even further reverse logistics procedures. Undoubtedly, this might also be applied to the other side of reverse logistics, namely forward logistics/last-mile delivery.

3. RESEARCH QUESTIONS, OBJECTIVES AND METHODOLOGY

In this chapter, the reader is provided with the research questions this dissertation would like to answer shedding the light on the objectives the candidates are willing to achieve (Section 3.1). The methodology deployed in the thesis is then described and discussed both from a theoretical and practical perspective (Section 3.2).

3.1 Research questions and objectives

To introduce research questions, it is worth getting literature gaps back since research questions are developed on the basis of existent gaps. The four gaps, as presented in the last section, concern the total absence/lack of:

1. Models for assessing the cost (monetary and environmental) of returning items in B2c e-commerce
2. Current state-of-art description of the methods consumers have to return items and comparison/integration with last-mile delivery
3. Studies on innovative ways to return good in reverse logistics
4. Holistic description of the return management process

Coming to the choice of the gaps to focus on, candidates have decided to investigate gap number 1: despite being likely the most challenging one from a conceptual point of view, developing models for cost assessment in returning items in B2c e-commerce was deemed insightful not only for academia and practitioners, but also for candidates themselves who had the chance to test their skills on a diversified engineering task, which requires not only a strong analytical mindset, but also great problem setting and solving expertise: a blend of hard and soft skills highly reusable in a working environment. Plus, the possibility to link the cost assessment to a broad array of different topics as profit maximisation (i.e. e-tailers and logistic service providers efficiency enhancement), sustainability (i.e. reduction of pollution, traffic jams), complex logistics and distribution decisions (e.g. where to place distribution centres to fulfil demand, how to schedule and organize forward/reverse tours) led the candidates to elaborate more on this literature gap. The choice to focus mostly on gap number 1 is deemed to be the right option considering the nature of the master thesis, a dissertation, authors would like to arrange, whose goal is the development of "new knowledge or innovative approaches about a topic of relevant interest for the scientific and practitioner communities". It is worth underlying that the contribution provided by this work has to be read not only in the light of the numerical results achieved but also on the approach the candidates have used to frame and study the topic.

Despite the choice to focus on gap number 1, it should be noted that readers have been provided with a great understanding of the topic under investigation. On the basis of the literature review, indeed, the models to handle returning items have been described and mapped, thus partially filling gap number 2 because a detailed comparison between last-mile delivery and reverse logistics is not supplied. The same holds for gap number 4 given the research on phases and actors carried out before. A sort of holistic description of the return process in B2c e-commerce is also given in the introduction (Chapter 1.2 and 1.3) of this dissertation (i.e. all the reasoning related to the return policies e-clients could use when buying online).
As far as gap number 3 - use of innovative ways to return good in reverse logistics – readers are given a snapshot of traditional and cutting-edge solutions currently available (Chapter 1.6), thus again partially bridging the gap. As regards gaps number 2,3 and 4, it is worth noticing that differences between forward and reverse logistics from a process perspective are not huge: the discriminating factors revolve around the direction of the flows, which is opposite in forward and reverse logistics as the names suggest, and the volume of the flow, lower in the case of reverse logistics. This last consideration alongside with the willingness to provide valuable, innovative and practical contribution endorses the choice to dig into gap number 1.

Gap number 1 is now translated in the research questions this master thesis is going to answer in the next chapters.

RQ1: Which are the elements that impact the most in the cost of returning an item?

RQ2: To what extent the cost of returning an item differs from one return methodology to another?

In developing the research questions based on gap number 1, candidates have decided to focus on the economical side of the cost, for the sake of conciseness, although the research questions and the subsequent procedures developed to answer them can be framed to consider the environmental cost as well.
The final purpose of this dissertation has to be read in the light of the gap addressed and corresponding research questions. The authors are willing to develop an innovative and dynamic framework that on the one side could enhance existing knowledge on reverse logistics in B2c e-commerce by means of truthful relationships input variables-return unitary cost tested across different scenarios, ideally following the package from customers' place back to the point of origin (i.e. couriers' hub, logistic service providers' distribution centres), but on the other it could perform as a practical tool for practitioners, logistic service providers (i.e. express couriers) above all, who always strive to increase their process efficiency. The development of a modular and customizable schema that could be used

depending on situations and peculiarities different stakeholders could face is deemed to be the right option to fulfil this goal. Plus, as mentioned before, the novelty of this dissertation lies not only on the results achieved but also on the process deployed to get to those.

3.2 Methodology

To accomplish the above-mentioned purpose, candidates decided to follow a modelling and simulation approach. Thanks to modelling, it is possible to represent a real and complex system without any physical interactions, focusing on what matters the most, indeed it is not possible to embody all the facets of the real world, due to computational time constraints on one side and huge complexity on the other. Despite the need of simplifications and assumptions to build a representative model of the real world and provide practical contribution, if models are combined with simulation, the achievable result would be greater, thus the decision to employ both. As a matter of fact, simulation allows authors to perform what-if type of analysis: different scenarios can be tested several times without interacting with the physical world. In this exercise, most of the times the criticalities lie in the availability and reliability of data: for confidentiality reasons, indeed, companies are not willing to disclose data on their processes and operations, because of high competitive level they have often to face. For this latter reason, the choice to use a modelling and simulation approach seems to be the proper one for practitioners: based on the data they plug into the model, they could understand where to work to improve efficiency and effectiveness. Authors have coded a modular and customizable algorithm, whose structure could fit different situations; depending on the available data users have then, the model could yield the most. So, the better the input data in terms of quality and quantity, the better the output and the possibility to improve procedures and processes.

Beside this theoretical background, the choice of the right software is fundamental to achieve the best results, so authors end up with R software "a system for statistical computation and graphics which provides, among other things, a programming language, high level graphics, interfaces to other languages and debugging facilities."[13] and RStudio as the integrated development environment for R. The determinants of this resolution have been the following:

- *Statistical computing.* R is mostly known as a statistical software; in this regard it stands out all the other programming languages.
- *Simulation.* R allows simulating different scenarios, one of the key requirements in the development and deployment of models. As input data for simulation, R can even consider

[13] https://cran.r-project.org/doc/manuals/r-release/R-lang.html#Introduction

statistical quantity, quantity that follows some statistical distribution (i.e. Normal, Pert, Uniform).

- *Support.* Users benefit from an unbelievable support on internet: original documentation, academic notes, specialized blogs and enthusiast websites provide a great support for everyone is willing to exploit R as a modelling and simulation tool.
- *Customization.* R has a huge variety of packages, currently more than 10000, which are set of functions that covers countless situations and sectors.
- *Visual representations.* With R, users can build engaging and informative graphs and plots which could enrich and complete the analysis, but also grab the audience.

For the sake of completeness, it should be added that R is considered by many difficult to use, slow, unsafe and not suitable for handling big data. Nevertheless, the focus of the thesis is not developing the most efficient algorithm from an IT perspective but assessing the cost of returning an item in B2c e-commerce, simulate scenarios on the basis of different input data and study the results, therefore the choice of the software seems to be reasonable and effective to provide factual contributions.
Besides the development of the algorithm and the visual analysis carried out with R, this dissertation makes use of Microsoft Excel to handle databases of input data and output spreadsheets.

As far as the approach embedded into modelling and simulation is concerned, this can be described as follows. First of all, a great emphasis has been placed on the problem setting phase, where relationships among variables have been investigated and introduced and a basic schema of the model has been built. Later on, candidates have tried to collect as much as possible data to be plugged into the algorithm: by doing this, it has been possible to appreciate criticalities, if any, and consequentially correct the model. Afterwards, the problem-solving phase has taken place which could be described as a trial-and-error approach: three different models have been introduced. The first one was very rough since too many simplifications have been used thus obtaining counterintuitive results; despite the unsuccess, however, the authors had the chance to better familiarize with the programming language. To overcome the imprecision of the first approach, two alternatives have been coded: a clustering algorithm based on the k-means approach and a “constrained” methodology. Both of them hold pros and cons, therefore the final decision has been to merge the two approaches one another in a sort of “time constrained k-means clustering” algorithm, which makes use of k-means clustering as baseline with time correction/constraint. The code developed to fulfil the goal of the dissertation will be widely discussed in the next chapter (Chapter 4), where the model will be introduced and explained. In Chapter 5, model will be tested through simulation whereas results will be widely analysed shedding the light on the contribution this dissertation would like to get to (Chapter 6).

4. MODEL DEVELOPMENT

This chapter is intended to explain in detail all the building blocks of the empirical model developed to study the return unitary cost in different scenarios: traditional home delivery/pick-up tours (TRADITIONAL in brief), exclusive home and parcel locker tours (EXCLUSIVE) and mixed home and parcel locker tours (MIXED). The word "tour", synonym with mission, indicates the trip one single van belonging to a certain express courier company (3PL) performs: according to the number of clients' orders to process daily and the relative market share of one specific courier, then, more than one missions (and so vans/operators of a single firm) can be activated to satisfy customers' request on a daily basis.

Three sections will follow (Figure 16): Section 4.1 aims at deepening the input variables selected, Section 4.2 provides a full description of the algorithm and Section 4.3 provides the output resulting from the model.

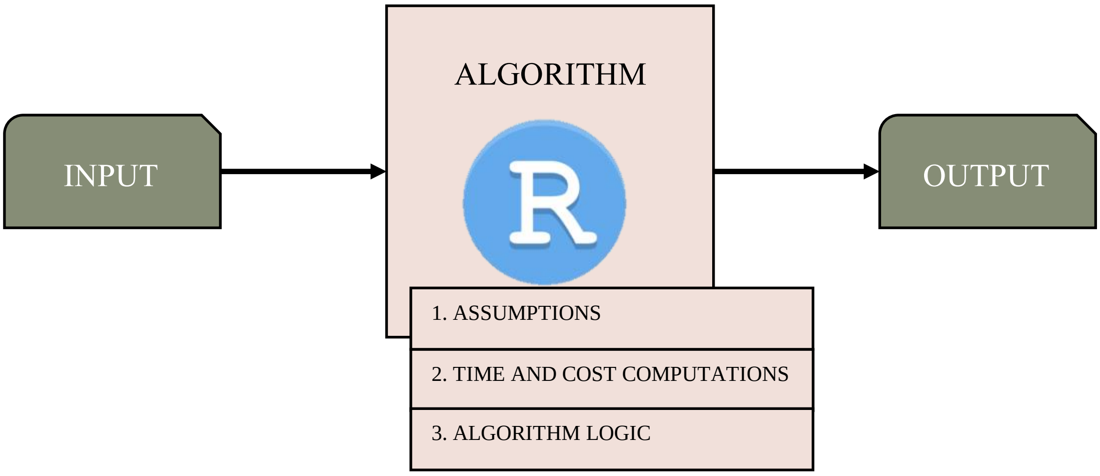


Figure 16: Flow for Section 4

The model makes use of the following scenarios:

- *SCENARIO 1 - BASELINE: traditional home delivery/pick-up tour (TRADITIONAL)*

  This scenario represents the traditional delivery and return methodology exploited by e-commerce B2c and consequently works as starting point and baseline scenario for investigating further delivery and return methods.

  In this analysis it is supposed that customers can only choose this methodology, no other delivery and return ways are available: therefore, the courier visits exclusively home locations, where home locations refer not only to residential addresses but also to other locations whose return process is the same as for home locations, such as offices, commercial activities and whatever different place the customer decides to schedule its delivery/pick-up.

Then the dissertation investigates different possibilities given to customers in receiving or sending online shopping purchases. Between the return ways coming from the literature review analysis beforehand presented, the choice of the authors was to focus on the parcel locker, an unattended collection and delivery point, whose representative modelling can be implemented for attended CDPs, like courier hubs, bars, supermarkets and others. The introduction of parcel lockers will be managed in two different ways, as explained in scenarios 2 and 3:

- *SCENARIO 2: exclusive home-parcel locker tour (EXCLUSIVE)*
  In the second scenario the tours related to one single express courier company will be differentiated in missions involving only home locations (with the approximation to other non-residential addresses as deepened before) and other tours visiting exclusively parcel lockers locations. As an example, a logistic service provider will organize a certain number of delivery/return missions/tours (one mission equal to one van) depending on the demand levels, under the assumption that each mission involves only one delivery/return method either parcel locker way or traditional home delivery-pick up.

- *SCENARIO 3: mixed home-parcel locker tour (MIXED)*
  Differently from scenario 2, within one courier tour both parcel locker locations and home locations can be visited by the single van, thus relaxing the exclusivity assumption.

In order to develop the model presented in this chapter, the background knowledge on the topic given in the literature review was fundamental. Relying on the map drawings provided in Section 2.3.9, the focus of the model will be fully on "Collection" phase and on "Transportation" one (until the first courier hub): the lack of information concerning the remaining parts of the process made impossible to include the other phases in the model.
The mappings clearly highlighted activities, actors and roles: the perspective adopted by the model is the one of the logistics service providers, therefore, only its related activities will be modelled, neglecting the perspectives of both customers and e-tailers. Being customers' behaviors too difficult and complex to be investigated, because affected by a wide range of determinants, it was decided to focus only on the 3PL point of view, whose selected activities are: travelling to reach the drop-off/pick-up area, travelling within the delivery area between the different locations (home or parcel locker according to the scenario), operation activities to deliver or collect items in the different locations and then travelling back to the starting point (courier's hub).

4.1 Input

In this paragraph all the input variables used to build the model are presented, defined and linked to their units of measurement. These variables are classified in three macro categories according to the typology of factors influencing them:

- *Population density related:* the first category takes into account all the variables related to a specific geographical area, whose proxy can be the population density**,** so the ones whose values are strongly related to the infrastructural and demographical features of a specific territory (i.e. share of daily orders to be managed, locations corresponding to customers' homes, both in terms of quantity and spatial distribution, number of boxes to be delivered/retrieved in a single location…)
- *Logistics service provider related:* the second category of variables, instead, is affected by the logistics service provider operational choices. These are related to their procedures for picking-up/delivering orders and strategical policies.
- *Independent variables:* the third category includes independent variables that cannot be modified by logistics service providers as the speed of the van, urban layout and uncertainty dependent, and the percentage of returns to be managed over the total number of boxes, customer behavior and e-tailer policy dependent.

In Table 11 a full description of input variables is provided to the reader. Each variable will be defined and linked to its unit of measurement.

Category	Number	Input Variable	Definition	Unit of measurement
1st category Population density related	1	E-commerce sales share	Ratio between the number of locations to be visited daily on the total locations eligible in the geographical area	%
	2	Boxes per stop	Number of boxes to be delivered/returned in a single address	Boxes/stop
	3	Speed	AVG speed of the whole mission (perspective: van).	Km/h
2nd category Logistics service provider related	4	Courier Hourly Salary	Hourly salary of an express courier driving a van with category B driving license	€/h
	5	Home delivery time	Time needed for delivering the package in a home location (time needed to move from the parking lot to the doorstep is not included)	Min

	6	Home return time	Time needed for picking-up the package in a home location (time needed to move from the parking lot to the doorstep is not included)	Min
	7	Locker delivery/return time	Time needed for delivering/picking-up one box in a locker location	Min
	8	Distance to reach the drop-off/pick-up zone	Distance between the courier hub and the zone where the courier will perform his tour	Km
	9	Cost van ACI	Cost per kilometer travelled	€/km
3rd category Independent variables	10	Available compartments	Maximum number of compartments available per parcel locker	Boxes/locker
	11	Parcel locker share	Percentage of orders managed via parcel lockers	%
	12	Return Percentage	Ratio of returned boxes on the total number of boxes to be managed per tour (returns + deliveries)	%
	13	Market courier share	Percentage of orders managed by a specific courier company over the total number of orders to be managed per day	%
	14	Geolocated Addresses	List of all the possible locations, expressed through a couple of geographical coordinates (long; lat) eligible for delivery/pick-up requests	WGS84

Table 11: Input variables classification and definition

Starting from these input variables the algorithm is able to compute the return unitary cost in the three scenarios, as it will be explained in the following paragraph.

4.2 Algorithm

As anticipated, the goal of the algorithm is to compute the return unitary cost considering three different scenarios (TRADITIONAL, EXCLUSIVE and MIXED). The procedure to develop the model was to find relationships between the input variables: building blocks of formulas to rely on in order to reach the ultimate objective.

This chapter is structured as follows: Section 4.2.1 states the assumptions made, Section 4.2.2 explains time and cost computations, while Section 4.2.3 the algorithm logic.

4.2.1 Assumptions

For the sake of simplicity, some assumptions were made before entering the model development:

- The courier delivers/picks-up only one item from one customer.
  If a customer orders more items in the same online purchase order, these items are included within the same packaging box. (1 box = 1 client)
- Time windows are not taken into considerations when scheduling courier shifts.
- There are not couriers' tours dedicated to deliveries and returns (dedicated return tour): in each courier tour there is a certain percentage of deliveries and a complementary percentage of returns. This reasonable assumption has been justified by an express-courier-manager candidates had the chance to talk with. According to this latter, managing returns with dedicated tours is not an option for a matter of low volume at stake and so high cost to be beared. Even scheduling tour occasionally to consolidate orders is not a feasible solution: e-tailers are willing to process returns as soon as possible to provide clients a smooth user experience.
- Input database includes not only home addresses but also other locations like commercial activities and other not residential ones. It is assumed the possibility for customers to schedule home delivery/pick-up also in these not residential locations, as it happens in real life.
- The success rate of deliveries and returns is supposed to be 100%.
- The speed, as defined before, considers the perspective of the van, meaning that it will be a result of a weighted average between the time the van moves at a certain speed and the time the van is parked to let operators performing deliveries/returns (null speed). This assumption has been proposed to overcome the wide variety of situations an operator could face (i.e. van parked in a certain street and deliveries/returns performed on foot in a different road due to the lack of parking lots)

4.2.2 Time and cost computations

Initially, a backbone structure was designed to frame the complexity, the broadness and the computational needs of the analysis, trying to highlight differences and similarities in the three scenarios. The findings of the literature review section came handy because the return process has been deeply investigated and analysed: process maps proved to be a clear and meaningful starting point to spot the main costs factors to be taken into consideration. The following section of this paragraph is intended to deepen in sequence the three scenarios, explaining for each of them the relevant variables and the resulting unitary cost for returned box.

In Table 12 the reader is provided with the list of all the variables included in the cost and time computations:

DESCRIPTION	VARIABLE	UNIT OF MEASUREMENT
Distance to reach and come back from the delivery area	d_{out}	*km*
Distance within the delivery area	d_{in}	*km*
Vehicle typology	i	-
Cost per km for van typology	C_{f_i}	*€/km*
Hourly salary 3PL driver	SC	*€/hour*
Time for picking-up one box at home	t_{ruh}	*minutes*
Time for delivering one box at home	t_{duh}	*minutes*
Parcel locker share	$locker_{\%}$	%
Time for delivering/picking-up one box at the parcel locker	t_{ul}	*minutes*
Return percentage	$returns_{\%}$	%
Delivery percentage	$deliveries_{\%}$	%
Speed	s	*km/h*
Boxes per tour	$boxes_{tour}$	*boxes/tour*
Available compartments	$Available\ compartments$	*compartments/locker*

Table 12: List of variables used in time and cost computations

Based on this table, the next step was computing time and costs for one single courier tour, in the three different alternatives: traditional, exclusive and mixed.

4.2.2.1 Traditional tour

Time formulations for a courier tour are due to two main activities:

(TT1) *Travel Time:* it includes the time needed to reach the delivery area from the courier hub early in the morning and come back at the end of the working day, and the travel time within the delivery area. It is worth noticing that in the model the travel time within the area includes not only the time spent driving the van but also the time spent walking from the parking lot to the doorstep, in case it is not possible to park in front of it. It is obtained by dividing the sum of the distances within and outside the delivery area by the average speed of the courier's van.

$$Travel\ Time = \frac{d_{in} + d_{out}}{s}$$

(TT2) *Operation Time:* it includes the time interval between the courier arrival at customer's doorstep and his/her departure. Considering the usual logistics service provider's procedures, the delivery time might be solely due to the "delivery/pick-up" action and the scanning of the label, in few cases it might include also the waiting time for the customer to reach the courier and proof of delivery signing time. In the past, even if some differences from one company to another could be assessed, all these activities were performed by couriers' operator. Due to COVID-19 pandemic, now, regulations have been updated to keep social distancing: as a result, couriers delivery activities are usually limited to ringing the bell and dropping off the package within customer's property, without waiting for his signature. Instead, when deepening return-related-operation-time, the courier has to wait for the customer who delivers the box personally, since parcel scanning and proof of return signature are mandatory. According to this description, the operation time to manage returns is higher than the one to manage deliveries (whose activity was consistently faster due to the just drop-off action). Consequently, the final operation time will result on an average operation time weighted on the percentage of returns and deliveries managed, multiplied by the total number of boxes flowing in the tour (equal to the sum of delivered boxes and returned boxes).

$$Operation\,Time = Boxes_{tour} * (returns_{\%} * t_{ruh} + deliveries_{\%} * t_{duh})$$

In assessing the total time of the tour, given by the sum of the travel time and the operation time, a constraint has to be satisfied: the total time has to be lower than the standard duration of a working tour of the courier, which is considered as 8 hours in this model, and therefore:

$$Total\ time = (Travel\,Time + Operation\,Time) < 480min (= 8\ hours)$$

In addition to the time assessment and the verification of time constraint, the next step is made toward cost computation, considering as boundary of the analysis one single courier performing one delivery/pick-up tour. Costs are associated to three main activities:

(TC1) *Cost Van Unitary:* the cost for the van is computed as the cost per kilometer related to a specific typology of van, which includes fuel, maintenance, taxes, insurance and other indirect costs, as for Automobile Club d'Italia ACI tables[14] (ACI, 2017), multiplied by the total distance travelled by the van within and outside the delivery area. The cost for the van does not depend on the type of service to be performed (delivery/pick-up), hence, to get the cost van unitary, the cost of the van has to be split on the total number of boxes managed in a specific tour regardless on the percentage of deliveries and returns.

$$Cost\ Van\ Unitary = \frac{(D_{in} + D_{out}) * C_{f_i}}{Boxes_{tour}}$$

(TC2) *Cost Driver Travel Unitary:* this value accounts for the cost related to the time spent by the courier travelling. It is obtained multiplying the travel time by the hourly salary of the courier and

[14] http://www.aci.it/fileadmin/documenti/servizi_online/Costi_chilometrici/CKI_web_dicembre_2017.pdf

dividing it by the total number of boxes managed, regardless on the percentage of deliveries and returns.

$$Cost\ Driver\ Travel\ Unitary = \frac{Travel\ Time * \text{SC}}{Boxes_{tour}}$$

(TC3) *Cost Driver Return Unitary:* it represents the cost related to the time spent by the courier performing pick-up/delivery operations considering only returns. It is obtained multiplying the return unitary time by the courier hourly salary:

$$Cost\ Driver\ Return\ Unitary = t_{ruh} * \text{SC}$$

The return unitary cost is the sum of the three beforehand computed costs, resulting in the following equation:

$$Return\ Unitary\ Cost = Cost\ Van\ Unitary + Cost\ Driver\ Unitary + Cost\ Driver\ Return\ Unitary$$

4.2.2.2 Exclusive tour

In this second scenario there are some different procedures compared to the traditional home delivery/pick-up tour previously analyzed. Time and cost formulations will be explained again to show these differences.

When using parcel lockers, a preliminary step in the analysis is required. Due to the differences in the operational procedures when dealing with parcel lockers in respect to customers' home, the volume of boxes managed with parcel lockers has to be identified. It is equal to the parcel locker share, which is representative of the customers purchasing decision in choosing parcel locker as delivery or return mode (under the assumption that they can choose only between parcel locker and home delivery/pick-up), multiplied by the total number of boxes in the tour:

$$Boxes_{locker} = locker_{\%} * Boxes_{tour}$$

$$Boxes_{home} = Boxes_{tour} - Boxes_{locker}$$

Now that these measures are defined, the computation of times and costs formulas can be developed taking into consideration that this configuration (scenario 2) makes use of two types of missions: traditional and parcel locker. The first typology of tours, traditional, will be exclusively characterized by home locations, therefore the building blocks for times and costs will be the same as for the traditional tour scenario (1), with the only difference that the number of boxes belonging to the traditional part will be net of the boxes handled with parcel lockers. In addition, the second typology of tour, parcel locker, will include exclusively parcel lockers locations, hence the volume of boxes managed in the tour will be equal to the parcel locker share multiplied by the total number of boxes. Furthermore, for this second typology, some adjustments in formulas for costs and time will be introduced due to different operational procedures in dealing with parcel lockers locations rather than home locations.

(ET1) *Travel Time:* As before, it is obtained by dividing the sum of the distances within and outside the delivery area by the average speed of the courier's van, the formulas are not varying in relation to the different scenarios.

- Home tour:

$$Travel\,Time = \frac{d_{in} + d_{out}}{s}$$

- Parcel locker tour:

$$Travel\,Time = \frac{d_{in} + d_{out}}{s}$$

(ET2) *Operation Time:* compared to the operation time computation of Scenario 1, the different procedures in managing parcel locker boxes and traditional parcels have to be taken into account. Indeed, the unitary time related to deliver or pick-up a box from a parcel locker is lower than the corresponding values for home deliveries and pick-ups. The courier, indeed, has not to wait for the customers to reach the doorstep, thus any interaction with humans is included: he/she has only to perform standard scanning operations and queries on the parcel locker display. Moreover, there are not any differences if the box is delivered or picked-up, so the unitary cost for the operations dealing with parcel lockers can be considered unique. Because of these, a new formula for parcel locker tour has to be introduced to highlight the dissimilarities in respect to the traditional tour:

- Home tour:

$$Operation\,Time = Boxes_{home} * (returns_{\%} * t_{ruh} + deliveries_{\%} * t_{duh})$$

  As noticeable, this formula is equal to the one used for Scenario 1, with the only difference that the total number of boxes is net of the percentage of boxes managed with parcel lockers.

- Parcel locker tour:

$$Operation\,Time = Boxes_{locker} * t_{ul}$$

  As anticipated, the formula does not differentiate returns from deliveries, plus it manages as total number of boxes only the parcel locker related percentage.

For what concerns time verification then, the constraint is the same for both tours, no matter the type, and is formulated as in the case of scenario 1.

- Home tour:

$$Total\ time = (Travel\ Time + Operation\ Time) < 480min(= 8\ hours)$$

- Parcel locker tour:

$$Total\ time = (Travel\ Time + Operation\ Time) < 480min(= 8\ hours)$$

Considering costs computations, some adjustments have to be introduced by taking into account the number of boxes to be managed with a certain delivery/return mean.

(EC1) *Cost Van Unitary:* there are not theoretical differences in the formulas in respect to the previous setting.

- Home tour:

$$Cost\ Van\ Unitary = \frac{(D_{in} + D_{out}) *\ C_{f_i}}{Boxes_{home}}$$

The total number of boxes managed representing the denominator is the percentage of boxes managed with home deliveries/pick-ups.

- Parcel locker tour:

$$Cost\ Van\ Unitary = \frac{(D_{in} + D_{out}) *\ C_{f_i}}{Boxes_{locker}}$$

The total number of boxes managed representing the denominator is the percentage of boxes managed with parcel lockers.

(EC2) *Cost Driver Travel Unitary:* there are not theoretical differences in the formulas.

- Home tour:

$$Cost\ Driver\ Travel\ Unitary = \frac{Travel\ Time *\ \mathrm{SC}}{Boxes_{home}}$$

The total number of boxes managed representing the denominator is the percentage of boxes managed with home deliveries/pick-ups.

- Parcel locker tour:

$$Cost\ Driver\ Travel\ Unitary = \frac{Travel\ Time *\ \mathrm{SC}}{Boxes_{locker}}$$

The total number of boxes managed representing the denominator is the percentage of boxes managed with parcel lockers.

(EC3) *Cost Driver Return Unitary:* there are not theoretical differences in the formulas.

- Home tour:

$$Cost\ Driver\ Return\ Unitary = t_{ruh} *\ \mathrm{SC}$$

The unitary operation time for the return is specific for home locations.

- Parcel locker tour: $$Cost\ Driver\ Return\ Unitary = t_{ul} *\ \mathrm{SC}$$

  The unitary operation time is specific for parcel locker locations and does not distinguish retrieved boxes from delivered ones.

To get the total return unitary cost the theoretical formula is the same for both the typologies of tours:

- Home tour
  $$Return\ Unitary\ Cost = Cost\ Van\ Unitary + Cost\ Driver\ Unitary + Cost\ Driver\ Return\ Unitary$$
- Parcel locker tour
  $$Return\ Unitary\ Cost = Cost\ Van\ Unitary + Cost\ Driver\ Unitary + Cost\ Driver\ Return\ Unitary$$

4.2.2.3 Mixed tour

As beforehand presented, the courier performing a mixed mission is visiting both home locations and parcel locker ones within the same tour. For this reason, cost and time formulas need to be updated taking into consideration the different stop typology.

(MT1) *Travel time*: as before, it is obtained by dividing the sum of the distances within and outside the delivery area by the average speed of the courier's van.

$$Travel\ Time = \frac{d_{out} + d_{out}}{s}$$

(MT2) *Operation time*: it is a weighted average on the percentage of boxes managed with traditional home deliveries/pick-ups or with parcel lockers.

$$Operation\ Time = Boxes_{home} * (returns_{\%}\ * t_{ruh} + deliveries_{\%} * t_{duh}) + Boxes_{locker} * t_{ul}$$

Also in the case of this third scenario where couriers visit both home locations and parcel lockers locations within the same tour, the constraint for the total time has to be verified:

$$Total\ time = (Travel\ Time + Operation\ Time) < 480min (= 8\ hours)$$

Considering costs computations, the relationships used are as follows:

(MC1) *Cost Van Unitary:* the formula used to compute the cost van unitary is not affected by the different procedures concerning the operations, hence the relation is equal to the one used in the previous scenarios.

$$Cost\ Van\ Unitary = \frac{(D_{in} + D_{out}) *\ C_{f_i}}{Boxes_{tour}}$$

(MC2) *Cost Driver Travel Unitary:* the cost driver travel unitary does not change and, as for traditional tours, it is equal to the travel time multiplied by the courier hourly salary split on the total number of boxes flowing in the tour.

$$Cost\ Driver\ Travel\ Unitary = \frac{Travel\ Time * \mathrm{SC}}{Boxes_{tour}}$$

(MC3) *Cost Driver Return Unitary:* it represents the cost related to the time spent by the courier doing pick-up/delivery operations considering only returns. In this scenario the different operation times (parcel locker vs home delivery/pick-up) have to be considered.

$$Cost\ Driver\ Return\ Unitary = \frac{returns_{\%} * \ ((Boxes_{home} * \ t_{ruh}) + (Boxes_{locker} * t_{ul}))}{returns_{\%} * (Boxes_{home} + Boxes_{locker})} * \mathrm{SC}$$

Once identified these three cost items, the resulting return unitary cost for boxes managed according to a mixed tour configuration, where both locker locations and home locations are visited, results in the following equation:

$$Return\ Unitary\ Cost = Cost\ Van\ Unitary + Cost\ Driver\ Unitary + Cost\ Driver\ Return\ Unitary$$

4.2.3 Algorithm logic

In this section of the dissertation the algorithm developed to compute the return unitary cost, coded in R, will be explained step by step. The first scenario, traditional, represents the baseline scenario analysis on which the further two implementations encompassing parcel lockers will be built on. Indeed, the mail building blocks of the algorithm are deepened in the baseline scenario while only additional steps or modifications will be provided when describing the exclusive tours and the mixed ones with parcel lockers.

4.2.3.1 Baseline case: traditional tour

All the inputs needed in the model are:

- Dataset of all addresses within a specific municipality
- Share of daily locations to be visited
- Speed
- Boxes per Stop
- Home return unitary time
- Home delivery unitary time
- Return percentage
- Hourly salary of the courier operator

- Typology of the van used and related cost per kilometer

The first computation made was finding the points to be visited in one day, obtained by multiplying the share of daily locations to be visited by the total number of addresses within the municipality. For the scope of the analysis, this means selecting a subset of points in the initial input database: all the physical home locations requiring e-commerce deliveries or returns in a specific day. Then, since the express couriers market in Italy is not managed by one single player, some market analysis considerations are made. A study conducted by AGCOM (2019) shows that the express courier market in Italy results to be quite fragmentated with a number of 8 couriers companies leading the market. The competitive scenario in December 2018 highlighted that these main players are Poste Italiane, SDA (within Poste Italiane group), DHL, Bartolini, TNT – Fedex, UPS, GLS Italy and Nexive. This means that the daily demand is split and managed by these different couriers according to their specific market shares.

The point of view of this analysis is the one of a single courier, so the locations identified will be furthermore filtered according to the market share of a single courier company, identifying the final set of yellow locations (Figure 18) the company's vans have to visit in a specific day.

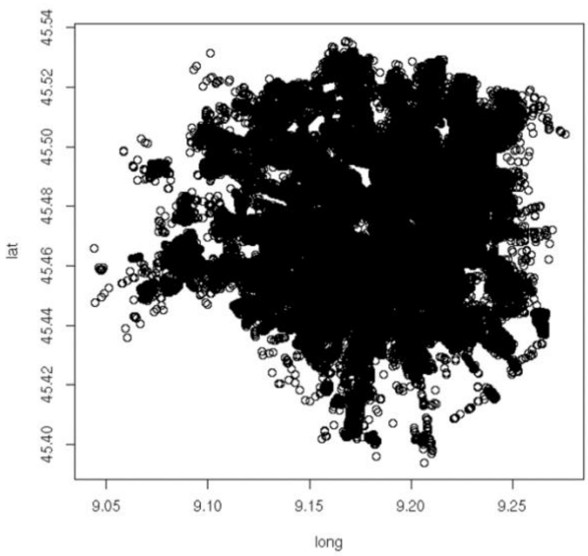


Figure 17: Initial dataset of geolocated addresses

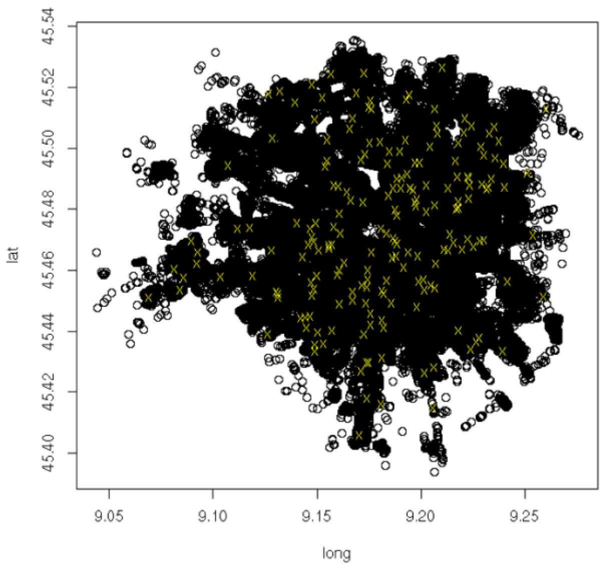


Figure 18: Initial dataset with selected locations in yellow (after the filters of e-commerce sales share and market share couriers)

The main idea of the model is grouping the locations to be visited by means of clustering algorithm based on distance and time considerations. Each cluster will represent the set of locations assigned to one single van of a specific 3PL company in an 8 hours courier working shift. To cover the whole demand of e-commerce deliveries and returns within the area, and therefore to visit all the yellow locations identified in Figure 18, multiple clusters, hence multiple tours (=missions/vans/operators) will be needed.

The next lines of this paragraph aim at shedding the light on all the algorithm sections, whose flow can be represented by the following visual chart (Figure 19):

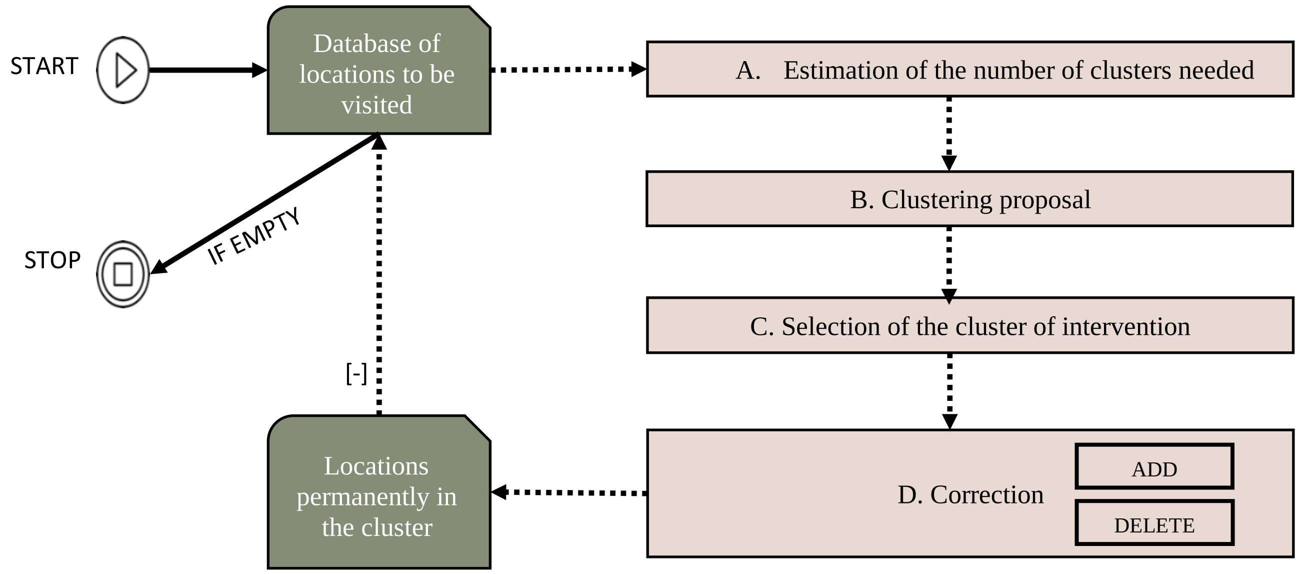


Figure 19: Flow for the algorithm in the traditional scenario

The dashed line represents the cycle to be repeated until the database of locations to be visited is empty. If it is empty, meaning that all the locations have been assigned to a courier's tour (cluster), the cycle stops.

A. Estimation of the number of clusters needed

The initial section of the algorithm aims at identifying the number of clusters needed to cover all the locations to be visited daily within a certain area, where each one of these clusters will be assigned to a single van/courier. The logical flow (Figure 20) of this paragraph is:

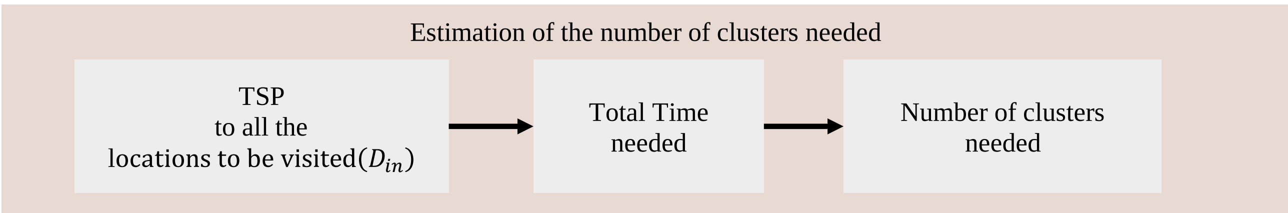


Figure 20: Flow for the estimation of the number of clusters needed in the traditional scenario

In order to find the optimal path to connect all the locations selected, the Travelling Salesman Problem (TSP) theory was exploited. It is an algorithm used to assess routings, indeed, given a specific set of points and knowing the distances between each pair of these points, it is able to individualize the minimal path to connect them all and come back to the starting point. In this model, the hub location where the courier starts the tour is not known, therefore it was assumed to restrict the TSP

optimization within the delivery area, where the starting and ending point of the path is the optimal location identified by the algorithm itself.
For the sake of simplicity, the travelled distances will be represented by Manhattan formulas, due to the urban application of the model and the possible approximation of the road network to rectilinear distances. The formula used to compute Manhattan distances between two locations in the model is, according to Melacini & Perego (2018), as follows:

$$Location\ A = (LongA;\ LatA)$$
$$Location\ B = (LongB;\ LatB)$$
$$Distance\ AB = |LongA - LongB| + |LatA - LatB|$$

In addition, to get distances in kilometers the beforehand expression has to be multiplied by these two conversion factors:

- *69 = factor to convert geographic coordinates into miles*
- *1.609 = factor to convert miles into km*

In Figure 21, the reader is provided with a visual representation of possible combinations of rectilinear distances between A and B.

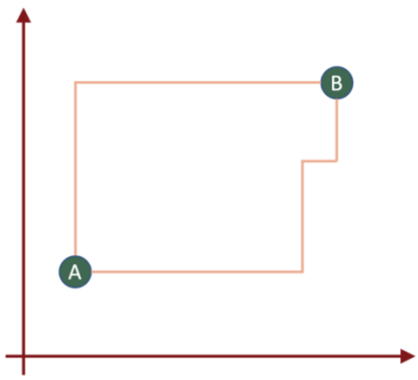


Figure 21: Example of Manhattan distances

Now that the Manhattan distances input of the TSP have been clarified, the algorithm is explained in detail. 'TSP' package, published by Hahsler & Hornik (2020), comes handy to solve the TSP problem of this model. More in detail, three functions were used in the code:

- *TSP:* this function is a constructor to create an instance of a symmetric traveling salesperson problem (TSP) that works given the distances matrix between each possible pair of points. The problem is symmetrical since the approximation of Manhattan distances gives same results between pairs of points independently on the direction (from A to B or vice versa). If the real road network had been addressed, but this is not the case because of the lack of API key required to exploit this function, the problem would have been better formalized by an asymmetric TSP since it considers one-way traffic road and other constraints.

- *Solve_TSP:* this function solves the TSP finding the optimal minimal path between all the points and the origin. Its output is the sequence of points to be visited in order to minimize the path.
- *Tour_length:* this function is used to compute the distance of the tour.

In this initial step, the tour length resulting from the TSP, that is represented by the variable d_{in} is first summed to the distance needed to reach the area from the logistic service provider's hub and come back, d_{out}, and then associated to its related travel time according to the formula previously mentioned $(TT1)$. The next step is computing the operation time for all the boxes to be handled, following the expression given upstream $(TT2)$. Then, in order to find the estimated number of needed couriers working in parallel to cover the demand of the area, the total time, here defined as $START\ total\ time$, resulting from the sum of travel and operation times is divided by the standard working duration of a courier shift: 8 hours. This number is then rounded up to ensure that all the locations are included in the analysis.

$$\#Clusters\ needed\ \left[\frac{shifts}{municipality}\right] = \left\lceil \frac{START\ total\ time\ \left[\frac{hourus}{municipality}\right]}{shift\ duration\ \left[\frac{hours}{shift}\right]} \right\rceil$$

The number of clusters needed works as a suggested starting point for the clustering proposal, deepened in the next section.

B. Clustering proposal

Knowing the number of clusters needed in a specific area in relation to the input variables plugged in the model, a first clustering proposal is designed (flow in Figure 22).

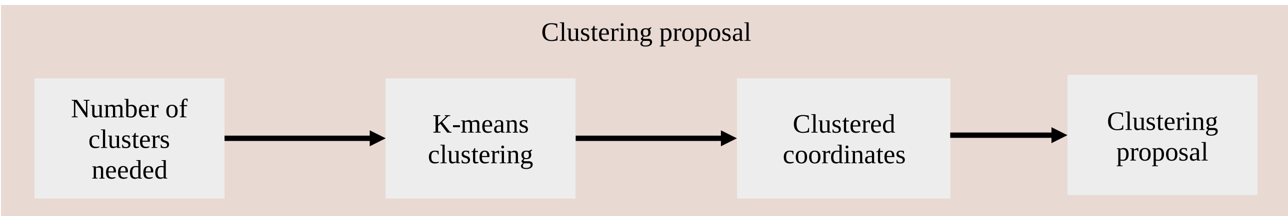


Figure 22: Flow for the clustering proposal in the traditional scenario

In this section, the main functionality exploited is the k-means clustering. This function takes a set of *n* observations and partitions them in a *k* sets of observations, where *k*<*s*, so to minimize the within-cluster sum of squares (WCSS) (variance) (Wikipedia, s.d.)[15].

[15] https://en.wikipedia.org/wiki/K-means_clustering

R Studio offers a package focused on statistical analysis, stats-package {stats} (R Core Team and contributors worldwide, n.d.), including k means clustering function which has been widely used in the algorithm.

- *Kmeans:* function that takes the data given, in this case all the locations to be visited, and partitions them into a number of groups such that the sum of squares from the datapoints to the assigned cluster centers is minimized. The number of groups in the model is equal to the number of clusters needed coming from the previous step.

In this way, the locations to be visited are grouped in different clusters as highlighted in the following figure (Figure 23):

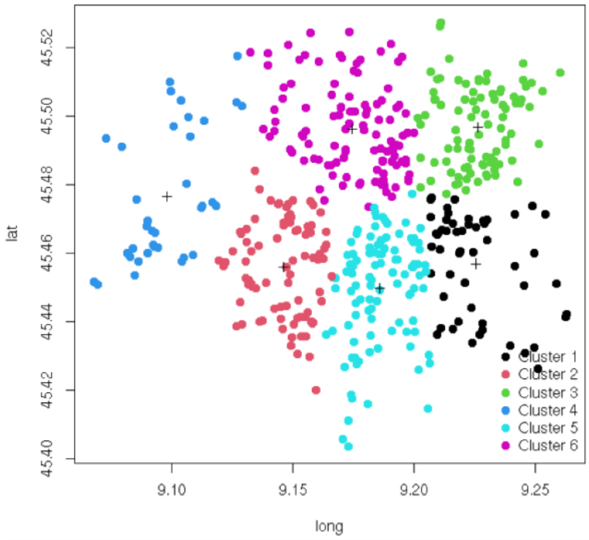


Figure 23: K-means clustering output - clustering proposal

After that, total times will be computed within each cluster exactly as explained previously where all the locations were included within the same cluster. To recap, in each cluster the minimal path to connect the locations is provided by the TSP, then, the resulting distance is summed to the distance needed to reach the delivery area and come back in order to find the travel time. In addition, to compute the total operation time the total number of boxes managed in a tour is needed. Since a single location can be associated to more customers (i.e. block of flats case), the number of boxes per stops has to be considered to compute the number of boxes per tour as follows:

$$\#Boxes\ per\ tour = \#Stops\ per\ tour * \#Boxes\ per\ stop$$

Analyzing results provided by this k-means clustering, it is possible to spot unstable results: some clusters are characterized by total time lower than 8 hours whereas other clusters with total time higher than 8 hours. From an operative point of view, this would mean having couriers/vans using extra time and others working significantly less, which reflects a non-optimal allocation of couriers/vans. The next step of the model is therefore to find a strategy in order to avoid this situation. The authors first tried to solve this issue with the implementation of a different clustering algorithm: k-means clustering was replaced with a density-based clustering algorithm, specifically named density-based spatial clustering of applications with noise (DBSCAN). This framework was theoretically developed by Ester et al (1996) (Wikipedia, s.d.)[16] and then modeled into an R Package 'dbscan' by Hahsler, et al., (2019). As it is stated in the open source documentations, the function used is described as follows:

- *dbscan: "*estimates the density around each data point by counting the number of points in a user-specified eps-neighborhood and applies a used-specified minPts thresholds to identify core, border and noise points. In a second step, core points are joined into a cluster if they are density-reachable (i.e., there is a chain of core points where one falls inside the eps-neighborhood of the next). Finally, border points are assigned to clusters."

  This function needs two input parameters, a distances database and the size of the epsilon neighborhood (eps).

The implementation of this new procedure resulted to be not meaningful because some clusters were characterized by one or very few locations, showing an outstanding heterogeneity between all the clusters identified. In Figure 24 the reader is provided with the clustering output of the dbscan function, which clearly presents this dissimilarity:

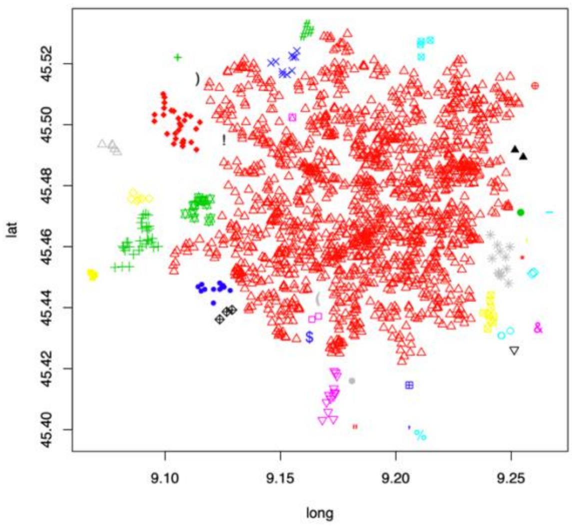


Figure 24: dbscan clustering output

[16] https://it.wikipedia.org/wiki/Dbscan

Since the model generates very heterogeneous clusters, it was deemed to be unsuitable in the realm of this model, so candidates looked for a different solution. The alternative the authors went through was to act on a single cluster to force its time saturation following an iterative cycle.
In order to have a clear understanding of the following paragraphs, here a brief preview of this strategy: "select the first cluster (cluster of intervention), add or delete locations to force an 8 hours total time, delete the final locations included in the corrected cluster from the initial dataset (since they do not need to be visited again), and restart from the "Estimation of the number of clusters needed" for all the remaining locations until all the datapoints will be assigned to a cluster.".

C. Selection of the cluster of intervention

The logic introduced to force the saturation of every cluster requires firstly the selection of the cluster of intervention. The strategy developed was to execute a sort of horizontal scanning of all the clusters, from left to right, selecting in sequence the centroid of the cluster of intervention. In operative terms, this means selecting the cluster whose centroid is characterized by the minimum longitude, thus cluster design is carried out starting from the west and going to the east side of the area in order to maximize the efficiency of couriers' path: locations in each cluster are all close one to the each other without isolated datapoints which could distort clustering construction. In Figure 25 all the locations that still have to be assigned to a courier tour are grouped as resulting from the clustering proposal. The first cluster to be corrected is Cluster number 4 (blue cluster), whose centroid has the minimum longitude.

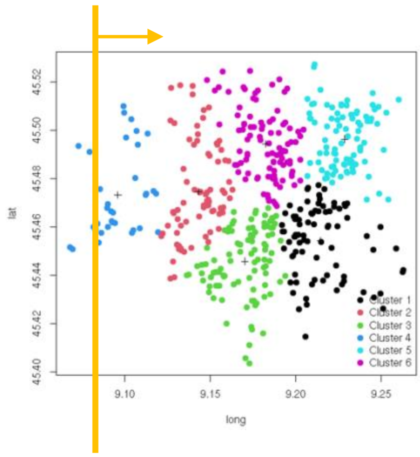


Figure 25: Selection of the cluster of intervention

D. Correction

Once identified the cluster of intervention two different procedures can follow, according to total time associated with this cluster. If the proposal for this centroid results with a total time lower than 8 hours new locations are added, else, if it is higher than 8 hours some locations are excluded from the cluster in order to have homogeneous workload among clusters and therefore overcome the limits of the initial k-means algorithm of huge heterogeneity among tours (clusters). The two different alternatives will be here explained:

a. ADD: Correction in case the cluster selected has total time lower than 8 hours

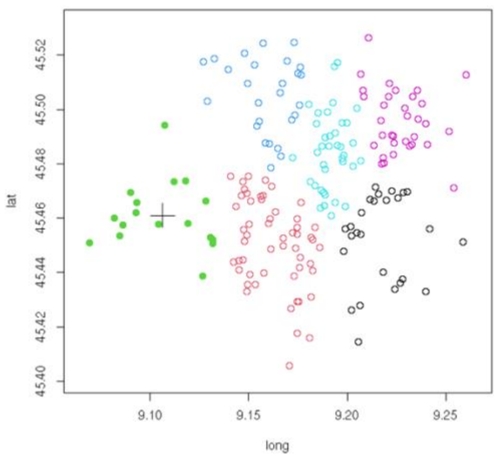


Figure 26: Initial situation for the ADD correction

Supposing the cluster selected is characterized by a total time lower than 8 hours, the algorithm developed force the courier to visit the closest locations until a total time of 8 hours is reached. In the following figure it is possible to identify the cluster to be corrected which is the one made by green full dots. The locations outside the cluster are the empty dots.

The algorithm follows the flow here presented (dashed line represents the iterative cycle) (Figure 27):

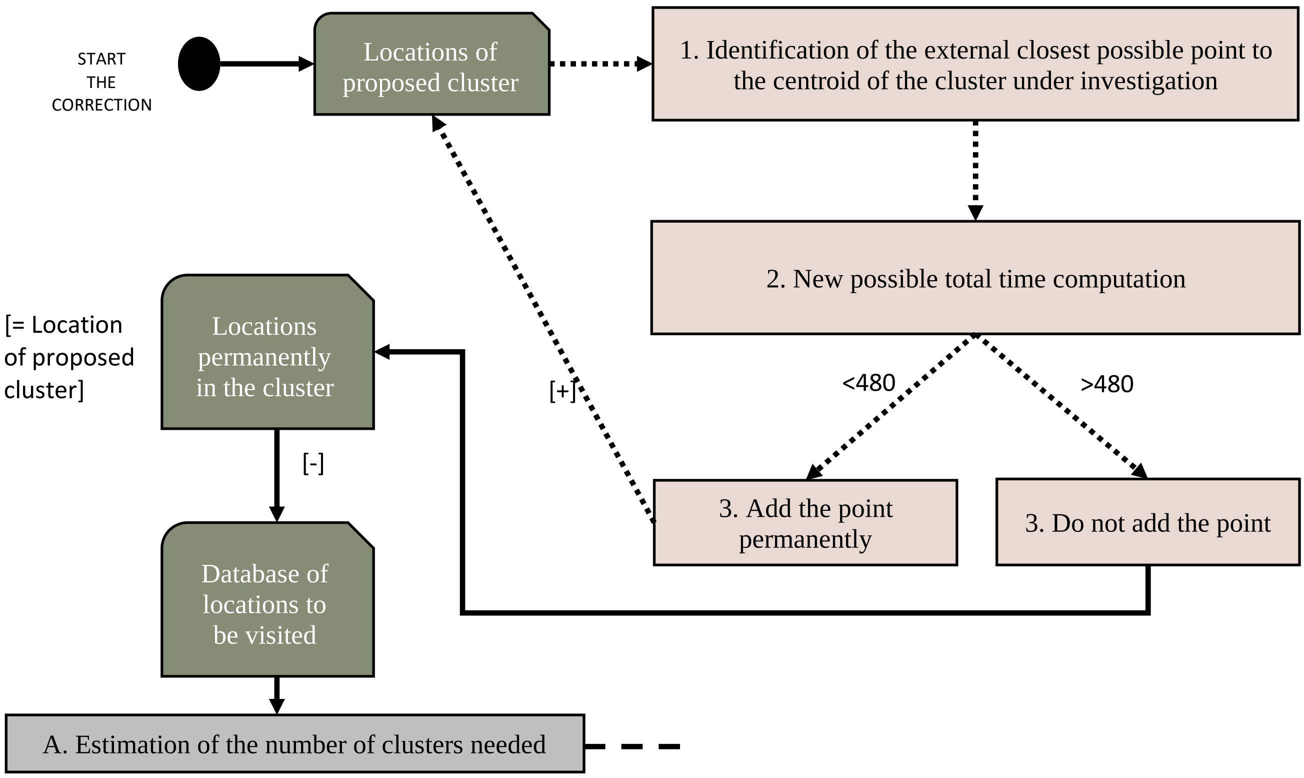


Figure 27: Flow for the ADD correction in the traditional scenario

The code formalizes the following steps:

1. Once the cluster of intervention has been identified (green full dots), a distance matrix based on Euclidean distances is computed between the external locations (empty circles) and the centroid of the investigated cluster (+). This situation is provided in Figure 28:

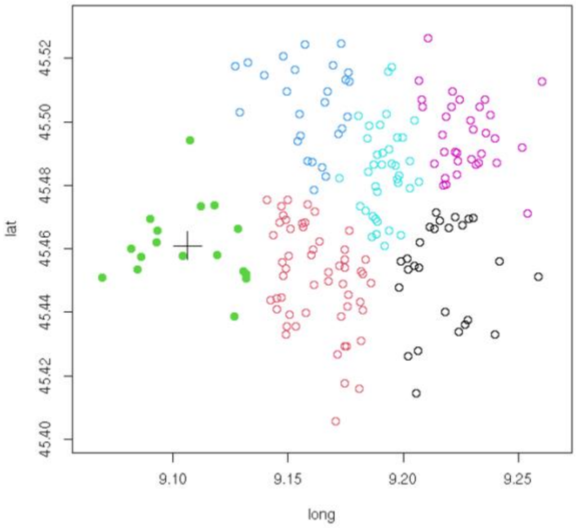


Figure 28: Initial situation for the ADD correction

The choice of using Euclidean distances, and not Manhattan ones, was justified by the fact these distances are not intended to be physically travelled, thus supporting the use of Euclidean relationships (see Figure 29).

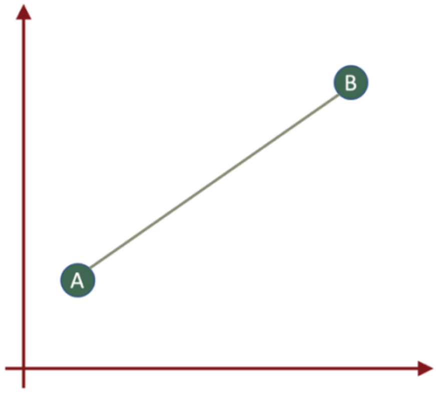


Figure 29: Example of Euclidean distance

In this context, distances are computed with Euclidean formulas as follows (Melacini & Perego, 2018):

$$Location\ A = (LongA;\ LatA)$$

$$Location\ B = (LongB;\ LatB)$$

$$Distance\ AB = \sqrt{(LongA - LongB)^2 + (LatA - LatB)^2}$$

In addition, to get distances in kilometers, the beforehand expression has to be multiplied by these two conversion factors as per the Manhattan distances case:

- *69 = factor to convert geographic coordinates into miles*
- *1.609 = factor to convert miles into km*

In the “delete” correction, supposing to have *n* locations outside the cluster under investigation, the matrix will have dimensions [1 x *n*] and will contain all the Euclidean distances between the centroid of the cluster and the *n*-locations outside the cluster. Then, between the *n*-locations will be chosen the one associated to the minimum distance of the matrix.

The candidate location accordingly when correcting the green full dot cluster will be the closest one to the centroid (in Figure 30 the orange dot).

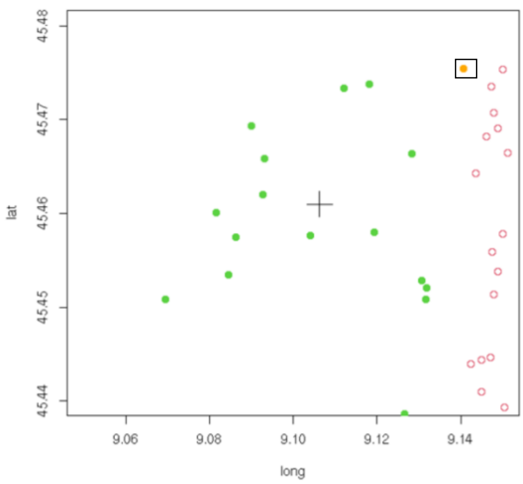


Figure 30: ADD correction example - in orange the candidate location to join the cluster

2. A validity test concerning the total time is computed starting from a new TSP computation: it is performed considering the additional point to the set of initial coordinates within the cluster.
3. Two alternatives are possible:
   a. If the total time computed in *Step 2* is lower than 8 hours, the point is first added permanently to the list of coordinates within the cluster and then deleted from the list of coordinates without the cluster (the acceptable light green dot of Figure 31 takes the same color of the investigated cluster, meaning that it is permanently added to the green cluster, as in Figure 32).

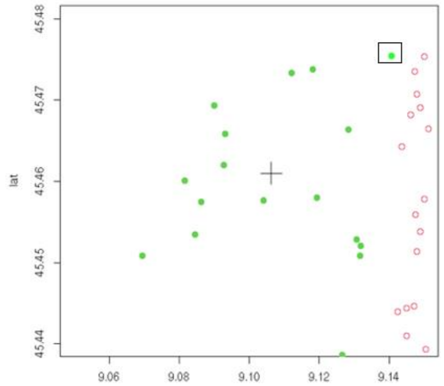


Figure 31: ADD correction example - in light green the validated location to join the cluster

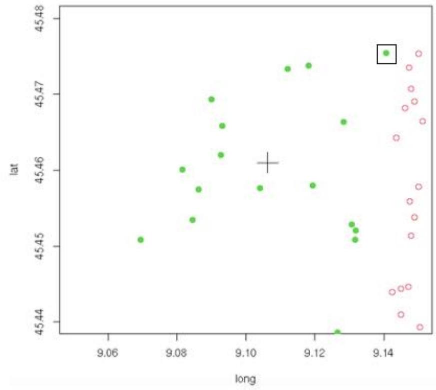


Figure 32: ADD correction example - in green the location added to the cluster under investigation

The process goes on again from *Step 1*, identifying the next closest point and verifying the total time deriving from its addition to the list of coordinates within the cluster. In Figure 33 an iteration is presented: the closest point is identified (orange dot), if the new total time based on a new TSP computation is acceptable the location is validated (light green dot) and then is added to the cluster permanently (full green circle).

(Coming next: *Step 1*)

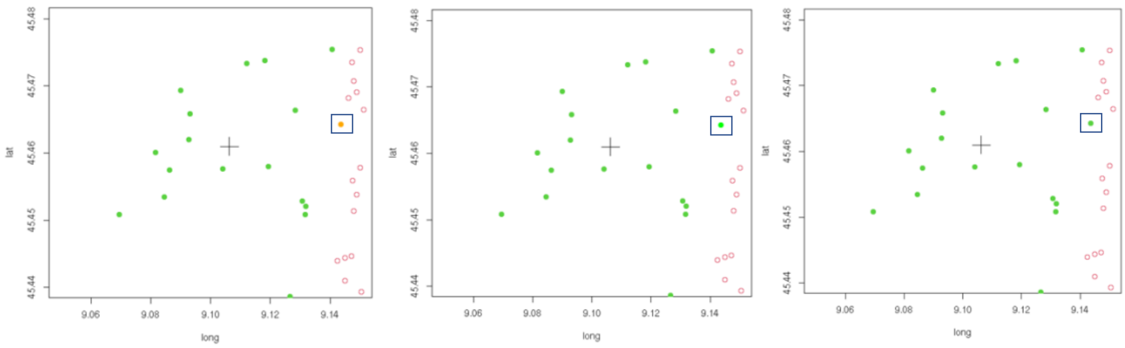


Figure 33: ADD correction example - identification of the location to add, total time is validated, the point is added to the cluster

b. If the total time computed is higher than 8 hours, the point is not included in the cluster and the list of final locations within the green cluster is not updated. This situation is described in Figure 34: the closest point is identified (orange dot), the total time resulting from the new TSP is not acceptable (red dot), hence the point is left out of the cluster (empty circle).

   The final datapoints valid for this cluster will be the ones resulting from the prior iteration.

   (Coming next: *Step 4*)

4. When the location (orange dot) cannot be added because the updated total time turns out to be higher than 8 hours, the final coordinates (without this last location which is not acceptable) of

this "corrected" cluster are permanently deleted from the dataset of the locations to be still visited and a new cluster will be corrected, following the procedure again, starting from Step A

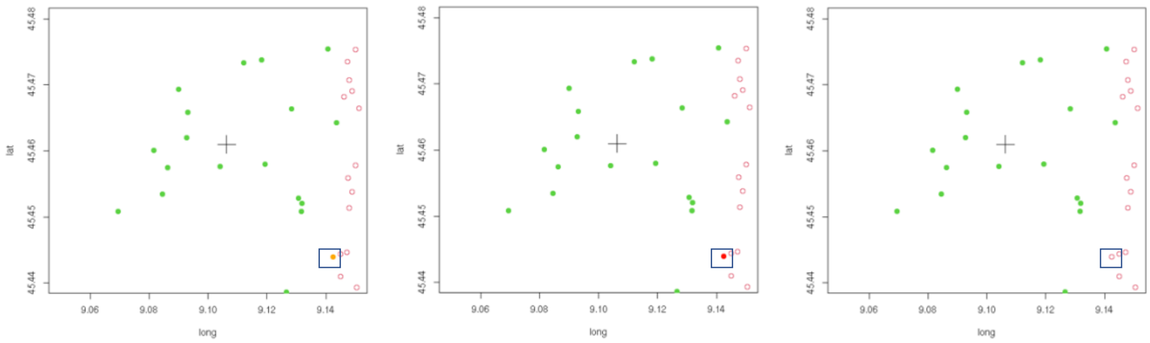


Figure 34: ADD correction example - identification of the location to add, total time is not validated, the point is not added to the cluster

(Estimation of the number of clusters needed).

To conclude, this way of working allows the achievement of a saturated cluster whose total time is as close as possible to the standard 8h shift duration, exploiting at best couriers' resources.

b. DELETE: Correction in case the cluster selected has total time higher than 8 hours

Supposing the cluster selected is characterized by a total time higher than 8 hours, the algorithm developed will force the courier to visit less locations than the ones included in the clustering proposal, reaching the first acceptable total time with less than 8 hours.

In Figure 35 it is possible to identify the cluster to be corrected (green full circles), the locations outside the cluster (empty circles) and the centroids of the clusters not selected as first to be corrected (+).

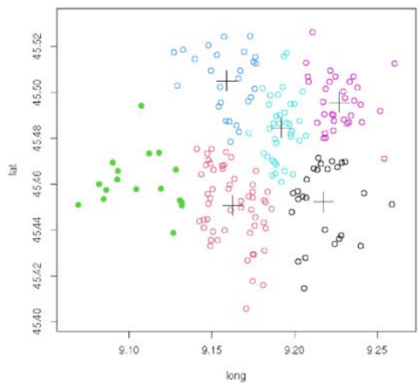


Figure 35: Initial situation for the DELETE correction

As per the ADD procedure, the methodology will be presented and explained step by step making use of visual representation to provide the reader with a clear understanding of the reasonings developed. The logic of the algorithm is represented in the flow of Figure 36 (dashed line represents the iterative cycle):

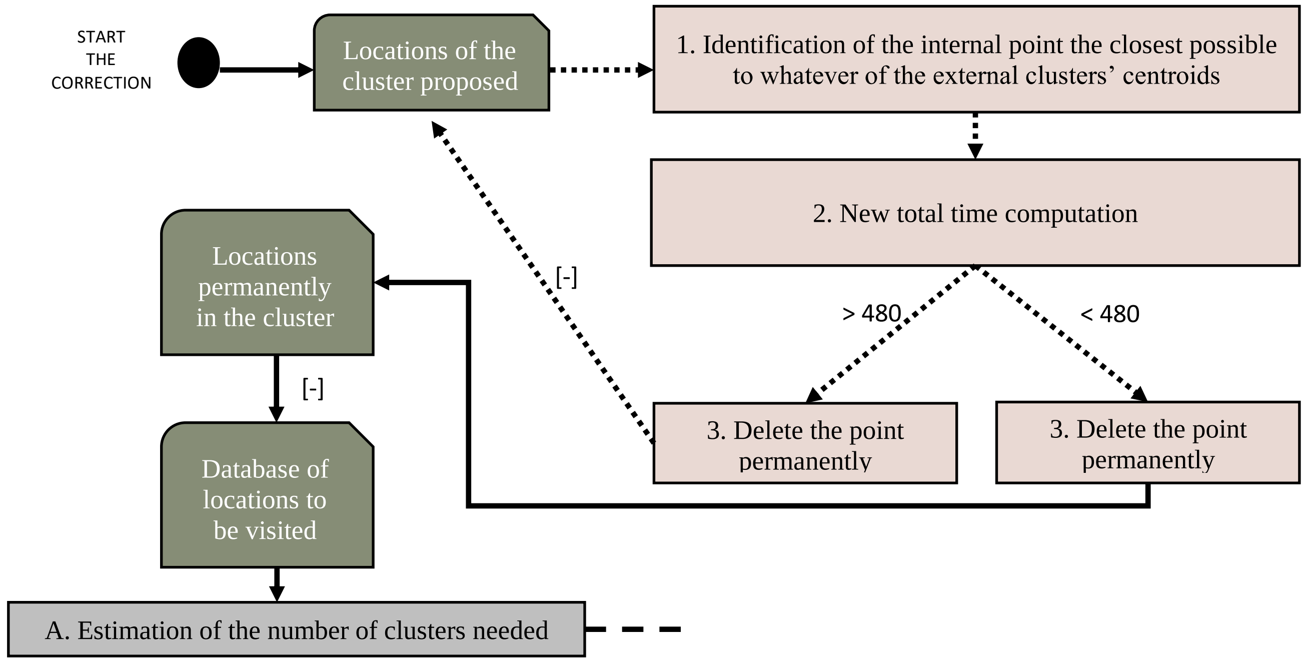


Figure 36: Flow for the DELETE correction in the traditional scenario

1. The internal closest point to whatever external centroids (+) will be identified, by selecting in the Euclidean matrix between all the external centroids and all the internal locations (green full circles in Figure 37) the one associated to the minimum distance in the matrix.

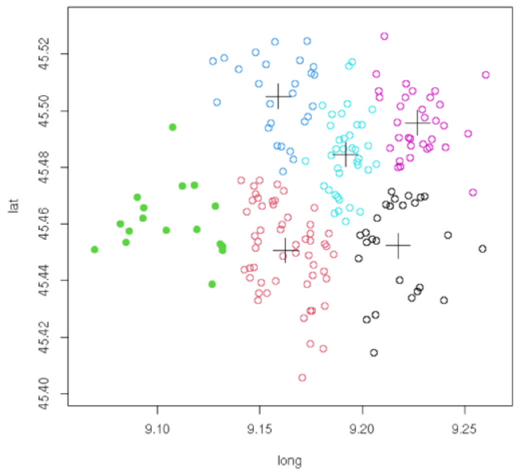


Figure 37: Initial situation for the DELETE correction

To clarify the procedures encompassing the choice of the point to be deleted, the following example is provided to the reader (Table 13).

$\# \, Centroids (C) of \; the \; not \; investigated \; clusters, resulting \; from \; the \; Clustering \; Proposal: 4 \; (A - B - C - D)$
$\# \, Locations \; (L) within \; the \; cluster \; under \; investigation: 8 \; (a - b - c - \cdots h)$
$Euclidean \; distances \; matrix \; [4 \; x \; 8] \; (Table \; 13) \; where:$

		8 locations within the cluster							
		La	*Lb*	*Lc*	*Ld*	*Le*	*Lf*	*Lg*	*Lh*
4 centroids not investigated	*CA*	*1.9*	*3.4*	*1.7*	*2.0*	*...*	*...*	*...*	*...*
	CB	*...*	*2.4*	***1.3***	*6.7*	*...*	*...*	*...*	*...*
	CC	*...*	*2.1*	*3.4*	*1.5*	*...*	*...*	*...*	*...*
	CD	*...*	*2.8*	*1.9*	*...*	*...*	*...*	*...*	*...*

Table 13: Example of Euclidean distances matrix used in the DELETE correction

The minimum Euclidean distance (1,3) in the matrix is associated to the location (c) to be deleted from the cluster under investigation because it is the closest possible to whatever of the external centroids (in this case, centroid of Cluster B).

In Figure 38 the candidate location to be excluded from the cluster is represented by the orange dot.

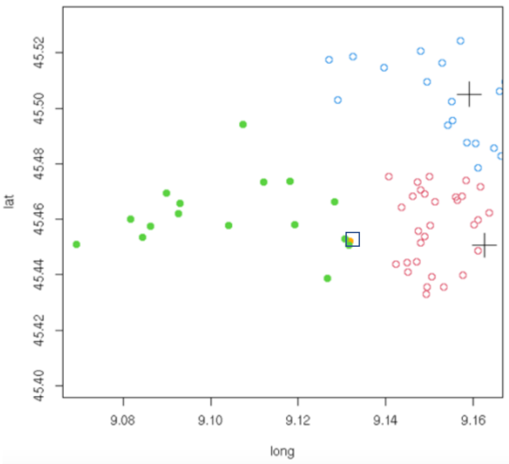


Figure 38: DELETE correction example - in orange the candidate location to be excluded from the cluster

The point is deleted from the list of locations included in the cluster and switched in the list of the coordinates not yet visited (empty circles) (Figure 39).

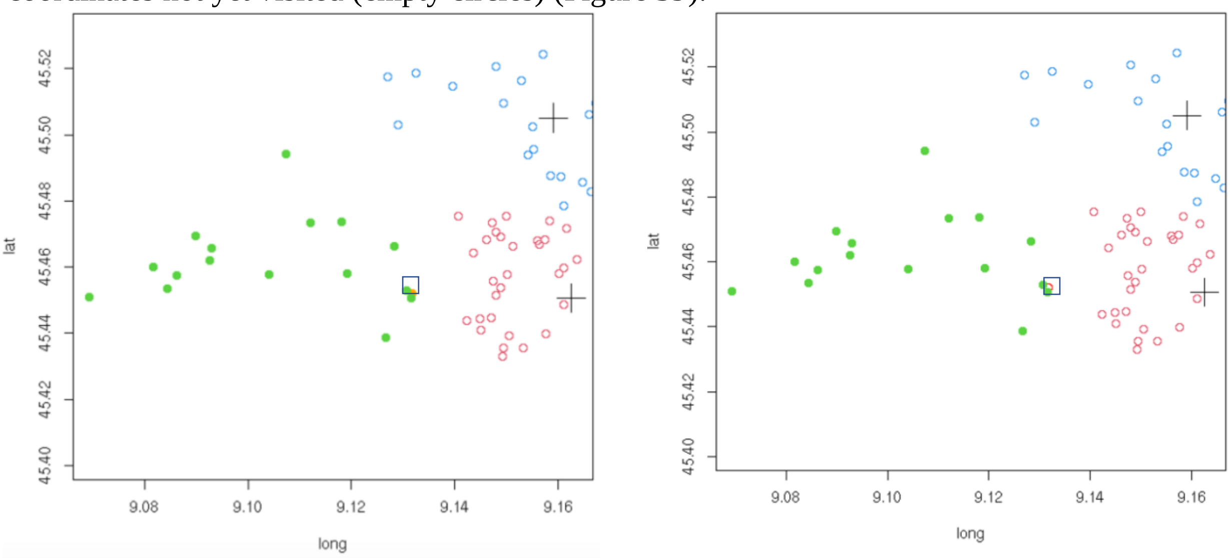


Figure 39: DELETE correction example - in orange the candidate location to be added, in red the location deleted from the cluster

2. Total time is computed starting from a new TSP computation: it takes as input the updated database of internal coordinates (without the point just deleted).
3. Two alternatives are possible:
    a. If the total time here computed is not yet lower than 8 hours, a new point will be excluded from the studied cluster, starting again from *Step1*.
    b. If the total time computed is lower than 8 hours, the correction for this cluster is completed: all the coordinates included in this cluster will be permanently deleted from the database of the locations to be visited and a new cluster will be selected and corrected, following the iterative procedure (starting from Step A (Estimation of the number of clusters needed)).

After having explained the two possible corrections (ADD and DELETE) aiming at forcing clusters to their maximum time saturation, the cycle will be repeated until the database of coordinates to be visited will become empty. This means that all the initial locations, the yellow ones presented in Figure 18 will be assigned to a specific cluster, hence courier tours will be identified, and the daily demand will be fulfilled.

4.2.3.2 Exclusive and mixed tours

In Scenario 2 (EXCLUSIVE) and 3 (MIXED), customers are given the possibility of arranging deliveries/returns not only through home delivery/pick-up but also through parcel lockers. The peculiarities of parcel locker have been presented in detail in Section 1.6 alongside with other delivery/return modes.

Focusing on the algorithm, comparing it to the baseline case formulation, some new parameters have been introduced to represent the peculiarities of this new delivery/return way:

- Parcel locker share
- Available compartments
- Locker delivery/return unitary time

The initial step was to find the volume of boxes flowing towards parcel lockers, in line with the value of parcel locker share, which represents the diffusion rate of this method amongst ecommerce B2c online buyers and under the assumption that available return methodologies are just parcel lockers and traditional home delivery/pick-up.

(ELN/MLN) Given this quantity, the numbers of needed lockers can be identified according to:

$$\#lockers\ needed = \left\lceil \frac{Boxes_{lockers}}{Available\ compartments} \right\rceil$$

(EBPS/MPBS) Then, assuming a uniform distribution of boxes lockers amongst the lockers needed, the number of boxes per stop when dealing with a parcel locker is:

$$Boxes\ per\ stop = \frac{Boxes_{lockers}}{\#\ lockers\ needed}$$

As presented in the introduction (Section 1.6), parcel locker location is strategic in fulfilling customer requests and maximizing efficiency: several trade-offs have to be considered in selecting the right locker position as the easiness to reach the locker, security and privacy issue, parking availability for both customers and service operators. In this context, candidates propose this assumption for the sake of simplicity: apply a k-means clustering on the whole possible set of coordinates within the area under investigation, initialized with the number of lockers needed (the output of formula (ELN/MLN)) as n-start, and placing parcel lockers in the centroids of the identified clusters. Such an approach has been driven by the willingness to provide generalizable outcomes.

To sum up these three considerations concerning boxes locker, numbers of lockers needed and locker locations, Figure 40 is provided. In the plot, the black dots represent home locations, the blue dots represent the customers who decided to make use of parcel lockers and the orange triangles are the parcel lockers needed, located according to the k-means clustering beforehand mentioned.

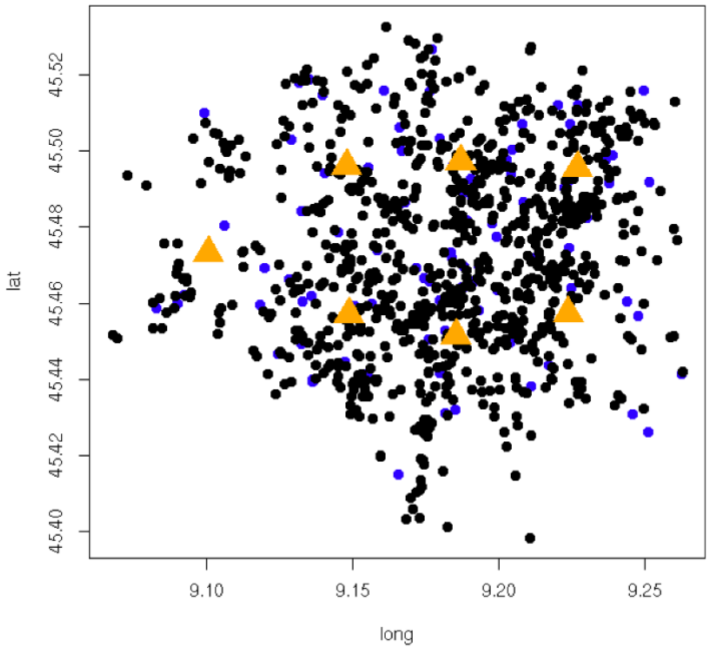


Figure 40: Initial dataset for the exclusive and mixed scenario

From this point on, the two alternative scenarios (2 and 3) can be built:

1) Exclusive Tours - EXCLUSIVE: vans dedicated to cover home locations tours and vans in charge of parcel lockers location tours (under the assumption of vans working for the same company)
2) Mixed Tours - MIXED: vans visit both home and parcel locker locations within the same tour.

Their explanation will be now encompassed.

1) **Exclusive Tours (EXCLUSIVE- Scenario 2):**

The algorithm manages separately home tours and parcel locker tours.

HOME/TRADITIONAL TOURS. To manage home tours, the baseline algorithm presented before is used with the only difference that the input database of coordinates to be visited includes only the home coordinates net of the ones referring to customers who decide to use parcel lockers (blue dots of Figure 40, see also Figure 41).

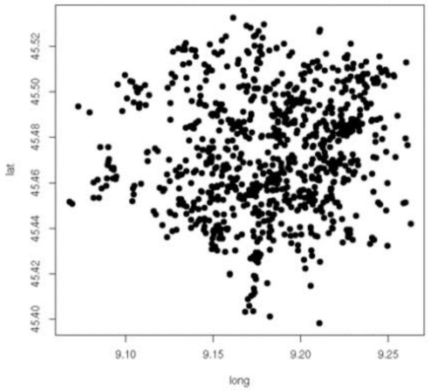


Figure 41: Initial dataset of home locations in the exclusive scenario

The logic behind the algorithm is the same as for the baseline model, according to the following flow of Figure 42:

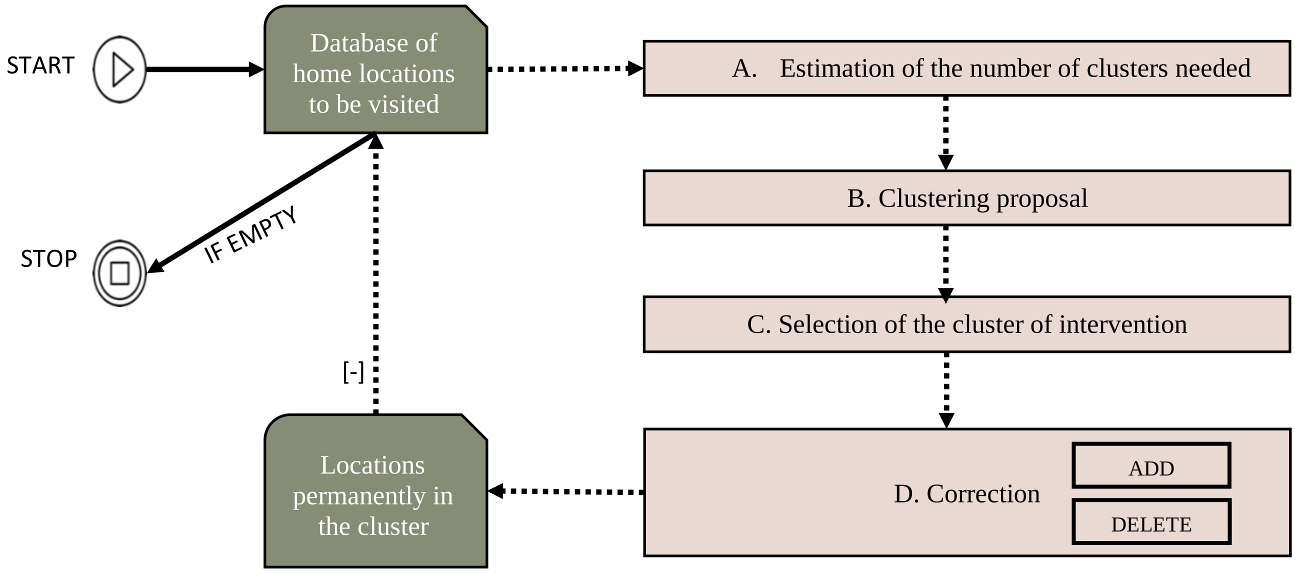


Figure 42: Flow for the algorithm in the exclusive scenario – home tour

PARCEL LOCKER TOURS. To manage parcel locker tours, the baseline algorithm is employed but three differences are introduced:

- The input database of locations to be visited includes only the parcel locker coordinates (Figure 43).

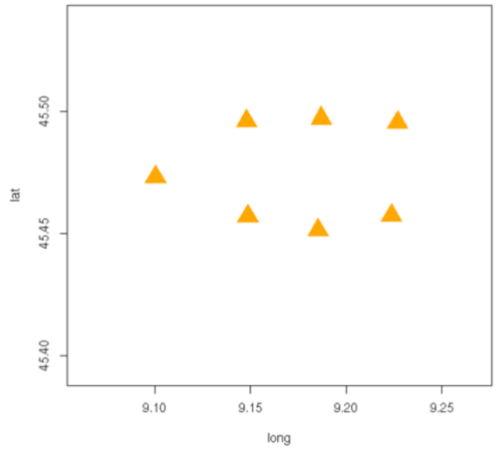


Figure 43: Initial database of parcel locker locations in the exclusive scenario

- The number of boxes per stop is computed as presented in EBPS/MPBS.
- The unitary operation time for return and delivery managed with parcel lockers is unique. Moreover, it will account for less seconds than the ones for home returns and deliveries due to the characteristics of the parcel locker as detailed before in Section 4.2.2.2.

Despite these three differences, the logic is the same as shown below in Figure 44:

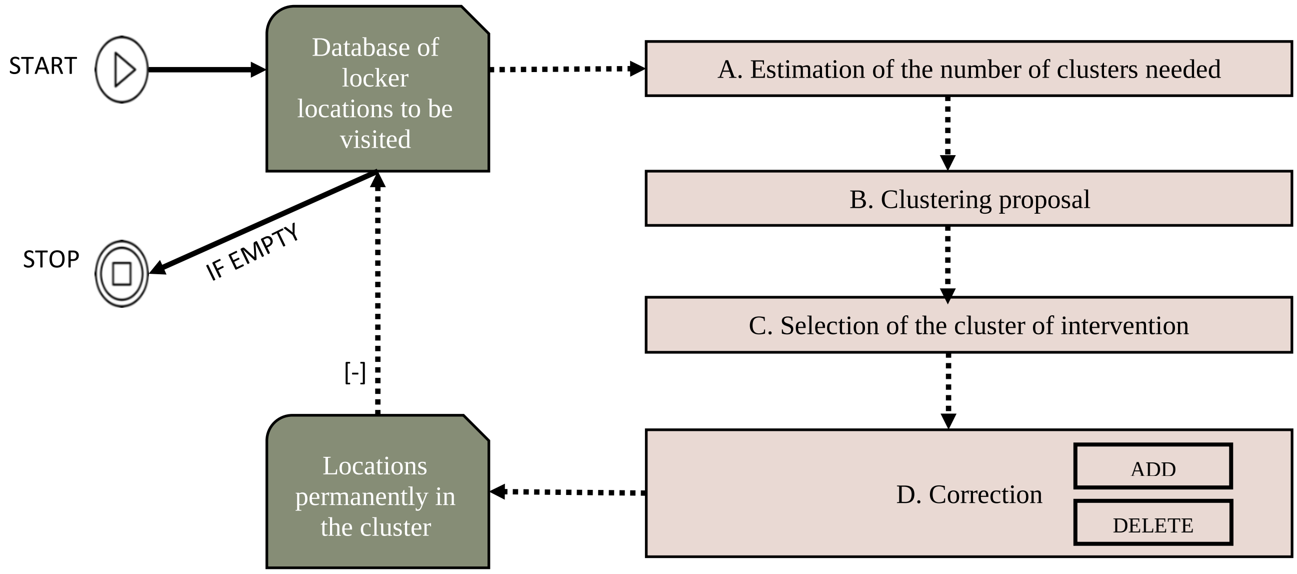


Figure 44: Flow for the algorithm in the exclusive scenario - parcel locker tour

2) **Mixed Tours (MIXED – scenario 3)**

Focusing on the three factors deepened in the exclusive tour scenario, some adjustments have to be introduced:

- The input database includes home and parcel locker locations, black dots and orange triangles respectively in Figure 45. In order to provide the information on the point type, in the initial set of data a label characterizing the point type is added, "H" for home locations and "L" for parcel locker ones.

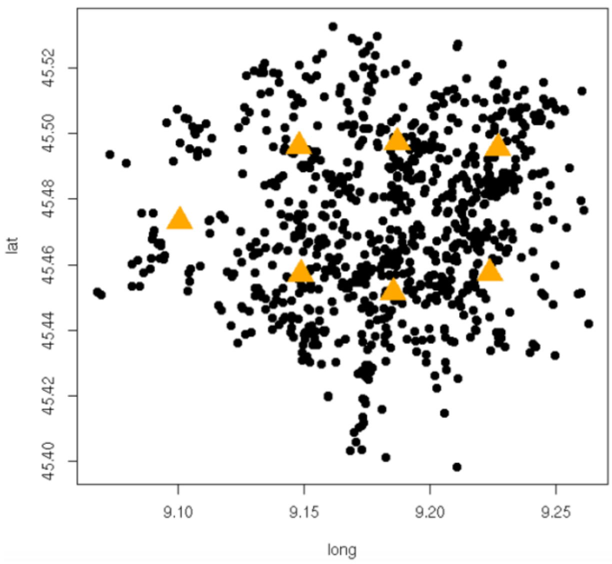


Figure 45: Initial dataset for the mixed scenario

- The number of boxes per stop is formulated differently according to the typology of points visited. If the location is labelled as “H” it is equal to the input value provided, whereas, if it is labelled as “L” it is computed according to the expression provided before (MBPS).
- The delivery and return unitary time are computed in different ways according to the label of the point, reflecting the operational differences in dealing with customers or else automatic storage machines (parcel lockers).

Compared to the exclusive scenario, important differences are rising in the implementation of the model including both home and parcel locker locations within the same tour (scenario 3). Firstly, a new flow is shown in Figure 46, secondly, new procedures are justified and clarified.

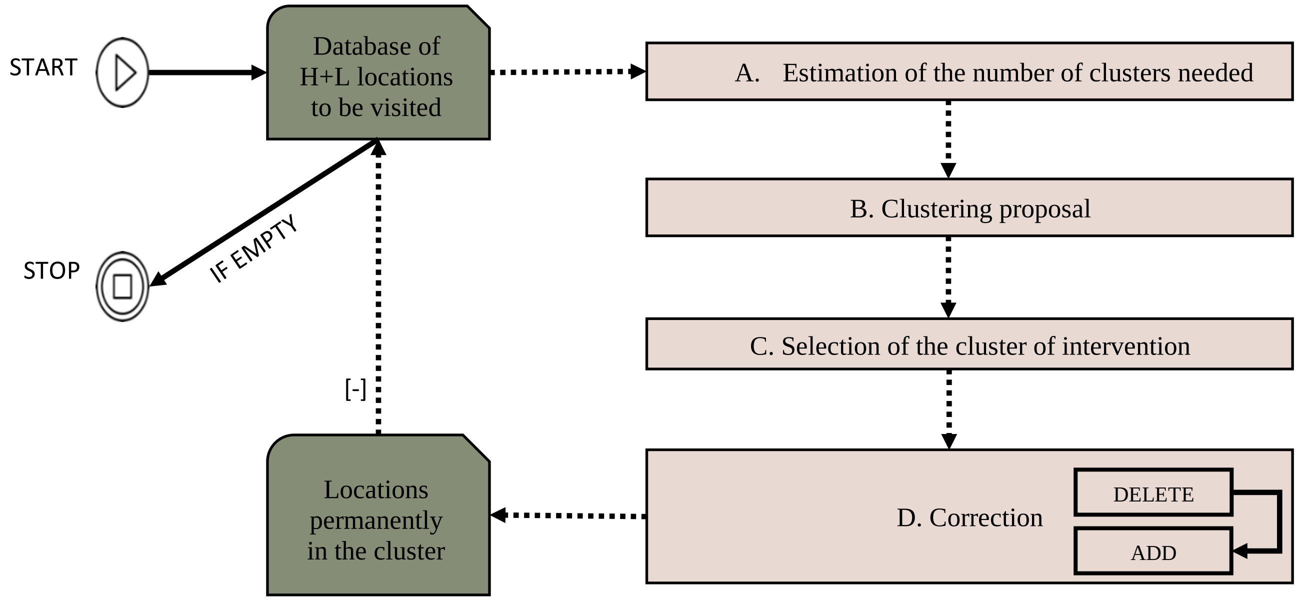


Figure 46: Flow for the algorithm in the mixed scenario

Comparing this flow with the previous ones both delete and add alternatives have to be modified in the clustering correction part as follows:

- DELETE: the procedure for deleting points from the cluster under investigation is the one already known, but it is followed by an additional condition. If the final point deleted (the one which lower the time below 8 hours) is labelled as a parcel locker, then, the cluster goes through the add correction. This decision was empowered by the consistent operation time contribution associated with a parcel locker, under the assumption that partial fulfillment is not allowed. Indeed, if a parcel locker location is eliminated from a tour the total time is consequently lowered by a relevant amount of time (due to the higher number of boxes to be managed per single locker). This consideration is associated to the possibility of finding other home locations whose inclusion to the cluster under investigation still keeps the time below the 8 hours working threshold. Taking as reference Figure 47, the delta time associated to the addition of a home location (empty circle) is not as consistent as the one deriving from a parcel locker (pink full triangle), due to the lower number of boxes per stop to be handled on average resulting in faster operation activities. Even if travel distances are higher than the one to reach the parcel locker excluded, the resulting total time will be lower. The parcel locker is then deleted, and new home locations added in order to increase the saturation of the cluster, as presented in Figure 47.

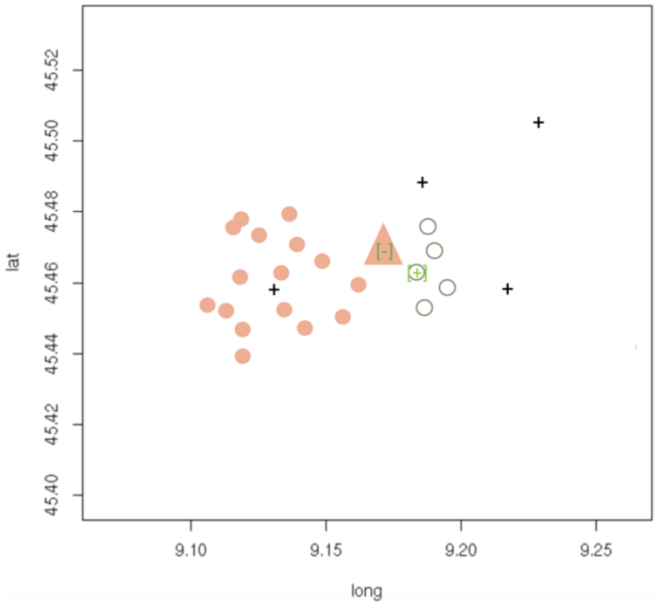


Figure 47: Modification in the DELETE correction, if the location deleted is a parcel locker then it is possible to enter the ADD correction to saturate the cluster with home locations

An example will be provided to the reader below to better understand this situation. According to the standard delete procedure, the parcel locker (pink full triangle in Figure 47) is identified being the internal location the closest possible point to whatever of the external centroids. So, the point is automatically deleted from the set of coordinates within the cluster and the total time is computed.

$$Prior\ Total\ Time > 8\ hours$$

$$Total\ Time\ without\ the\ parcel\ locker = (\ Prior\ Total\ Time - \ \Delta Locker) \ll 8\ hours$$

$$\text{where } \Delta Locker\ = \Delta Travel\ Time_{Locker} + \Delta Operation\ Time_{Locker}$$

Now, since the total time results to be significantly lower than 8 hours, the possibility of adding a new home location to the dataset of coordinates within the cluster is investigated. In this regard, the closest point to the centroid of the cluster under investigation is selected (empty point highlighted)

$$\Delta Home = \ \Delta Travel\ Time_{Home} + \ \Delta Operation\ Time_{Home}$$

$$\text{with: } \Delta Travel\ Time_{Home} > \Delta Travel\ Time_{Locker}$$

$$\text{with: } \Delta OperationTime_{Home} \ll \Delta Operation\ Time_{Locker}$$

This results in $\Delta Home \ll \Delta Locker$, and consequently

$$\underbrace{Total\ Time\ without\ the\ parcel\ locker + \Delta Home}_{< 8\ hours} \gg \underbrace{Prior\ Total\ Time - \Delta Locker}_{\ll 8\ hours}$$

In this way the time saturation of the cluster is maximized obtaining value closer to the capacity of the working shift (8 hours).

- ADD: the last possible location investigated, which is the closest point to the cluster's centroid among the external points, gives a total time higher than 8 hours. If this point is labelled as a parcel locker, "L" (see the grey empty triangle in Figure 48), the next closest location is investigated (empty dot connected with the dashed gray line): it may happen to find a home location that results in a total time lower than before and still acceptable, even if the distance could be higher than in the case of a parcel locker. The reason could be that a higher travel distance is largely compensated by the lower operation time, as it happened when explaining why $\Delta Home$ is lower than $\Delta Locker$ (see previous section of the DELETE correction modification).

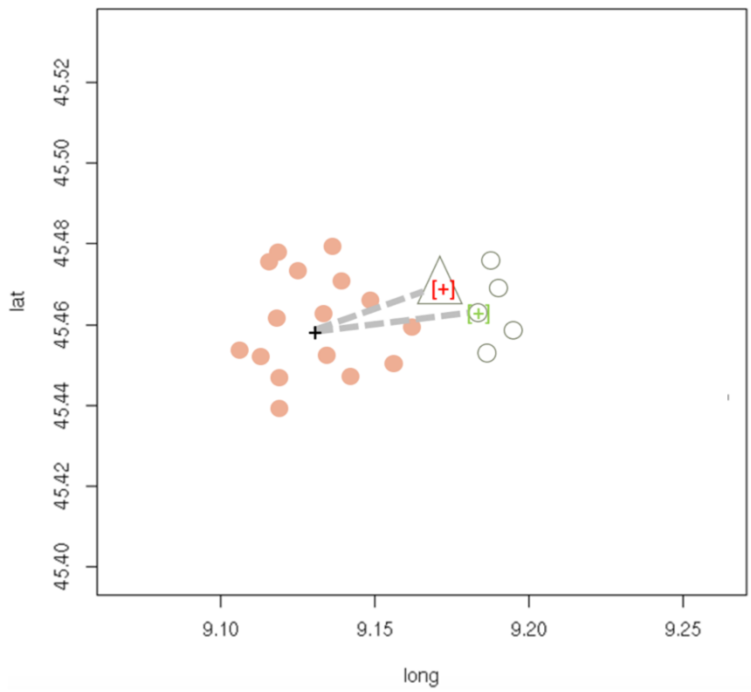


Figure 48: Modification in the ADD correction, if the location which cannot be added for total time constraints is a parcel locker, then home locations will be investigated

Once the algorithm has corrected all the clusters, so when all the points have been associated to specific clusters, the cost measures are assessed following the formulas presented in Section 4.2.2. In this way, according to the typology of the tour (traditional, exclusive and mixed), the return unitary cost is assessed as the sum of three components: cost van unitary, cost driver travel unitary and cost return unitary.

4.3 Output

As far as the output of the model proposed is concerned, a wide set of information is provided. In this regard, it is worth underlying that the model is not addressing the pure return unitary cost solely, indeed it sheds the light on the determinants of the return unitary cost. In addition, the information coming from the implementation of the model will be functional to assess differences and peculiarities of different return methodologies and relationships between input data and response. Plus, through the model just presented, links between forward and reverse logistics might be investigated.

For the sake of comprehension and precision, the output can be divided into the following categories:

- Design output
    - Numbers of clusters
        - drop-off/pick-up-area is partitioned in clusters based on the ecommerce daily demand for one single express courier company. The number of clusters determines the number of vans/operators of one single company to be activated on a daily basis to fulfill the demand. It is worth noticing that one cluster is equal to one feasible 8h-constrained tour by construction.
    - Types and number of addresses within each cluster (H points and L points)
        - this piece of information completes the overall structure of the different clusters
    - Number of parcels to be managed within each cluster.
        - Boxes per tour can be then divided into the addresses they belong to (home boxes and parcel locker boxes).
    - TSP problem applied to each cluster
        - As explained before in Chapter 4.2.3.1, TSP algorithm is used to compute the optimal within-cluster distance. The TSP distance is taken as a good proxy of the

path couriers have to follow to satisfy the demand and the 8h constraint within each drop-off/pick-up zone.

- Time features[17]
  - Total time
    - In dealing with total time, readers should be notified that, by construction, this piece of information is not particularly relevant. Candidates, indeed, have developed an 8h-constrained algorithm to account for a regular working shift of one courier deployed in last-mile/reverse logistics. The reason why it might happen that total time figures are not close to 480 minutes has to be ascribed to the final iteration of the algorithm when the remaining points are inserted into a last cluster.
  - Travel time
    - In line with the reasoning above, travel time proves to be more insightful because it might differ a lot from clusters to clusters on the basis of the points distribution in the selected area.
  - Operation time
    - As per the travel time, operation time is more meaningful than the total time figure. Compared to travel time, differences among clusters might be due to the types of addresses to be visited within each cluster (handling a parcel locker mission is different from the house case).
- Cost features[17]
  - Return unitary cost
    - It is the main output this dissertation would like to shed the light on. It could be considered as a great summary of the model developed and the reasoning provided, because it condensates all the steps performed by the candidates. Return unitary cost can be further studied considering its building blocks, as in the case of the total time.
  - Cost van unitary
    - it is the cost of the van to be ascribed to fuel, maintenance, taxes and other indirect costs.
  - Cost driver travel unitary
    - it is the cost of the driver due to its time spent travelling in the tour/cluster/mission.
  - Cost driver return unitary

[17] Both time and cost features are computed on a cluster-basis. As an example, if the model identifies ten clusters in the area under investigation, ten total time and return unitary cost will be computed, one per each cluster.

- it is the cost of the driver due to its time spent dealing with customers or parcel lockers interface to pick-up parcels.

In line with the objectives of the dissertation to provide new contribution to extant knowledge, the outcome of model application, well-described by the list of output above, is twofold: from an academic perspective the return unitary costs are computed based on trustworthy input data, which could be then compared on the basis of the scenario they are based upon in addition to what-if kind of analysis aiming at investigating which input variable impact the most on them. Beside the academical perspective, the outcome could be insightful for practitioners too: through model proposed they could map their as-is situation and simulate different scenarios to improve efficiency and effectiveness. With regard to this last point, input data accuracy is deemed fundamental to achieve the best possible contribution.

5. MODEL APPLICATION AND ANALYSIS OF THE RESULTS

Chapter 5 is devoted to the application of the theoretical framework presented in Chapter 4 on a real case and the analysis of the corresponding results, with the final objective to fill the literature gap this dissertation has unveiled and targeted: lack of models for assessing the monetary cost of returning items in B2c e-commerce. Software choice, R, has been fundamental in this section due to the easiness in simulating instances with many different inputs, analysing results and visualizing maps.

For the sake of a better comprehension, the chapter is divided into three sections: background, input data and analysis. The background section (5.1) aims at explaining the rationale that guided authors in the selection of Milan as model setting, while input variables section (5.2) is devoted to systematizing and discussing the input plugged into the model. Section 5.3 – Analysis – then presents model application output considering three relevant dimensions, namely "design, time and cost output" (Section 5.3.1) to shed the light on the structural features of the output achieved, "return unitary cost tendency" (Section 5.3.2) to investigate how return unitary cost behaves with the number of parcels managed and the drop density and finally "sensitivity analysis" (Section 5.3.3) to identify important links between observations, model inputs and output (return unitary cost), thus answering academic requirements to extend current knowledge on reverse logistics cost modelling on the one side and practitioners needs to improve processes and procedures on the other. The scenarios introduced in the previous chapter will offer the basis for this exercise, because numerical results will be presented considering the different settings they belong to.

5.1 Background

The model presented in Chapter 4 has been tested on a real case application by considering the municipality of Milan. The determinants beneath this choice are the following:

- *Model development convenience*. Candidates had the chance to live and attend the university in Milan, moreover they could test themselves how e-commerce is spread in the city. Such a condition could have come handy in model development, because algorithm intermediate steps could have been criticized and analysed considering both secondary sources (i.e. reports and websites) and primary ones (e.g. personal experience of the authors). Once again, the role of R tools (i.e. plots and maps) has been essential in order to assess the quality of algorithm generation especially in the intermediate steps.
- *Dataset consistency*. The consistent amount of people who gravitates around the municipality of Milan is deemed to be a good training dataset in the deployment of the model, because flaws and criticalities can be much easily spotted and consequentially corrected. Model

robustness check via sensitivity analysis can also benefit from a wider dataset, indeed a higher number of people generates higher number of e-commerce orders other else being equal.

- *Returning modes variety.* As one of the most innovative and modern cities in Italy, reverse logistics as the forward one can be managed through traditional home pick-up/delivery model but also via a widespread parcel lockers network, the handling modes deployed in the chosen scenarios, thus the resulting output of model application might be more complete and insightful fitting both academia and practitioners' needs. Although many different last-mile delivery options are available in Milan, candidates have chosen to select just traditional and parcel locker methodologies: the framework developed, however, could be extended taking into account different last-mile/return options (i.e. attended CDPs, omnichannel …)
- *Economic relevance.* The economic relevance of the city as well as the number of people hosted, and its innovative nature imply that more data are available, therefore the chance to provide handful and impactful contribution increases. The model, indeed, may gain more recognition among researchers and companies, because tested on a relevant case study.
- *Model appeal.* Given the final objective to provide generalizable results to both practitioners and researchers, the choice of Milan has been natural. On practitioners' side the model could be seen more appealing because these latter might be more interested in improving efficiency and effectiveness in a relevant scenario from an economic perspective as Milan is, whereas the model could be more likely applicable in many other settings by academia since it has been tested on a real, trustworthy and consistent case. In this regard, given its modular nature, the model can easily fit different scenarios.
- *Dataset availability.* Last but not least, it should be noted that the choice to select Milan municipality has been constrained by the availability of few complete databases of geolocated addresses. Regione Lombardia provides a county-level open database related to different subject areas, among them geolocated addresses dataset of Milan municipality is available and can be downloaded for free.

It should be added that authors could have developed a pure theoretical framework, however it would have been difficult both to develop the algorithm due to the lack of a visual interface and to assess its real feasibility and consistency, but also it would have been less attractive and innovative given the absence of hard facts and figures. Notwithstanding, the dissertation should be read not only in the light of the numerical results, which are strongly affected by the quality of input data, but in the light of the model itself and its ability to replicate the real world given reliable input data and answer what-if questions.

5.2 Input data

In this section, the reader is provided with the input data used both in model development and model deployment phase. While input data have been handful in the creation and development of the algorithm to check the intermediate steps validity, in model application phase they have been instrumental in generating results and critically analysing output and so the final contribution this dissertation would like to originate.

As far as the input data coming from primary sources are concerned, in October 2020 the authors had the chance to discuss with a prominent manager employed by one of the biggest logistics service providers in Italy. In the light of this master thesis, the discussion proved to be really relevant since candidates had the chance to double check the information retrieved in academic literature and other secondary sources by comparing them with real time insights from a top leading company. Despite the impossibility to access trustworthy and precise input data for confidentiality reasons, the express courier manager has been fundamental in the validation process of input variables. Indeed, since e-commerce sector is ever-changing and strongly affected by customers' choices, what has been written, discussed and applied in the past might not hold in the present, thus the need to such a validation procedure.

The input data are listed and systematised in Table 14, which is organised in different columns as follows:

- Category
- Number
- Input variable → name of the variable
- Value → value the input variable can assume, either a probability distribution or not. In the first case, the output is generated by selecting the mean. Probability distribution will widely be considered in Section 5.3.3, when sensitivity analysis will be carried out.
- Comment → for each input variable, a comment on the determinants the authors followed in selecting a certain value is provided alongside with the assumptions and calculations made, if any.
- Source → input variable source is recorded considering its nature: secondary source (i.e. peer reviewed articles, reports, websites …), primary source (i.e. expert interviews, personal experience) or a combination of the twos.

Category	Number	Input variable	Value	Comment	Source
1st category Population density related	1	E-commerce sales share	27 %	Considering 281 million e-commerce B2c product annual orders, assuming a uniform distribution of orders among Italian citizens, knowing the percentage of Milan population over the Italian one (1.352 M/60.36 M = 0.0224), daily e-commerce B2c orders account for 17244 units. Dividing the Milan daily orders by the number of addresses within the municipality (63781, as September 2020), the resulting share is 27%, under the assumption that one order equals one location. The figure will then be corrected considering the number of boxes per stop. The resulting share applied to the 63781 addresses within Milan represents the number of addresses which has to be visited daily to fulfil the average customers' request volume.	[18]
	2	Boxes per stop	1.23 boxes/stop	The number of boxes to be delivered in one single address is strictly related to the urban layout of the area under investigation (i.e. presence of block of flats). For the sake of simplicity, the algorithm is run considering an average value of 1.23 as reported by Cardenas et al. (2017). However, this variable may range from 1 up to several boxes if the area changes as also claimed by the interviewee. According to this latter, a reasonable value for Milan municipality is pert (1,1.23,2) where pert is a continuous probability distribution which takes 1 as minimum, 1.23 as most likely and 2 boxes as maximum value.	[19]
	3	Speed	10.21 km/h	Speed is computed starting from a secondary source analysis. In this regard, the study carried out by McLeod et al (2020) on daily couriers' tour within London comes handy. Considering one observation (= delivery tour performed by one single van), in 67% of the work shift the van which performs a delivery/return mission is parked, while in 33% of the shift the van is travelling. The paper recorded then a 7.5 hours long work shift, 40 km travelled per day (10 km in the drop-off/pick-up zone and 15 km to	[20]

[18] https://www.osservatori.net/it/ricerche/comunicati-stampa/continua-la-crescita-dellecommerce-b2c-in-italia-gli-acquisti-online-superano-i-31-mld-di-euro-e-il-40-provengono-da-smartphone

[19] "The E-Commerce Parcel Delivery Market and the Implications of Home B2C Deliveries Vs Pick-Up Points" (Cardenas et al., 2017) & manager validation

[20] "Quantifying environmental and financial benefits of using porters and cycle couriers for last-mile parcel delivery" (McLeod et al., 2020) & https://www.lastampa.it/cronaca/2012/05/16/news/velocita-media-15-chilometri-all-ora-br-in-citta-si-viaggia-lenti-come-nel-1700-br-1.36478702 & manager validation

				reach/leave the drop-off/pick-up zone per way). Considering an average speed in the city centre of Milan of 15 km/h, and assuming a 50 km/h speed to reach and leave the city early in the morning and late in the evening respectively, the speed can be computed as follows: ➔ avg speed while travelling = (15 km/h * 10 km + 50 km/h * 30 km)/ 40 km = 41.25 km/h ➔ avg speed while parked = 0 ➔ AVG SPEED FINAL = (41.25 km/h * 7.5h * 0.33 + 0 * 7.5 * 0.67)/7.5h = 10.21 km/h From the same source, if observation 2 is considered, the average daily speed is: - 70% time parking - 30% time travelling - 9.5 h work shift - 47.3 km (17.3 km in the city centre, 30 outside) - avg speed in the city centre 15 km/h, avg speed to reach/leave drop-off/pick-up zone 50 km/h ➔ avg speed while travelling = (15 km/h * 17.3 km + 50 km/h * 30 km)/ 47.3 km = 37.2 km/h ➔ avg speed while parked = 0 ➔ AVG SPEED FINAL = (37.2 km/h * 9.5h * 0.3 + 0 * 9.5 * 0.7)/9.5h = 11.16 km/h In order to validate one value rather than another, the expert manager was kindly asked to validate speed figures. He claimed that on average a van which performs an “e-commerce mission” in the city of Milan travels 80 km per day on an 8 h shift, thus the resulting average speed is 80km/8h = 10km/h. In the light of this latter value, candidates decided that an average daily speed of 10.21 km/h could have been plausible to be plugged into the model application.	
2nd category Logistic service provider	4	Courier hourly salary	20 €/h	The hourly salary has been computed considering the latest available Italian contract in logistics and transportations. Assuming a worker employed by an express courier company who owns a driving licence type B, the average monthly wage is 1644 €/month (based on a normal 39 working hours per	[21]

[21] https://www.confindustria.ud.it/schede/get_file_scheda/9010/10669 & https://intraprendere.net/18201/quanto-costa-un-dipendente/

				week). Considering 4 weeks in a month, the hourly figure is: ➔ 1644 €/month / (39 h/week * 4 weeks/month) = 10.54 €/h It should be noted that this value might differ from one firm to another, due to the different features of the contract they signed with their blue collars. In this realm, the perspective of the firm must be taken into account since the return unitary cost is computed from a logistic service provider point of view (from collection to transportation to courier's first hub). Considering a ratio of circa 1:2 between the net wage and the employee cost beared by the firm, this dissertation makes use of 20 €/h as hourly salary value.	
	5	Home delivery time	1.5 minutes	As stated in the previous section (Chapter 4), home delivery time does not include the time to reach the doorstep of the client, since there might be too many variations.	[22]
	6	Home return time	2 minutes	See above (home delivery time)	[23]
	7	Locker delivery/return time	0.75 minutes	Considering the study by Perboli & colleagues (2018), the following figure can be retrieved: - avg number of parcels to be delivered per locker = 20 boxes - time to load a locker = 15 minutes ➔ loading/unloading time per box = 20 boxes/locker / 15 minutes/locker = 0.75 minutes/box	[24]
	8	Distance to reach drop-off/pick up zone	15 km (one way)	Considering the study carried out by McLeod et al. (2020) in the city of London, 15 km has been considered a realistic input data to account for the so-called stem distance, the distance to reach/leave the drop-off/pick-up area. The value has also been validated by the express courier manager, who told candidates that his company's hub is located few kms south to Milan. Hub location is one of the key decisions logistic service providers have to take in network design phase: several trade-offs have to be carefully read beforehand. For example, having a hub close to the city might be a huge fixed investment on	[25]

[22] Personal experience and manager validation
[23] Personal experience and manager validation
[24] "Simulation–optimisation framework for City Logistics: an application on multimodal last-mile delivery" (Perboli et al., 2018)
[25] "Quantifying environmental and financial benefits of using porters and cycle couriers for last-mile parcel delivery" (McLeod et al., 2020) & manager validation

				the one side, but lower distances have to be travelled to fulfil customers' request on the other (the opposite holds in case of a further hub location).	
	9	Cost van ACI	1.6 €/km	It is the cost per kilometer related to a specific typology of van, which includes fuel, maintenance, taxes, insurance and other indirect costs, as for Automobile Club d'Italia ACI tables. It was assumed that the courier's van is a Fiat Ducato.	[26]
3rd category Independent Variables	10	Available compartments	20 compartments	As reported by the interviewee, for a matter of cost and typology of products handled (usually low value and low/medium value), the most common lockers in Milan are the ones owned by Amazon. Amazon lockers have modular features, so the compartments can vary from minimum 35 to maximum 135. The experts claimed that based on his experience on average an express courier operator ships and/or retrieves 20 parcels per parcel locker. For a matter of precision, this variable may also be placed in category number 2: it is the case of Amazon, which is not only an e-tailer, but also a logistic service provider, therefore the number of available compartments could be its strategic decision, thus available compartments would turn out to be a logistics service provider dependent variable.	[27]
	11	Parcel locker share	14 %	To account for the number of packages that on average and on a daily basis are managed via parcel lockers, the research carried out by Mitrea proves to be useful. The author has framed a research on e-commerce B2c via a survey whose respondents come from the municipality of Turin and its province. The result of his project work shows that on average 14% of the respondents are using parcel locker as most preferred delivery methodology. The underlying assumptions made by the candidates is that the most preferred delivery methodologies correspond to the most preferred return ones and the municipality of Turin can be benchmarked to the city under investigation: Milan.	[28]

[26] http://www.aci.it/fileadmin/documenti/servizi_online/Costi_chilometrici/CKI_web_dicembre_2017.pdf

[27] http://www.trelab.it/wp-content/uploads/2019/04/DUM-e-E-commerce-Parcel-Locker-come-Soluzione-per-lUltimo-Miglio.pdf & manager validation

[28] https://webthesis.biblio.polito.it/14704/1/tesi.pdf

	12	Return percentage	10 %	The interviewee claimed that his firm has to handle a 5-10% of returning parcels over the total number of packages to be managed per day. The website Qaplà in 2015 reported a 13% for Italy. Knowing that return percentage is strongly related to the product category, this dissertation makes use of 10 % as return share over the total number of boxes/parcels to be managed on average.	[29]
	13	Courier market share	12.5 %	To account for the share each market courier has in the municipality of Milan, candidates have decided to consider the 7 biggest express courier firms by volume and value which operated in the Italian context in 2018 as reported by AGCOM, namely BRT, Gruppo Poste Italiane, Amazon, GLS, TNT, UPS and DHL. The remaining players are then merged into an eighth category. Since the model would like to be as more generalizable as possible, perfect competition assumption has been formulated, thus the total market share has been divided equally among the 7 + 1 firms. The result is that the average market share is 12.5 %.	[30]
	14	Geolocated addresses	Longitude and latitude	As far as the database of geolocated is concerned, it should be noted that the database is dynamic, since data points can be either added or cancelled from the list. For the sake of precision, the database has been retrieved at the beginning of September 2020.	[31]

Table 14: List of the input variables with values, comments and sources

5.3 Analysis

As anticipated before, this chapter is divided into three main sections for the sake of completeness and accuracy: design, cost and time output (5.3.1), return unitary cost tendency (5.3.2) and sensitivity analysis (5.3.3).

[29] https://www.qapla.it/blog/ecommerce/confronto-resi-tra-i-paesi-eu/ & manager validation
[30] https://www.agcom.it/documents/10179/15776720/Allegato+20-9-2019+1568974621343/ff014663-b943-481d-836e-ec8531b5690b?version=1.0
[31] https://geoportale.comune.milano.it/sit/open-data-toponomastica/

5.3.1 Design, cost and time output

The reader is now provided with a design, cost and time-based analysis for each of the three scenarios under investigation.

SCENARIO 1: *traditional home delivery/pick-up tour (baseline case)* (Figure 49).

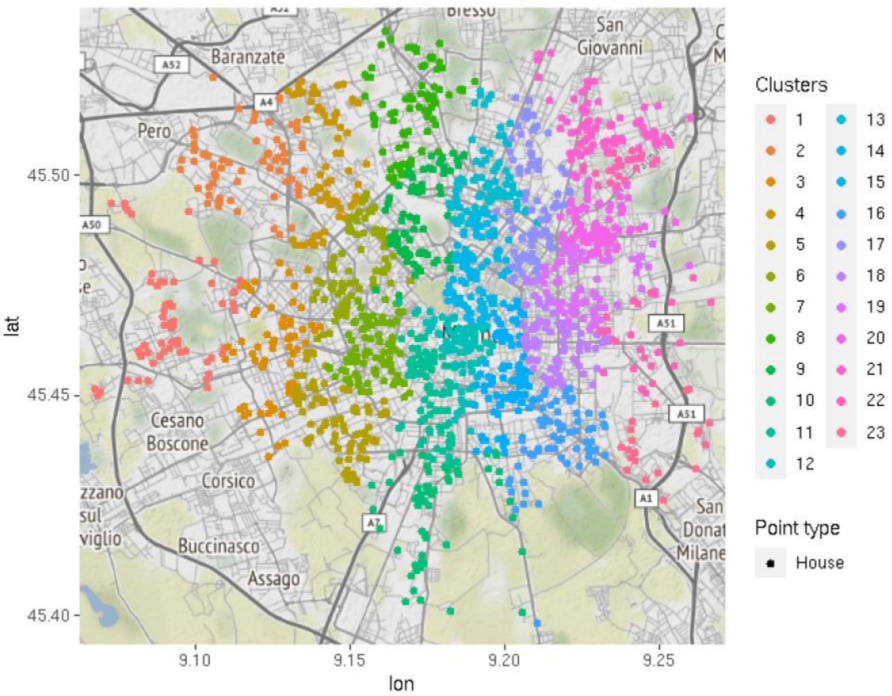


Figure 49: Corrected clusters for the traditional scenario

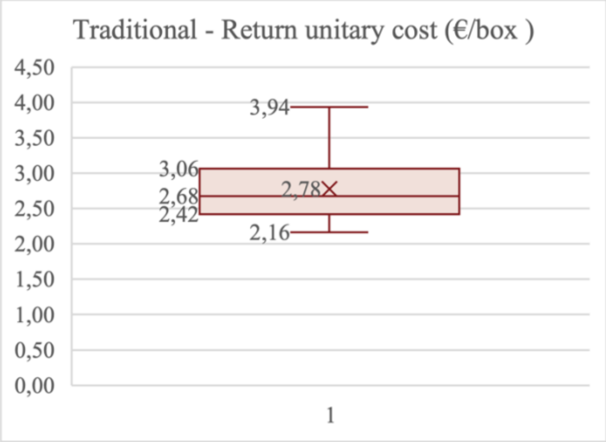
➢ Design (Table 15):

Variable	Value	Comment
Number of clusters	23	22 clusters are fully saturated, 1 is not saturated by construction (in the last step of algorithm application, a cluster with total time close to 8 hours might not be achieved due to the absence of datapoints).
Number of boxes per cluster*	Minimum = 67.65 boxes Maximum = 119.31 boxes Average = 96.67 boxes	-
Distance within drop-off/pick-up area*	Minimum = 20.18 km Maximum = 32.15 km Average = 25.61 km	This figure has to be corrected by summing up 30 km: the fixed distance to reach and leave the drop-off pick-up zone. As a result, according to the model, the average distance travelled per day accounts for 55.61 km.

*Table 15: Cluster design for the traditional scenario (*the cluster resulting from the last iteration of the algorithm application is not taken into account in the computations)*

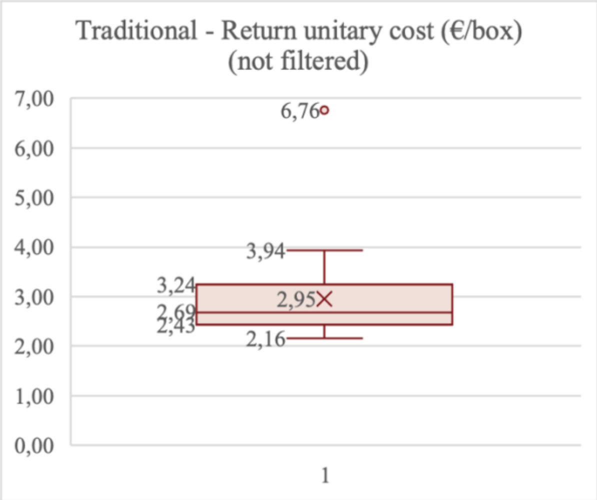
➢ Cost:

Return unitary cost is computed within each of the 22 fully saturated clusters identified by the algorithm. The boxplot[32] below shows the output (Graph 15):



Graph 15: Return unitary cost (€/box) in the traditional scenario (filtered)

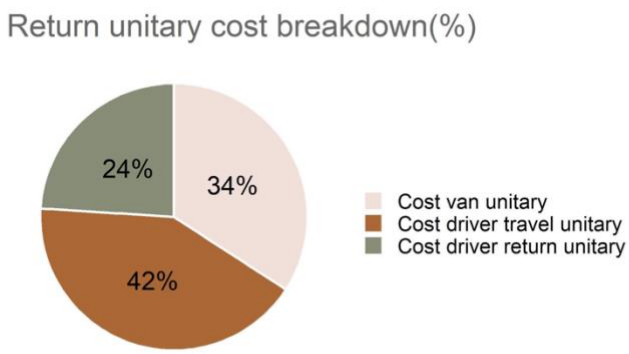
The average return unitary cost accounts for **2.78 €/box returned**.
For the sake of completeness, the average return unitary cost in case all the 23 clusters/tours are taken as reference is **2.95 €/box returned** (Graph 16). The outlier observation (6.76 €/box) is clearly due to the not-fully saturated cluster: given the lower number of parcels delivered and/or shipped, the cost per unit skyrockets, with a 6% increase in the average return cost per unit.



Graph 16: Return unitary cost (€/box) in the traditional scenario (not filtered)

[32] A boxplot is a graph that indicates how the values in the data are spread out. In particular, it is a standardized way of displaying the distribution of observations based on a five-number summary ("minimum", first quartile (Q1), median, third quartile (Q3), and "maximum"). The median (Q2/50th Percentile) is the middle value of the dataset, the first quartile (Q1/25th Percentile) is the middle number between the smallest number (not the "minimum") and the median of the dataset, the third quartile (Q3/75th Percentile) is the middle value between the median and the highest value (not the "maximum") of the dataset, while the interquartile range (IQR) is the range between the 25th and the 75th percentile. https://towardsdatascience.com/understanding-boxplots-5e2df7bcbd51?gi=b04345f6c02

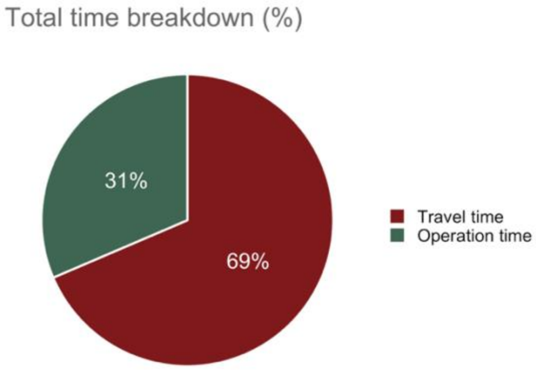
As already mentioned in Chapter 4, return unitary cost is the sum of three different variables: “cost van unitary”, “cost driver travel unitary” and “cost driver return unitary”. The highest incidence in the final cost is represented by “cost driver travel unitary” (42%), whereas “cost van unitary” weights more (34%) than “cost driver return unitary (24%) (see Graph 17, which summarizes the result coming from each full cluster by averaging output values). The latter variable “cost driver return unitary”, which is directly affected by the time needed to handle a return, could be hardly improved given its dependency on the operational time needed to pick-up the box at clients’ location and courier/e-tailer regulations. Instead, “cost driver travel unitary” which accounts for the largest percentage of the final “return unitary cost” might be improved either by increasing the number of boxes per tour or by decreasing the travel time. Lastly, “Cost van unitary”, which includes both fixed (i.e. insurance and taxes) and variable fees (i.e. fuel cost), is directly proportional to the distance travelled and indirectly related to the number of boxes managed within a tour (=cluster). In order to increase efficiency, thus reducing the incidence of “cost van unitary” on “return unitary cost”, the following options can be put in place: from a design perspective, distance has to be reduced or the number of boxes has to be increased or even a combination of the twos could be applied; from a cost perspective, assuming that fixed costs do not strongly differ from one van to another, efficiency might be enhanced by choosing different vehicles.



Graph 17: Return unitary cost breakdown (%) in the traditional scenario

- Time:

As already presented in Section 4, total time is given by the sum of the travel time and the operational time. The breakdown of total time is provided in the pie-chart Graph 18:



Graph 18: Total time breakdown (%) in the traditional scenario

As per Graph 17, it summarizes the results coming from each full cluster by averaging the output of fully saturated clusters.

The incidence of the travel time over the operation one on the total is more than double, 69% versus 31%. It should be noted that travel time might also be affected by a higher degree of uncertainty: urban congestions, for instance, could decrease by large vehicle speed thus requiring couriers to reschedule delivery/pick-up missions and/or to activate the overtime with a consequent cost increase. The link between time and cost can be found in two different relationships: firstly, "cost driver travel unitary" and "cost van unitary" are directly proportional to the travel time, secondly, "cost driver return unitary" depends on return unitary time, a component of operation time. The higher incidence of the "cost driver travel unitary" plus "cost van unitary" over "cost driver return unitary" (42%+34% vs 24% as per Graph 17) is therefore explained by these latter relations.

SCENARIO 2: exclusive home-parcel locker tour (Figure 50 and Figure 51).

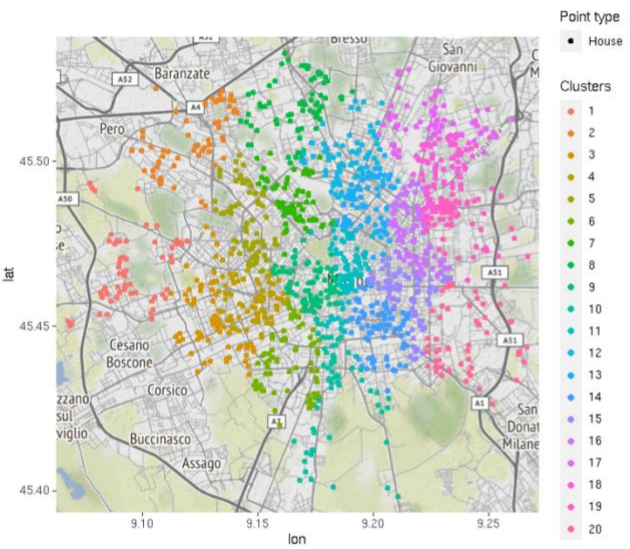


Figure 50: Corrected clusters for the exclusive scenario - home tour

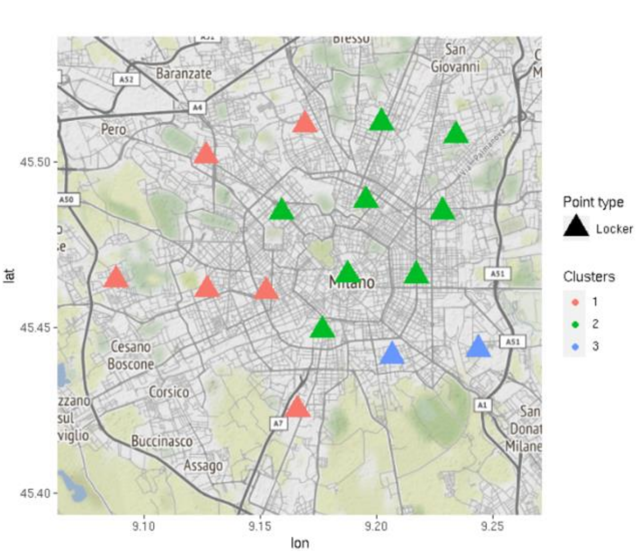


Figure 51: Corrected clusters for the exclusive scenario - parcel locker tour

Scenario 2 is presented considering the exclusivity of return/delivery methodologies, so the analysis will be split in two parts: "traditional" (drop-off and pick-up missions performed at customers' place) and "parcel locker" (missions which includes only parcel locker as return/delivery methodology).

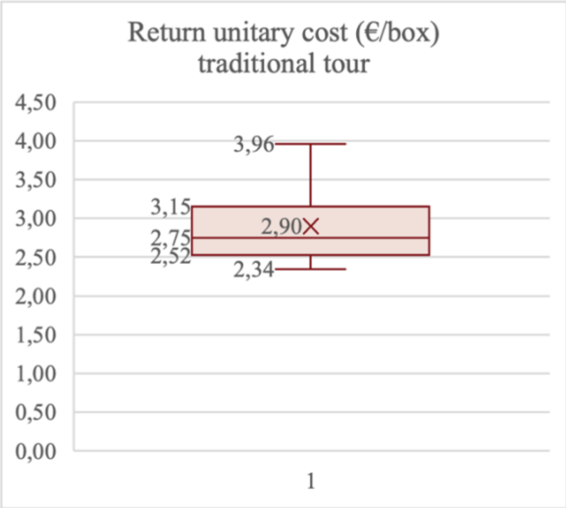
- Design (Table 16):

Variable	Value "Traditional" part	Value "Parcel locker" part	Comment
Number of clusters	20	3	20 fully saturated (traditional), 2 saturated + 1 not fully saturated (parcel locker).
Number of boxes per cluster*	Minimum = 66.42 boxes Maximum = 110.7 boxes Average = 92.56 boxes	Minimum = 113 boxes Maximum = 150.67 boxes Average = 131.84 boxes	The average number of boxes per tour managed via parcel locker is higher than the one dropped-off/picked up at home due to lower handling time per unit and so a higher number of packages managed within a single location.
Distance within drop-off/pick-up area*	Minimum = 21.67 km Maximum = 32.05 km Average = 26.53 km	Minimum = 30.66 km Maximum = 37.13 km Average = 33.89 km	As in the case of scenario 1, this figure has to be corrected by summing up 30 km: the fixed distance to reach and leave the drop-off/pick-up zone. Resulting average total distance travelled per day accounts for 56.53 km (traditional) and 63.89 km (parcel locker). The difference, 13%, is the countereffect of having a higher number of boxes per cluster/tour.

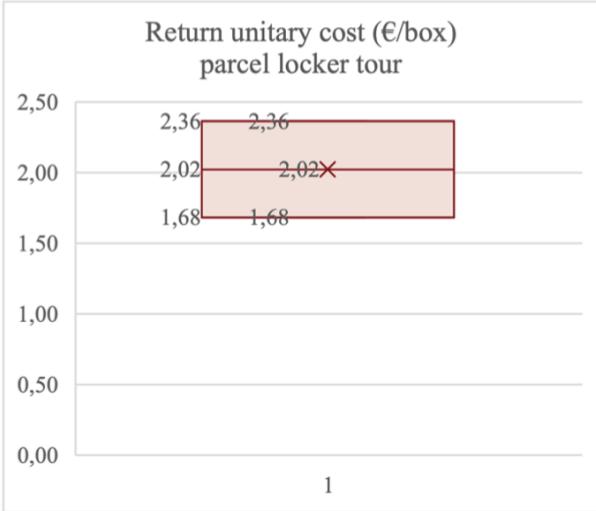
*Table 16: Cluster design for the exclusive scenario (*the cluster resulting from the last iteration of the algorithm application in "parcel locker" part is not taken into account in the computations)*

- Cost:

Return unitary cost is computed within each of the fully saturated clusters identified by the algorithm. The boxplots below (Graph 19 and Graph 20) show the output.



Graph 19: Return unitary cost (€/box) in the exclusive scenario - traditional tour

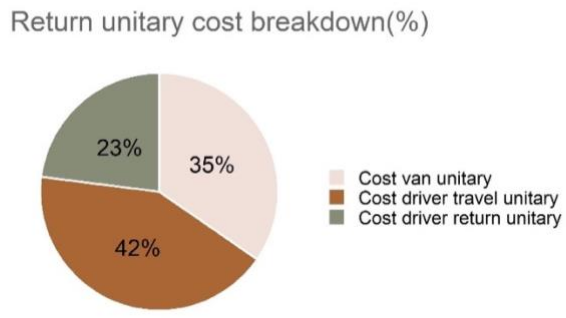


Graph 20: Return unitary cost (€/box) in the exclusive scenario - parcel locker tour

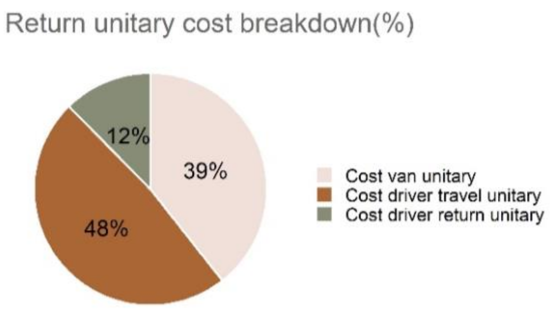
The average return unitary cost is **2.90 €/box returned** in the traditional setting and **2.02 €/box returned** in parcel locker option (the average value considering both tour typologies is 2.82 €/box returned). The difference in the two configurations have already been explained in the design table above (Table 16): given a higher number of pacages managed within a single stop, in parcel locker option couriers can better saturate delivery/pick-up missions by volume, meaning that in the same 8 hours shift a higher number of parcels can be handled thus increasing the value of the denominator (boxes per tour) and getting a lower final return unitary cost.

The breakdown analysis of return unitary cost in scenario 2 proves to be insigthful too. First of all, it should be noted that the traditional part, Graph 21, has the same percentage as the baseline scenario, even if in absolute terms the return unitary cost is higher (2.90 vs 2.78 €/box). This latter gap is due to the algorithm assumptions, indeed in scenario 2 a percentage equal to the share locker penetration (14% in the simulation) is excluded by the list of addresses to be visited in Milan every day. Such a condition implies that datapoints in scenario 2 traditional part are scattered in the municipality of Milan with a lower density as confirmed by the lower average value of boxes per tour/cluster (92.56 vs 96.67) and by the higher number of km travelled within the drop-off/pick-up zone (26.53 vs 25.61 km).

As regard parcel locker missions, the return unitary cost breakdown (Graph 22) is completely different from scenario 1 and traditional scenario 2. In particular, due to the lower unitary operation time, "cost driver return unitary" has a lower incidence compared to the other scenarios: managing a "parcel locker" box is affected to a lesser extent by variability and uncertainty since human interaction disappears.



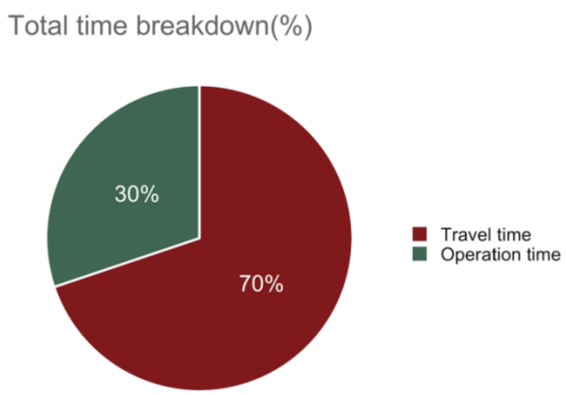
Graph 21: Return unitary cost breakdown (%) in the exclusive scenario - home tour



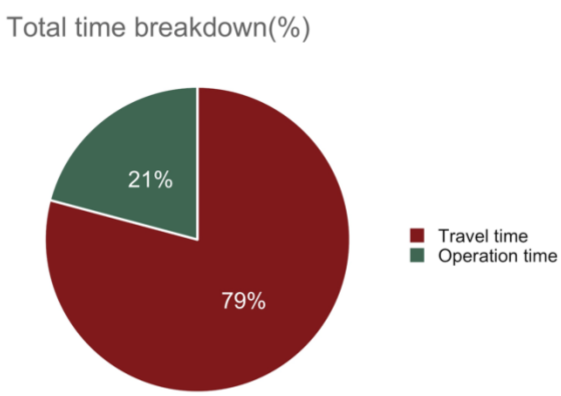
Graph 22: Return unitary cost breakdown (%) in the exclusive scenario - parcel locker tour

- Time:

Total time breakdown follows the pattern of return unitary cost breakdown in the traditional option, so the output is basically equal to the one observed in scenario 1: 70% of the total time is devoted to travelling and 30% to operational activities (Graph 23). Parcel locker option (Graph 24), instead, is slightly different with 21% operation time and 79% travel time. As already mentioned above, such gap is explained by the low unitary operation time needed to handle parcels at parcel locker locations.



Graph 23: Total time breakdown (%) in the exclusive scenario - traditional tour



Graph 24: Total time breakdown (%) in the exclusive scenario - parcel locker tour

SCENARIO 3: mixed home-parcel locker tour (Figure 52).

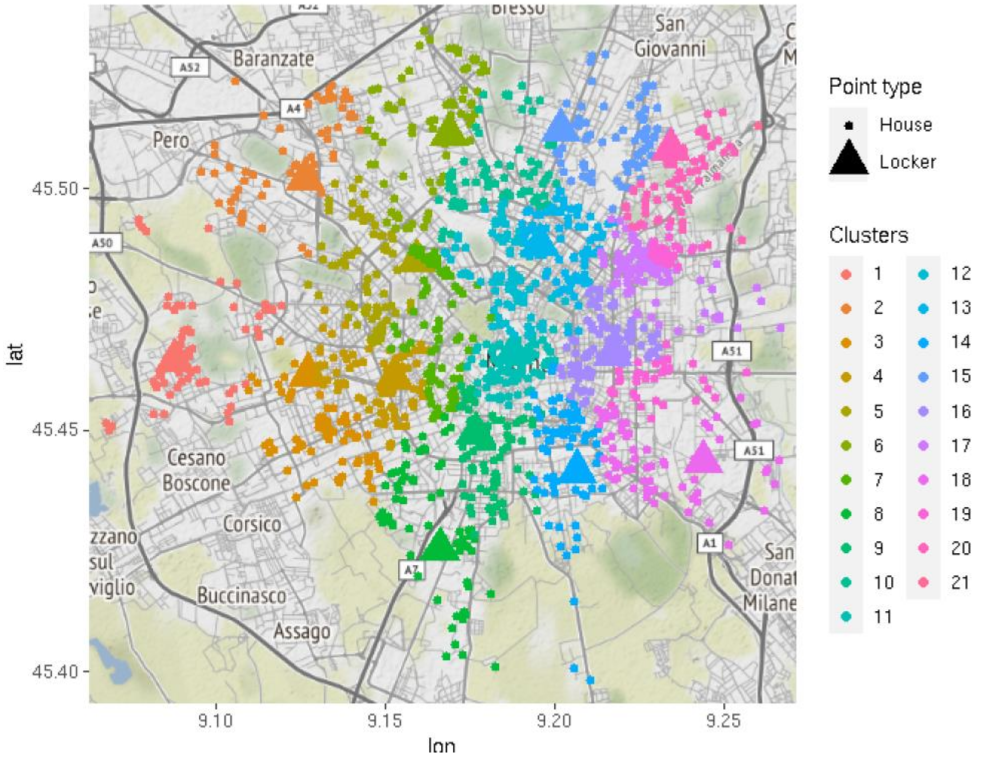


Figure 52: Corrected clusters in the mixed scenario

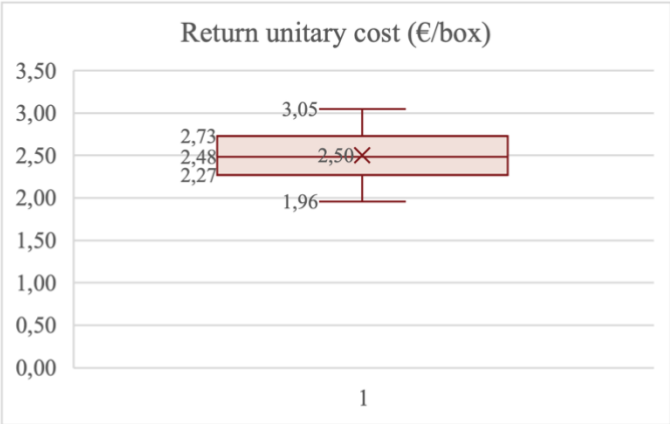
- Design

Variable	Value	Comment
Number of clusters	21	20 clusters are fully saturated, 1 is not saturated by construction.
Number of houses per cluster*	Minimum = 60 houses Maximum = 93 houses Average = 75.2 houses	-
Number of lockers per cluster*	Minimum = 0 locker Maximum = 1 locker Average = 0.8 locker	-
Number of boxes per cluster* (both parcel locker and houses)	Minimum = 86.1 boxes Maximum = 133.224 boxes Average = 107.564 boxes	Considering the clusters with at least one locker, the mean equals to 110.239, whereas the average number of boxes of 0-locker cluster equals to 96.86 boxes (13.8 % gap).
Distance within drop-off/pick-up area*	Minimum = 20.48 km Maximum = 32.01 km Average = 26.31 km	This figure has to be corrected by summing up 30 km: the fixed distance to reach and leave the drop-off/pick-up zone. As a result, according to the model the average distance travelled per day accounts for 56.31 km.

Table 17: Cluster design for the mixed scenario (the cluster resulting from the last iteration of the algorithm application is excluded from the computations)*

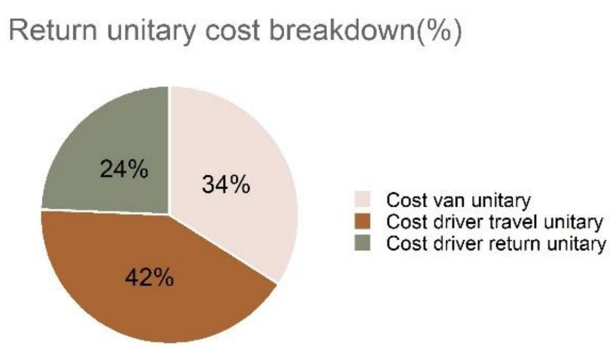
➢ Cost and Time:

Return unitary cost is computed within each of the 20 fully saturated clusters identified by the algorithm. The boxplot below (Graph 25) shows the output.

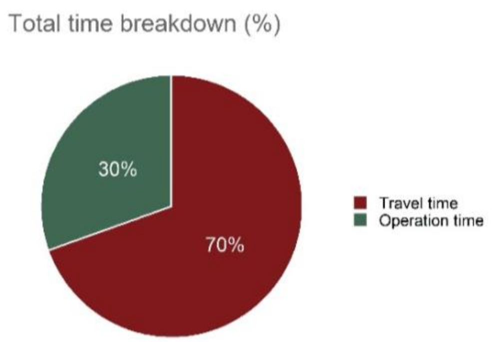


Graph 25: Return unitary cost (€/box) in the mixed scenario

The average return unitary cost accounts for **2.50 €/box returned**.
The "return unitary cost" and "total time" breakdowns are as follows (Graph 26 and Graph 27):



Graph 26: Return unitary cost breakdown (%) in the mixed scenario



Graph 27: Total time breakdown (%) in the mixed scenario

In relative terms, return unitary cost composition is equal to the baseline case (scenario 1), whereas the total time breakdown is just slightly different compared to scenario number 1 (30 % vs 31% travel time, 70 % vs 69 % operation time). It can be argued that there are not differences in the relative weights of return unitary cost and total time elements between traditional and mixed scenarios.

5.3.2 Return unitary cost tendency

In this section the reader is provided with an analysis of the return unitary cost trend considering two key variables: boxes per tour and drop density.

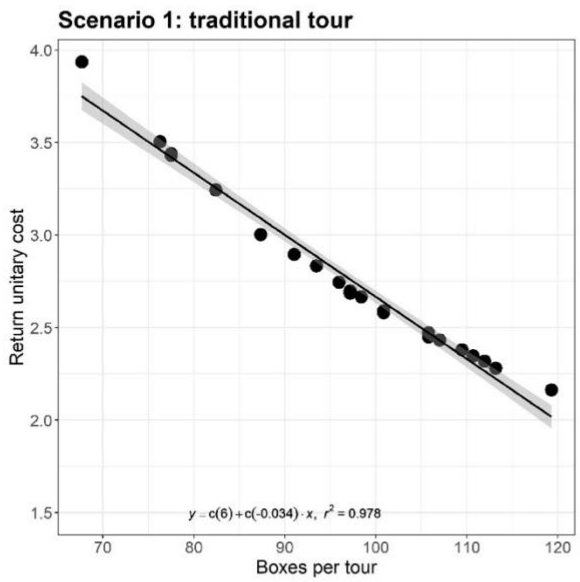
Boxes per tour represents the number of parcels handled within a single tour (=cluster), deliveries and returns included. The impact of such a variable over the return unitary cost can be easily foreseen: since reverse logistics is a sub-process of e-commerce parcel delivery, an inverse proportionality between boxes per tour and cost is expected. Indeed, considering two vans employed in a same-duration shift delivery/return mission, the unitary cost per box (no matter the type) will be higher if a lower number of boxes are managed and vice versa in the case of more boxes are shipped.

Nevertheless, for the sake of completeness an additional variable is benchmarked against the return unitary cost, namely drop density. Even if drop density computed as boxes per tour divided by the area of the tour itself is built upon the number of parcels managed (numerator), it is deemed to be more precise: given an equal shift length, the return unitary cost is analysed considering the relative weight of the number of boxes in a single tour over the surface of the tour itself.

The following graphs show how boxes per tour and drop density behaves in respect with the return unitary cost.

SCENARIO 1

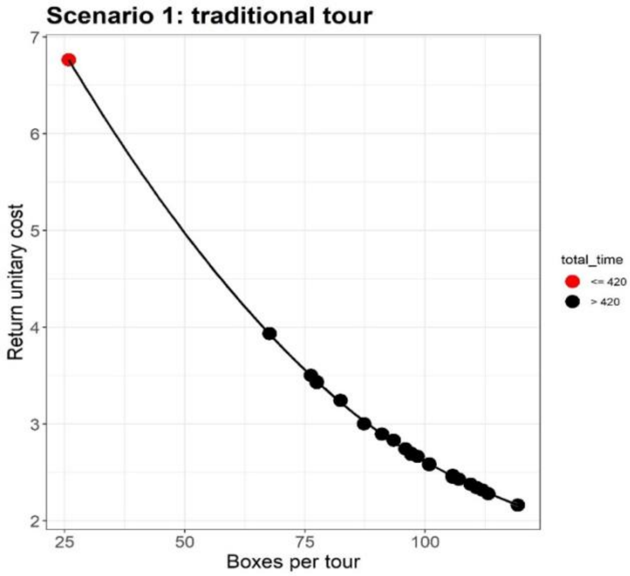
- *boxes per tour*



Graph 28: Boxes per tour VS Return unitary cost - traditional scenario

In Graph 28, black dots point out the observations within each cluster, continuous line represents the fitted line according to linear smoothing methodology, whereas grey shadow indicates the standard error.

It should be pointed out that the last step of the algorithm clustering creation, whose output is a not-fully saturated cluster, is not represented: this last data point, indeed, prevents candidates to provide a fair comparison (in Graph 29, the outlier observation, red point, which refers to the last cluster of model application, disrupts the tendency as presented in Graph 28).



Graph 29: Boxes per tour VS Return unitary cost (not filtered) - traditional scenario

The reader is also provided with a formal analysis of the relationships between the two variables under investigation, namely return unitary cost and boxes per tour. Such a formal analysis takes on the form of a linear regression model which aims at investigating whether or not there is a statistically significant effect of boxes per tour over return unitary cost variable. The linear regression output is as in Figure 53:

```
TRADITIONAL regression analysis: Return unitary cost VS Boxes per tour
===============================================
                         Dependent variable:
                    ---------------------------
                         Return unitary cost
-----------------------------------------------
Boxes per tour                -0.034***
                               (0.001)

Constant                       6.020***
                               (0.110)

-----------------------------------------------
Observations                     22
R2                              0.978
Adjusted R2                     0.977
Residual Std. Error         0.072 (df = 20)
F Statistic             878.022*** (df = 1; 20)
===============================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

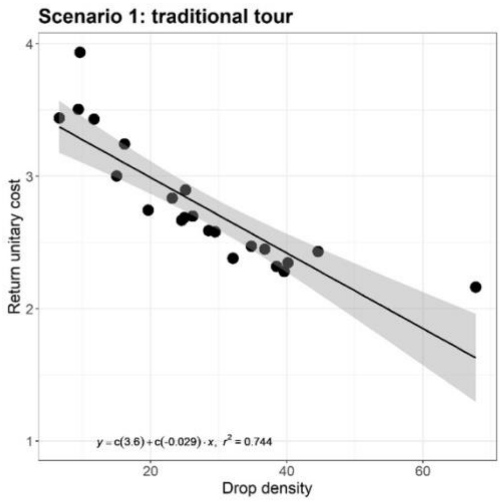
Figure 53: Output of the linear regression for Boxes per tour VS Return unitary cost – traditional scenario

The main takeaways of the regression analysis[33] are the following:

- *R-squared*, coefficient of determination, is high and suggests that 97.8 % of the variance in the response (y – return unitary cost) can be explained by the predictor variable (x – boxes per tour), so basically that knowing the number of boxes is a good proxy to compute the return unitary cost.
- *F statistic*, regression mean squares divided by residual mean squares, is linked to the F-test, the statistical test which indicates whether the regression model provides a better fit to the data than a model that contains no independent variables. F-test has two hypotheses: the null one states that the model with no independent variables fits the data as well as the current model analysed, whereas the alternative one states that the current model fits data better than the intercept-only model. To confirm/reject hypothesis, p-value has to be benchmarked to the significance level (10%, 5% and 1%). In this case, the p-value for the F-test is lower than any if the three level of significance (0.1, 0.05, 0.01), therefore, the null can be rejected, and the alternative hypothesis holds: the current model is better than the intercept-only model.
- *Slope coefficient*. The slope coefficient accounts for -0.034, meaning that an additional unit of x (boxes per tour) decreases by 0.034 units y (return unitary cost), assuming that all other predictor variables, if any, are held constant. As per the F-test, the slope coefficient is statistically significant because the p-value is below any of the levels of significance used, the null hypothesis can be rejected, therefore return unitary costs depend on boxes per tour.
- *Intercept*. The intercept, constant value, accounts for 6.020. The intercept is simply the expected mean value of the response (y – return unitary cost) when all the predictors (x – boxes per tour) are null. However, if the predictor never equals 0, then the intercept has no intrinsic meaning, as in this case because it does not make any sense to consider the situation where no boxes are managed within a tour.

[33] https://www.theanalysisfactor.com/interpreting-the-intercept-in-a-regression-model/#:~:text=The%20intercept%20(often%20labeled%20the,intercept%20has%20no%20intrinsic%20meaning.

- *drop density*



Graph 30: Drop density VS Return unitary cost – traditional scenario

The linear regression analysis applied to the model including drop density, number of boxes per tour divided by the surface of the tour, and return unitary cost is the following (Figure 54):

```
TRADITIONAL regression analysis: Return unitary cost VS Drop density
===============================================
                        Dependent variable:
                    ---------------------------
                        Return unitary cost
-----------------------------------------------
Drop density                 -0.029***
                              (0.004)

Constant                      3.561***
                              (0.115)

-----------------------------------------------
Observations                    22
R2                             0.744
Adjusted R2                    0.731
Residual Std. Error       0.243 (df = 20)
F Statistic            58.118*** (df = 1; 20)
===============================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

Figure 54: Output of the linear regression for Drop density VS Return unitary cost – traditional scenario

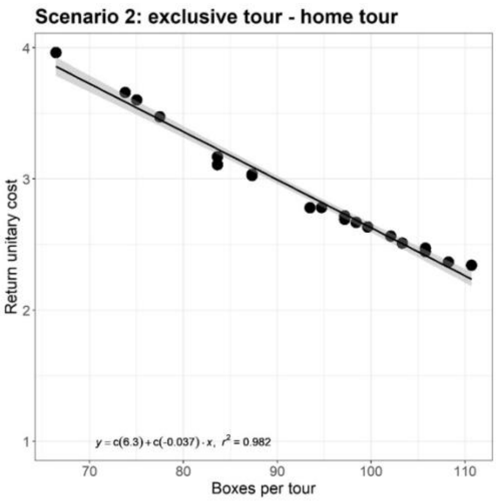
Although R-squared is lower than the one found in Figure 53, the model is still statistically significant (see F-test value). As for the predictor boxes per tour, then, drop density is statistically significant in predicting the response return unitary cost, therefore the null hypothesis of no interaction between the two variables can be rejected. Consequentially, an increase by one point in the drop density implies a decrease by 0.029 in the average return unitary cost.

The tendency of drop density over return unitary cost confirms what has already been studied by Gevaers et al. (2014): in their paper called “Cost Modelling and Simulation of Last-mile Characteristics in an Innovative B2c Supply Chain Environment with Implications on Urban Areas and Cities”, the authors claimed that “the density of an area is positively correlated with the number of possible stops a driver can execute in a specific time frame.” but also that last mile costs/unit is inversely proportional to the population density. Although candidates have plugged drop density (and not population one) in the model, it is reasonable to assume that a higher number of people is likely to affect positively the number of e-commerce orders and so density into the model, thus confirming that positive variation in drop density marks lower return unitary costs and vice versa for negative variation. For a matter of precision, the underlying assumption of this reasoning is that last mile cost computation developed by Gevaers et al. (2014) can be applied to this reverse logistic framework.

SCENARIO 2

Following the approach of Section 5.3.1, scenario 2 will be divided into two parts: traditional and parcel locker. For each part, the graphs referring to the variables under investigation namely boxes per tour and drop density are reported alongside with the linear regression analysis output (see Graph 31, Figure 55, Graph 32 and Figure 56).

- scenario 2 traditional part – *boxes per tour*

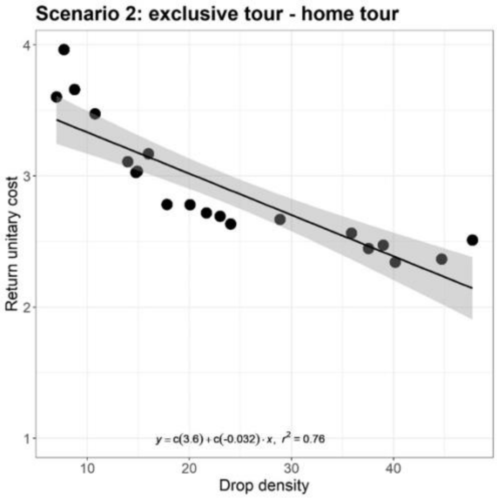


Graph 31: Boxes per tour VS Return unitary cost - exclusive scenario - home tour

```
EXCLUSIVE (home) Regression analysis: Return unitary cost VS Boxes per tour
===============================================
                         Dependent variable:
                     ---------------------------
                         Return unitary cost
-----------------------------------------------
Boxes per tour                -0.037***
                               (0.001)

Constant                       6.289***
                               (0.108)

-----------------------------------------------
Observations                     20
R2                              0.982
Adjusted R2                     0.981
Residual Std. Error        0.064 (df = 18)
F Statistic             997.201*** (df = 1; 18)
===============================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

Figure 55: Output of the linear regression for Boxes per tour VS Return unitary cost - exclusive scenario - home tour

- scenario 2 traditional part – *drop density*



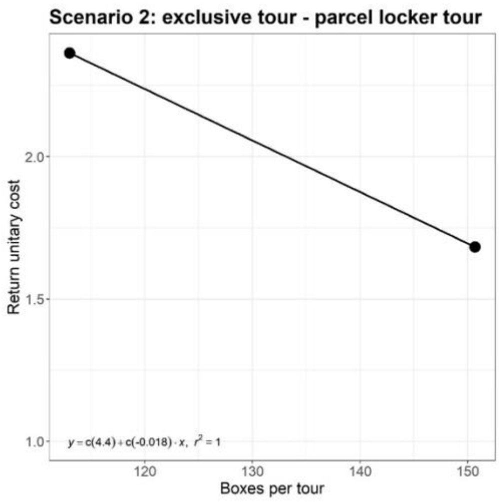
Graph 32: Drop density VS Return unitary cost - exclusive scenario - home tour

```
EXCLUSIVE (home) Regression analysis: Return unitary cost VS Drop density
===============================================
                         Dependent variable:
                     ---------------------------
                         Return unitary cost
-----------------------------------------------
Drop density                  -0.032***
                               (0.004)

Constant                       3.648***
                               (0.112)

-----------------------------------------------
Observations                      20
R2                              0.760
Adjusted R2                     0.746
Residual Std. Error        0.236 (df = 18)
F Statistic            56.925*** (df = 1; 18)
===============================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

Figure 56: Output of the linear regression for Drop density VS Return unitary cost - exclusive scenario - home tour

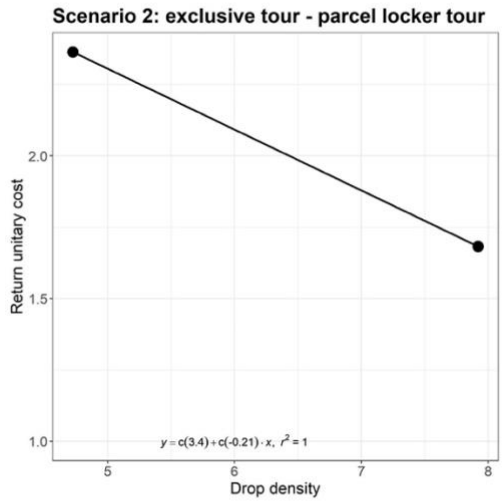
Unsurprisingly, the traditional part pattern is similar to scenario 1 both considering boxes per tour and drop density as predictors. Indeed, the two settings differ only in the number of datapoints that could be found in a given space, higher in scenario 1, lower in scenario 2 because a percentage of datapoints equal to the parcel locker share has been “cancelled” from the initial dataset.

- scenario 2 parcel locker part – *boxes per tour*



Graph 33: Boxes per tour VS Return unitary cost - exclusive scenario - parcel locker tour

- scenario 2 parcel locker part – *drop density*



Graph 34: Drop density VS Return unitary cost - exclusive scenario - parcel locker tour

It is worth noticing that in exclusive – parcel locker part the trend lines are not very insightful: R squared is equal to 1 suggesting a perfect fit. This condition is obviously due to the geometric axiom that 2 points, in this case the fully saturated parcel locker clusters, identify one and only one line. Consequentially, a two-observations regression analysis turns out to be completely meaningless (see Figure 57 boxes per tour VS return unitary cost)

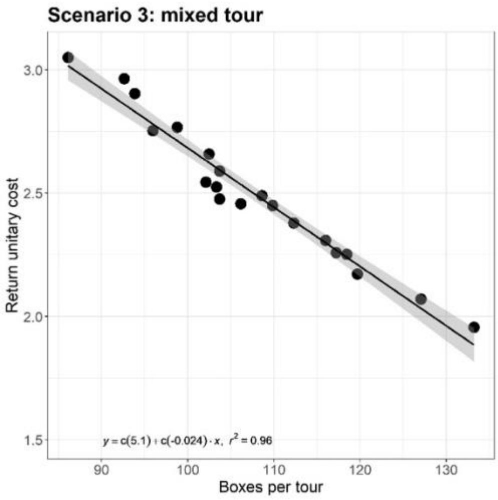
```
EXCLUSIVE (parcel locker) Regression analysis: Return unitary cost VS Boxes per tour
==========================================
                   Dependent variable:
               ---------------------------
                   Return unitary cost
------------------------------------------
Boxes per tour              -0.018


Constant                     4.409


------------------------------------------
Observations                   2
R2                           1.000
==========================================
Note:          *p<0.1; **p<0.05; ***p<0.01
```

Figure 57: Output of the regression analysis for Boxes per tour VS Return unitary cost - exclusive scenario - parcel locker tour

SCENARIO 3

Scenario 3 does not show any particular differences compared to the other two settings, both considering boxes per tour and drop density tendency over the response return unitary cost (see Graph 35, Figure 58, Graph 36 and Figure 59)

- *boxes per tour*

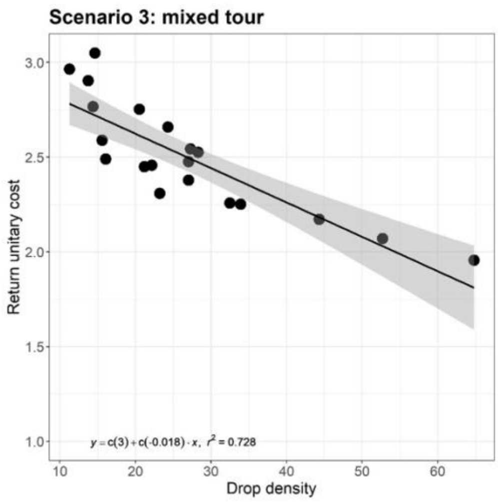


Graph 35: Boxes per tour VS Return unitary cost - mixed scenario

```
MIXED Regression analysis: Return unitary cost VS Boxes per tour
===============================================
                        Dependent variable:
                    ---------------------------
                        Return unitary cost
-----------------------------------------------
Boxes per tour               -0.024***
                              (0.001)


Constant                      5.085***
                              (0.125)


-----------------------------------------------
Observations                    20
R2                             0.960
Adjusted R2                    0.958
Residual Std. Error       0.060 (df = 18)
F Statistic           429.742*** (df = 1; 18)
===============================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

Figure 58: Output of the regression analysis for Boxes per tour VS Return unitary cost – mixed scenario

- *drop density*



Graph 36: Drop density VS Return unitary cost - mixed scenario

```
MIXED Regression analysis: Return unitary cost VS Drop density
===============================================
                        Dependent variable:
                    ---------------------------
                        Return unitary cost
-----------------------------------------------
Drop density                 -0.018***
                              (0.003)


Constant                      2.986***
                              (0.078)


-----------------------------------------------
Observations                    20
R2                             0.728
Adjusted R2                    0.713
Residual Std. Error       0.156 (df = 18)
F Statistic            48.253*** (df = 1; 18)
===============================================
Note:               *p<0.1; **p<0.05; ***p<0.01
```

Figure 59: Output of the regression analysis for Drop density VS Return unitary cost - mixed scenario

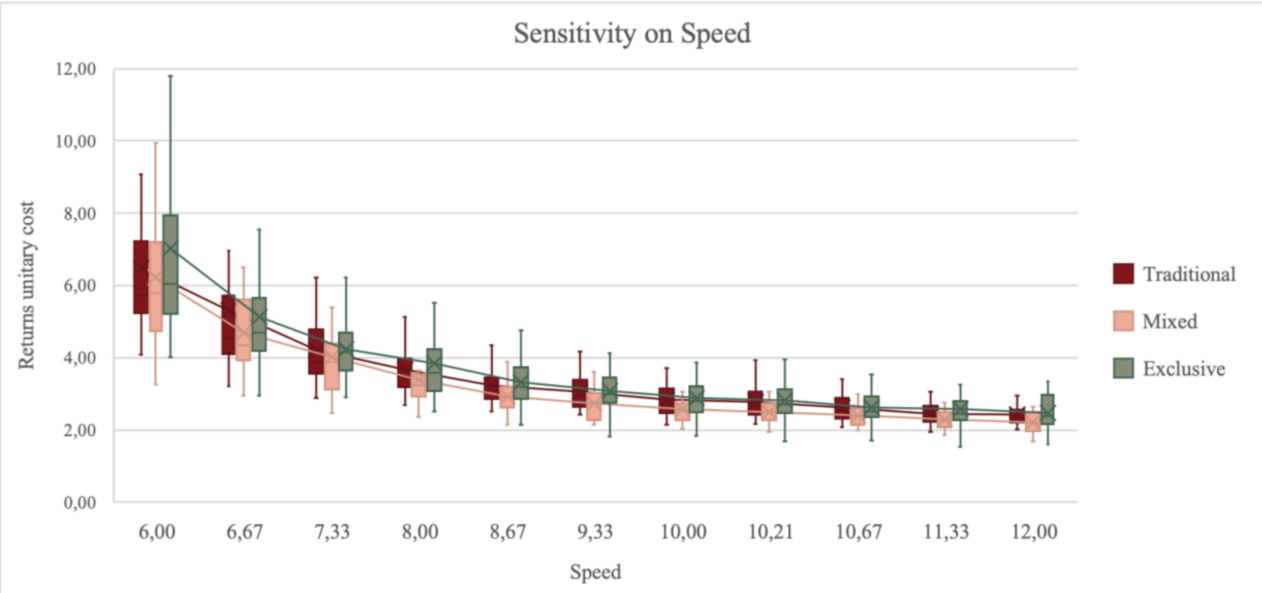
Coming to the conclusion of this part, it can be inferred that there is a negative relationship between return unitary cost and boxes per tour – drop density, these latter relations have been tested to be statistically significant in all of the scenarios under investigation, thus confirming in a formal and analytical way existing academic studies.

5.3.3 Sensitivity analysis

In this section, the outcomes of the sensitivity analysis are presented and discussed with the final objective to find out the relationships between all the input variables and return unitary cost. As for the previous two sections, all the three scenarios will be investigated to evaluate similarities and differences if any.

5.3.3.1 Input variables patterns and comparison between scenarios

1. Input variable: **SPEED**



Graph 37: Sensitivity on Speed - benchmark value 10.21 km/h

The takeaways of the analysis are:

- *decreasing tendency*: higher values in speed imply that more boxes can be handled in a tour, thus lowering the number of clusters (=tour) needed to fulfil the demand as well as the incidence of the fixed distance to reach drop-off/pick up area. The underlying determinant of this decreasing pattern of return unitary cost over speed is therefore ascribable to economies of scale.
- *asymptote*: return unitary cost is asymptotic in respect to speed. Indeed, given the same 8-hour-tour, distance-related-cost resulting from higher values in speed is not compensated by the higher number of packages delivered/returned: there are fixed costs that has to be beared in any case.

- *variability*: variability in y (return unitary cost) decreases as the speed rises because the incidence of the fixed distance to reach drop-off/pick-up area will be lower and the likelihood to have a fully-saturated tour will be higher (by construction, if the van is faster the probability to add an n-point to the cluster under investigation rises).

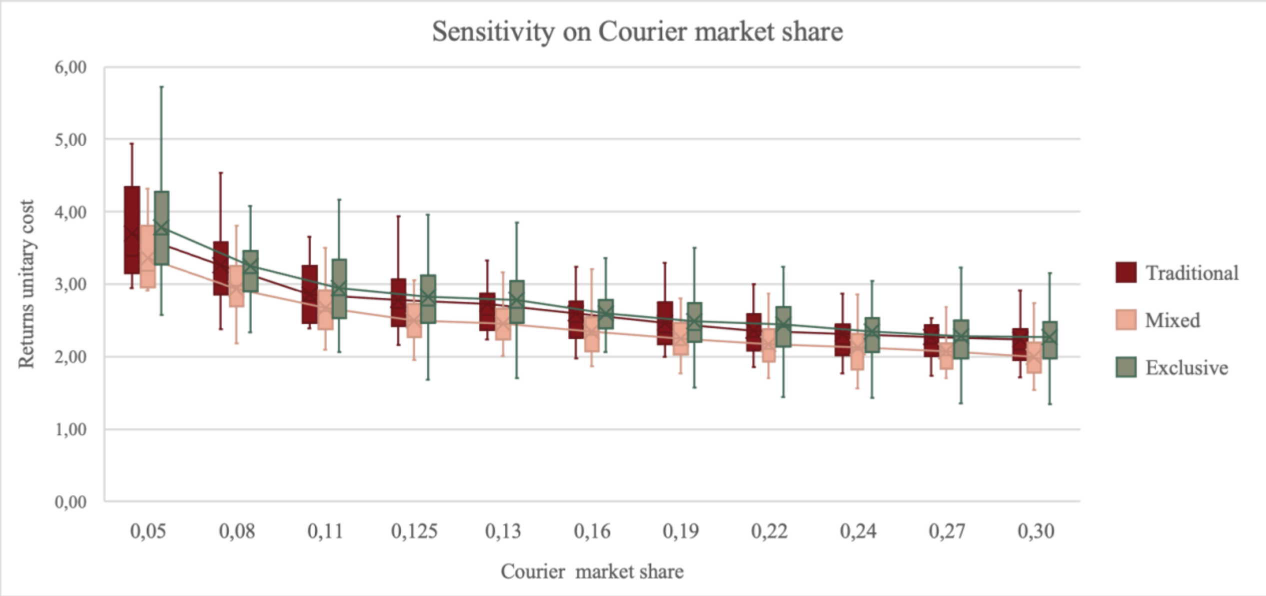
The reader is also provided with Table 18 describing the extent to which the three scenarios differ. On the first column the different levels of speed are shown taking the benchmark value of 10.21 km/h as reference, while the second column indicates the delta percentage of each level of speed in respect to the reference one. Then, the other three columns reveal how return unitary cost differs from one methodology to another with regard to each level of speed. Next in the chapter, the same procedure will be applied to the remaining input variables.

		Delta Return Unitary Cost		
Speed	Delta Speed	Traditional	Exclusive	Mixed
6,00	-41%	133%	149%	148%
6,67	-35%	91%	82%	88%
7,33	-28%	52%	50%	60%
8,00	-22%	32%	36%	36%
8,67	-15%	17%	17%	17%
9,33	-9%	10%	9%	9%
10,00	-2%	2%	2%	3%
10,21	**0%**	**0%**	**0%**	**0%**
10,67	4%	-5%	-7%	-4%
11,33	11%	-12%	-8%	-8%
12,00	18%	-12%	-13%	-12%

Table 18: Speed impact on Return unitary cost in the three scenarios

As it is possible to note, the variations in the return unitary cost are quite similar among scenarios, nevertheless a severe speed decrease generates stronger effect in scenarios 2 and 3. Indeed, scenarios 2 and 3 comprehend parcel locker locations: since there are parcel lockers is trivial to say that there is a higher probability of excluding parcel locker locations, and the corresponding consistent amount of packages, in a single tour from clustering creation phase. If this latter condition happens, the number of boxes managed within a single tour decreases and, as a countereffect, the return unitary cost would increase significantly.

2. Input variable: **COURIER MARKET SHARE**



Graph 38: Sensitivity on Courier market share – benchmark value 0.125

The outcomes of the analysis are:

- *decreasing trend*: by increasing the courier share, a higher number of packages has to be delivered/returned in the same area (Milan), resulting in a drop density increase. Drop density, as detailed in Section 5.3.2, is inversely proportional to return unitary cost, thus a market share courier rise decreases the return unitary cost. In addition, the determinant of the pattern can also be found in the economies of scale and scope effect: a higher number of missions results in a maximization of efficiencies (scale) and stronger experience levels (scope).
- *asymptote*: as for speed, return unitary cost is asymptotic toward market courier share due to fixed costs that have to be beared in any case.

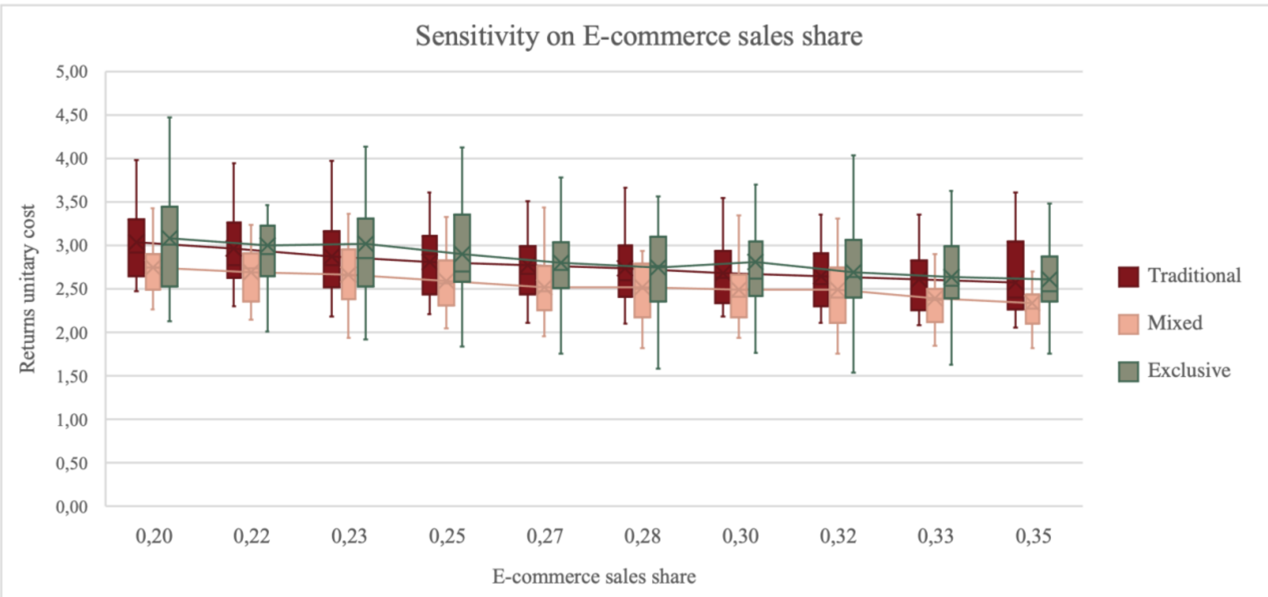
Coming to the precise comparison among scenarios, no differences can be appreciated (see Table 19): the variation in market courier share changes only the overall number of parcels to be handled per day independently on the configuration chosen (scenario 1,2 or 3) to managed them.

		Delta Return unitary cost		
Courier market share	Delta Courier market share	Traditional	Exclusive	Mixed
0,050	-60%	33%	34%	34%
0,078	-38%	17%	15%	17%
0,106	-16%	3%	4%	7%
0,125	0%	0%	0%	0%
0,133	7%	-2%	-1%	-2%
0,161	29%	-7%	-8%	-6%
0,189	51%	-11%	-12%	-10%
0,217	73%	-15%	-13%	-13%
0,244	96%	-17%	-17%	-15%
0,272	118%	-18%	-19%	-17%
0,300	140%	-19%	-20%	-20%

Table 19: Courier market share impact on Return unitary cost in the three scenarios

3. Input variable: **E-COMMERCE SHARE**

For the sake of completeness, the sensitivity analysis on e-commerce share is provided although the results are in line with market courier share. The only difference among the two variables is that on the one side, market courier share, the amount of parcels to be handled per day depends on strategical couriers' decisions and market dynamics, whereas on the other side, e-commerce share, the number of boxes to be shipped depends mostly on customer behaviours.



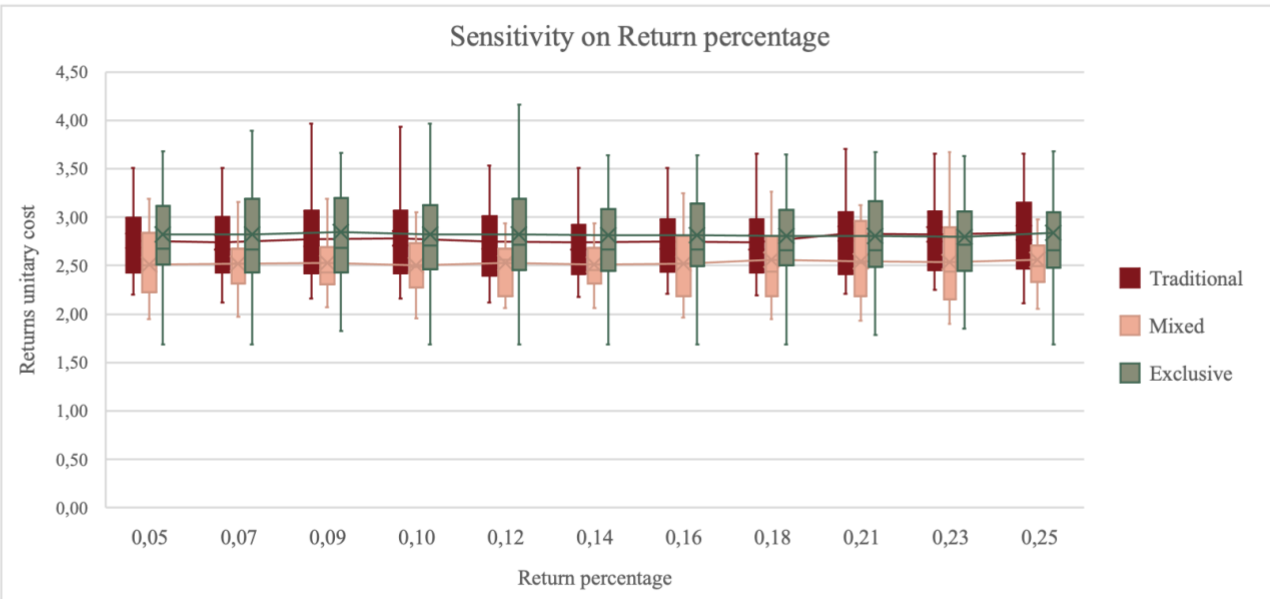
Graph 39: Sensitivity on E-commerce sales share - benchmark value 0.27

		Delta Return unitary cost		
E-commerce sales share	Delta E-commerce sales share	Traditional	Exclusive	Mixed
0,200	-26%	9%	9%	10%
0,217	-20%	7%	6%	7%
0,233	-14%	3%	7%	7%
0,250	-7%	1%	3%	4%
0,267	-1%	-1%	-1%	1%
0,270	0%	0%	0%	0%
0,283	5%	-2%	-3%	1%
0,300	11%	-3%	0%	0%
0,317	17%	-5%	-5%	0%
0,333	23%	-6%	-7%	-4%
0,350	30%	-7%	-8%	-7%

Table 20: E-commerce sales share impact on Return unitary cost in the three scenarios

It has to be noted that, compared to the previous analysis, candidates have chosen different levels of e-commerce share to overcome R limitations in dealing with huge amount of data, for this reason both decreasing and asymptotic tendencies are less visible.

4. Input variable: **RETURN PERCENTAGE**



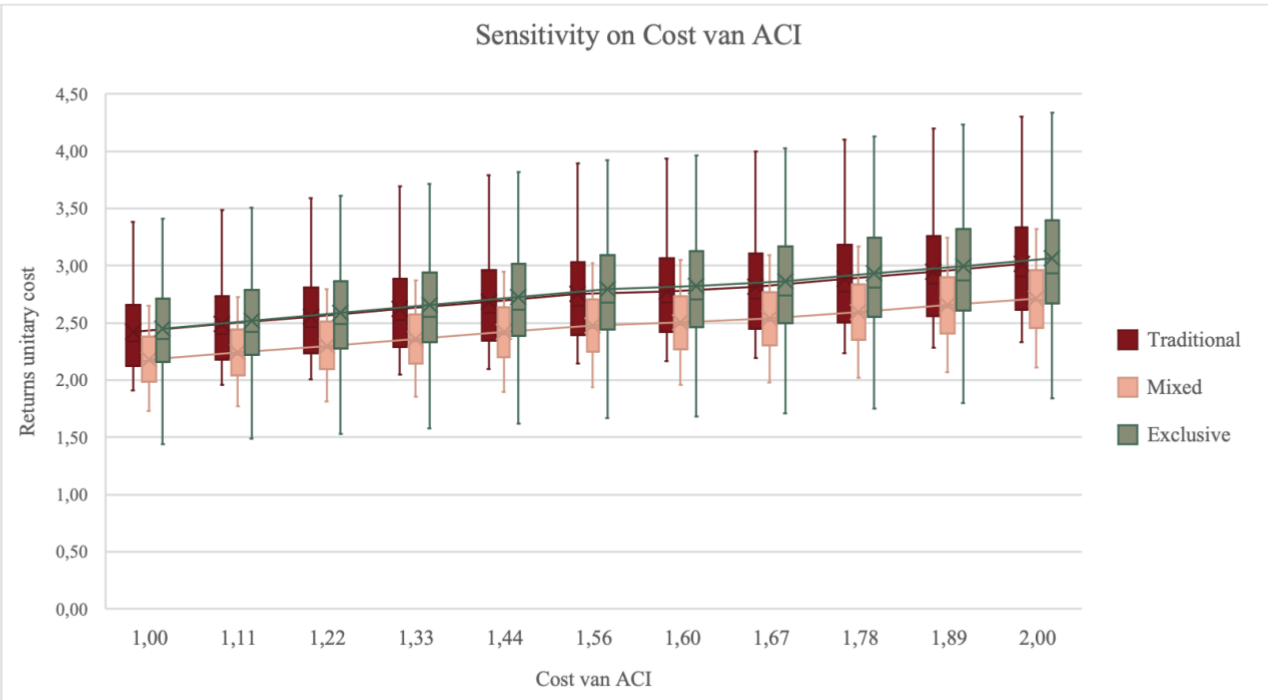
Graph 40: Sensitivity on Return percentage - benchmark value 0.10

		Delta return unitary cost		
Return percentage	Delta return percentage	Traditional	Exclusive	Mixed
0,05	-50%	-0,8%	0,0%	0,5%
0,07	-28%	-1,3%	0,1%	0,9%
0,09	-6%	0,0%	1,0%	1,1%
0,10	0%	0,0%	0,0%	0,0%
0,12	17%	-1,0%	0,0%	1,2%
0,14	39%	-1,4%	-0,3%	0,5%
0,16	61%	-0,9%	-0,3%	0,7%
0,18	83%	-1,5%	-0,6%	2,3%
0,21	106%	2,0%	-0,6%	1,7%
0,23	128%	1,6%	-0,8%	1,4%
0,25	150%	2,3%	0,5%	2,3%

Table 21: Return percentage impact on Return unitary cost in the three scenarios

The main takeaways coming from Graph 40 and Table 21 are that there is not a specific tendency, indeed by increasing the return percentage, operation time rise impacts in a very limited way return unitary cost, as already mentioned in Section 5.3.2. Given the low incidence of return percentage on return unitary cost, no differences can be appreciated from one return methodology to another.

5. Input variable: **COST VAN ACI**



Graph 41: Sensitivity on Cost van ACI - benchmark value 1.6 €/km

The key elements deriving from the analysis of cost van ACI, Graph 41, on return unitary cost are:

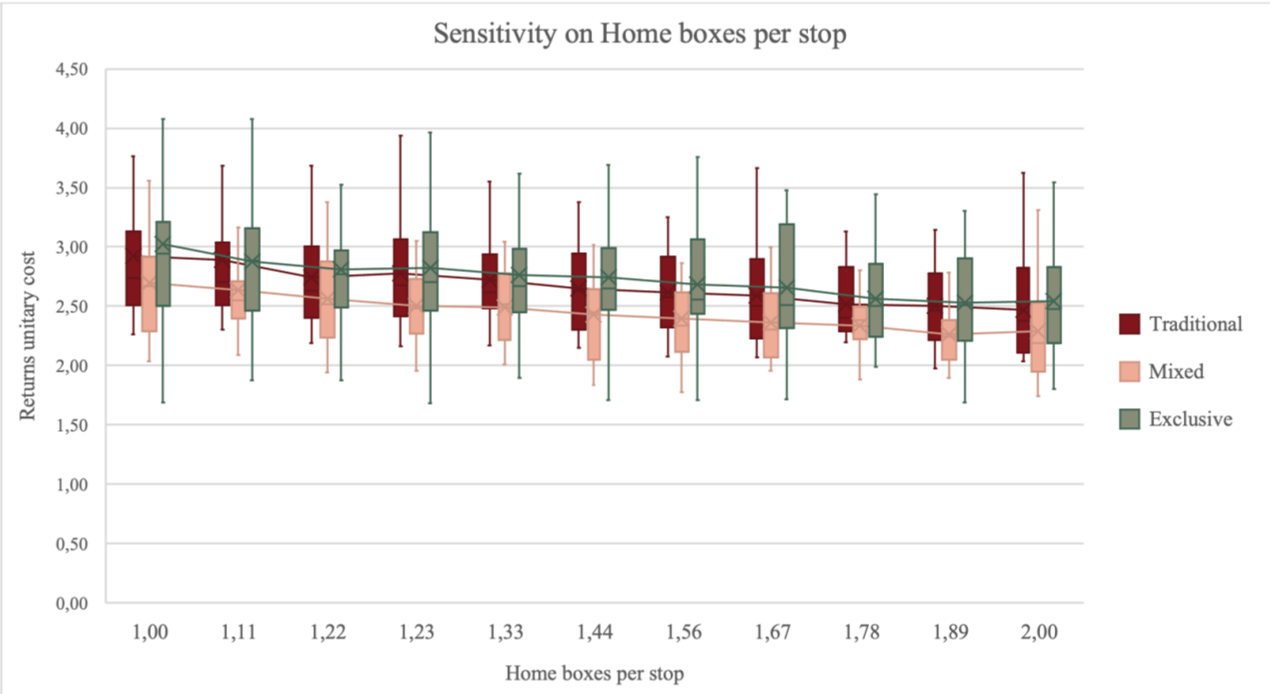
- *increasing trend:* given the direct proportionality between return unitary cost and distance and knowing that cost van is computed on a km level, the higher the cost per van unitary the higher the cost of returning one single box other else being equal.
- *stability*: the variable cost van ACI does not affect time variables, the elements upon which clusters are built, therefore the trend turns out to be steady.

As far as the comparison among scenarios is concerned (Table 22), no differences can be spotted as per expectations.

		Delta Return unitary cost		
Cost van ACI	Delta Cost van ACI	Traditional	Exclusive	Mixed
1,00	-37,5%	-12,8%	-13,1%	-12,8%
1,11	-31%	-10,4%	-10,7%	-10,4%
1,22	-24%	-8,1%	-8,2%	-8,0%
1,33	-17%	-5,7%	-5,8%	-5,7%
1,44	-10%	-3,3%	-3,4%	-3,3%
1,56	-3%	-0,9%	-1,0%	-0,9%
1,60	0%	0,0%	0,0%	0,0%
1,67	4%	1,4%	1,5%	1,4%
1,78	11%	3,8%	3,9%	3,8%
1,89	18%	6,2%	6,3%	6,1%
2,00	25%	8,5%	8,7%	8,5%

Table 22: Cost van ACI impact on Return unitary cost in the three scenarios

6. Input variable: **HOME BOXES PER STOP**



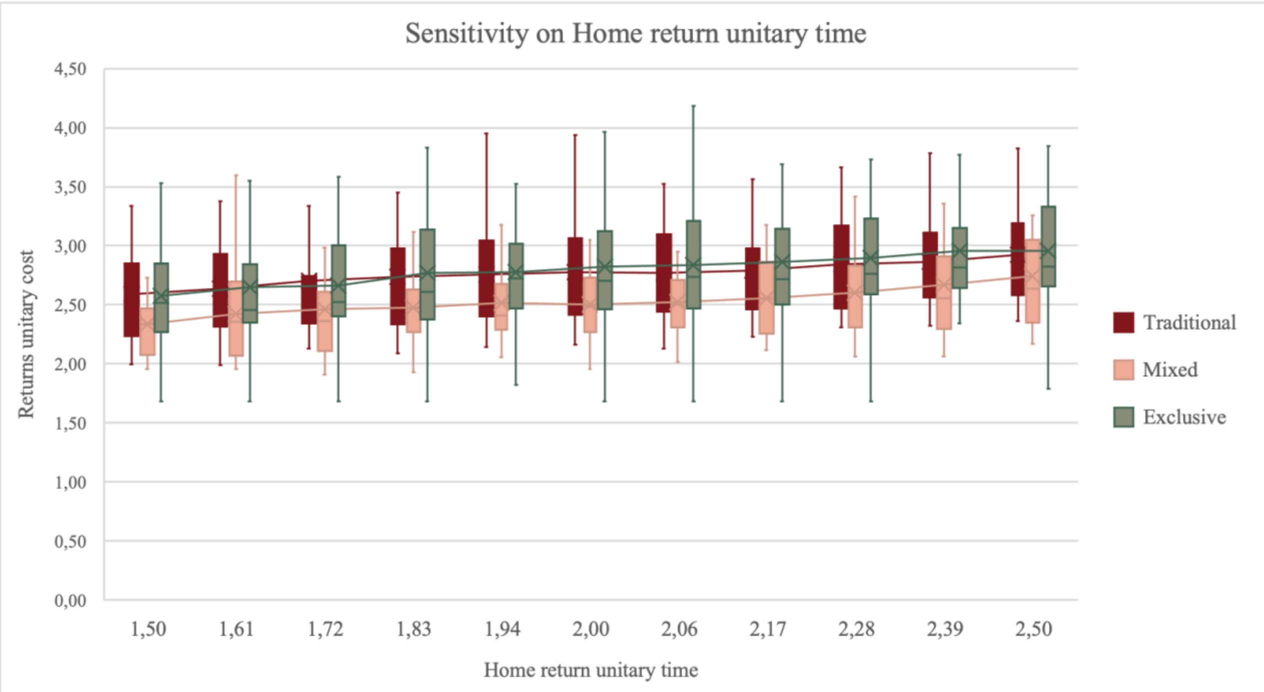
Graph 42: Sensitivity on Home boxes per stop - benchmark value 1.23 boxes/stop

The main takeaway coming from the sensitivity analysis (Graph 42) is:

- *decreasing trend:* a higher number of boxes per tour determines a lower return unitary cost. The determinant of this pattern is as follows: given the same distance travelled, it is possible to perform more deliveries/returns within a single tour leading to a clear cost per unit reduction.

It should also be noted that boxes per stop and speed do not have the same impact on the cost per unit variable since speed impacts mostly travel time (which accounts for the largest share in the total time figure), whereas boxes per stop operation time (smaller share in relation with travel time).
In this case, an absolute comparison among scenarios is meaningless and unfair, indeed the boxes per stop variable relates to the final cost of each selected scenarios in a different way, depending on the amount of home locations that has to be visited (100 % in scenario 1 - 86 % in scenario 2 and 3).

7. Input variable: **HOME RETURN UNITARY TIME**



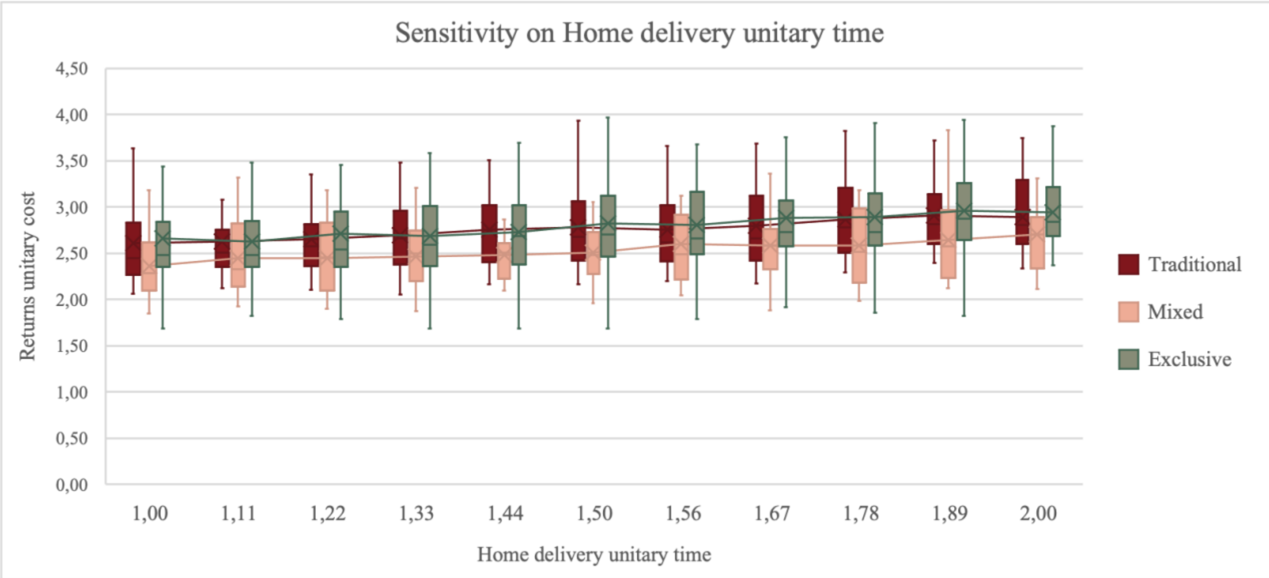
Graph 43: Sensitivity on Home return unitary time - benchmark value 2 min

The key elements of this analysis are:

- *increasing trend:* the tendency shown in Graph 43 is explained by the lower efficiency, meaning that if unitary time rises, the tour will consist in a smaller number of locations to be visited and so parcels to be handled.

Nevertheless, it is worth noticing that delivery unitary time affects cost driver return unitary, the least impactful element of return unitary cost, therefore the incidence of this input variable on the overall cost computation is low. As for the previous variable, boxes per stop, the absolute comparison among scenarios has not been computed since it would have not been fair.

8. Input variable: **HOME DELIVERY UNITARY TIME**

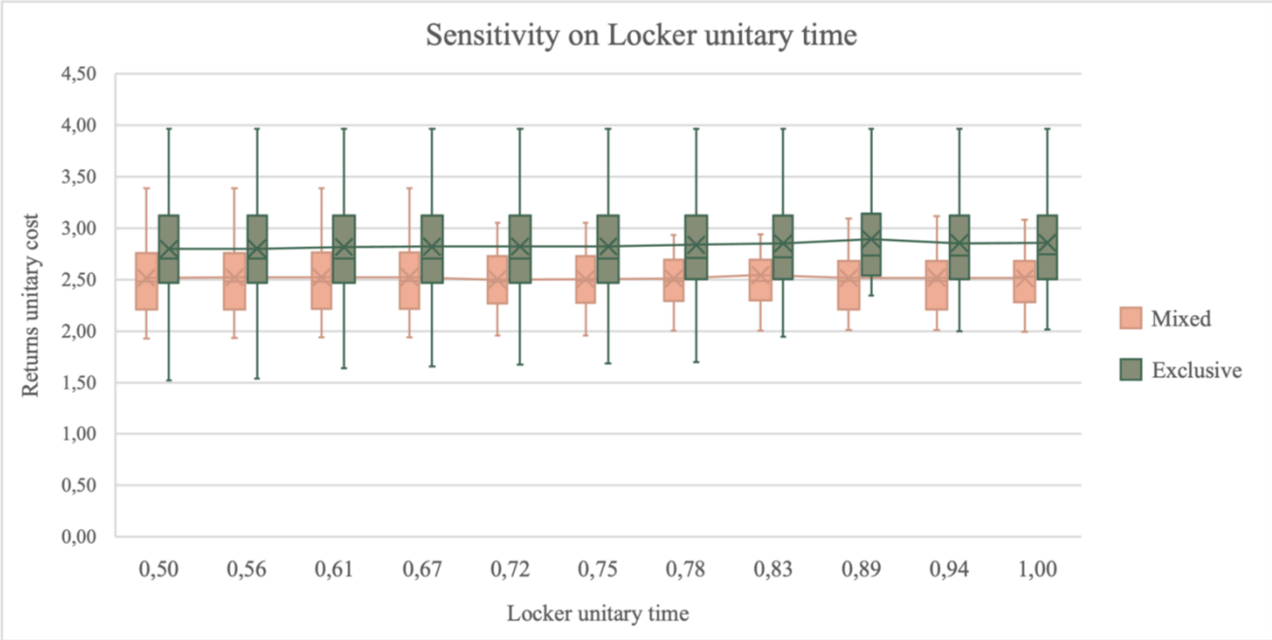


Graph 44: Sensitivity on Home delivery unitary time - benchmark value 1.5 min

Delivery unitary time graph (Graph 44) can be interpreted as return unitary time. The only difference lies in the magnitude of the relationship with return unitary cost, stronger for this latter variable weaker for the previous one.

The next three variables, namely locker unitary time, available compartments and parcel locker share, will affect just scenarios 2 and 3, because they depend on whether or not a scenario comprehends parcel locker as delivery/return methodology. By definition, scenario 1 does not involve any parcel locker interactions.

9. Input variable: **LOCKER UNITARY TIME**



Graph 45: Sensitivity on Locker unitary time – benchmark value 0.75 min

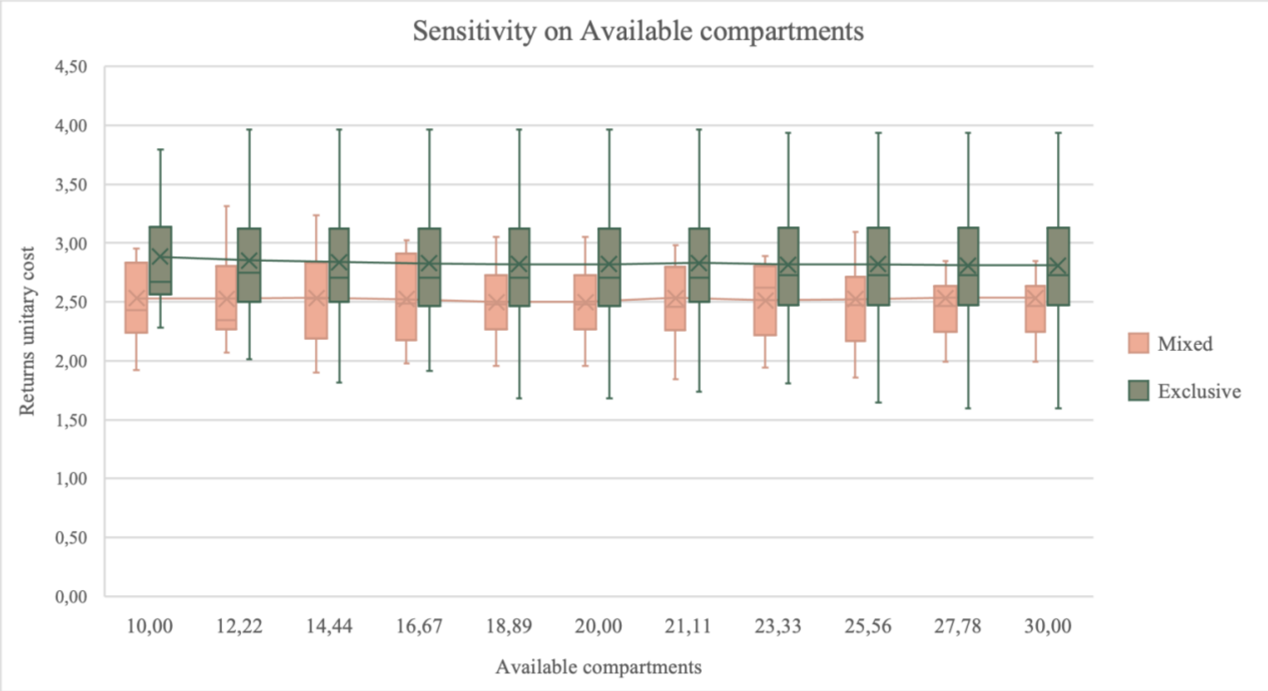
The lesson learnt from this analysis is that the impact of a locker unitary time change is very weak on return unitary cost (Graph 45), even weaker than the one presented in the variable home return unitary time. Once again, the difference between operation time and travel time magnitude comes handy in explaining this relation.

In absolute terms then, as shown in the table below (Table 23), the low incidence of the variable under investigation over y (return unitary cost) combined to the small reference value for parcel locker share (14%) implies counterintuitive outcome (a drop in return unitary cost in mixed scenario is expected as locker unitary time falls).

		Delta Return unitary cost	
Locker unitary time	Delta Locker unitary time	Exclusive	Mixed
0,50	-33%	-0,8%	0,6%
0,56	-26%	-0,8%	0,7%
0,61	-19%	-0,1%	0,8%
0,67	-11%	-0,1%	0,9%
0,72	-4%	0,0%	-0,1%
0,75	0%	0,0%	0,0%
0,78	4%	0,6%	0,4%
0,83	11%	1,0%	1,6%
0,89	19%	2,5%	0,5%
0,94	26%	1,1%	0,6%
1,00	33%	1,2%	0,4%

Table 23: Locker unitary time impact on Return unitary cost in the three scenarios

10. Input variable: **AVAILABLE COMPARTMENTS**



Graph 46: Sensitivity on Available compartments - benchmark value 20 compartments

As noticeable, no variations can be found by changing the number of available compartments within a single parcel locker (Graph 46): it might be assumed that the small value of parcels managed via lockers (parcel locker share) leads to this result. The single effect of this variable on return unitary cost is therefore not very impactful at 14% of parcel locker usage rate, as for locker unitary time.

In addition, the way parcel locker number is computed comes handy in explaining Graph 46 pattern. The number of lockers needed is the result of the number of parcels to be managed via parcel locker methodology (parcel locker share) over the available compartments. In case of high values of compartments, the number of lockers needed will drop (vice versa in the opposite case), with a consequent low parcel locker density within the drop-off/pick-up area. A small parcel locker density will increase the likelihood to have a not-fully saturated cluster (the van would not have enough time to visit the next n-parcel locker location, because by construction there need to be enough time to handle all the parcels within one parcel locker: the model does not allow a partial fulfilment request). This latter condition is valid only in the case of the exclusive scenario, indeed in the mixed setting the saturation is forced by swapping the n-parcel locker location which cause time constraint violation to lower "time consuming" home locations.

5.3.3.2 Magnitude analysis

To enrich the what-if analysis above, the magnitude of input variables variations per each scenario have been mapped: readers will get the chance to assess which variable impacts the most in the cost of returning an item and whether or not the variations differ from one setting to another.

The tables below are built as follows: on the first column the fixed percentage variation is displayed, from column 1 to column 8 the input variables can be found, whereas the values which populates these latters suggests the increase/decrease (delta) in the summary variable, return unitary cost, given a certain input variable drop/rise (defined by the first column). For instance, the reader could consider a -25 % variation: this delta is computed for each input variable taking the benchmark value of the input as reference, so that -25% in the variable cost van ACI, whose benchmark is 1.6 €/km, results in a cost van ACI of 1.2 €/km. Then, the algorithm is run considering the new value of the input variable (1.2 €/km instead of the baseline 1.6 €/km in this instance) and the corresponding average return unitary cost coming from all the saturated clusters (tours) is computed, keeping all the other variables steady at their benchmark value as per Table 21. Lastly, the average value just computed is compared against the baseline average return unitary cost (at 1.6 €/km cost van unitary) to find out differences.

Scenario 1: traditional

	Variables							
	Speed	Courier market share	E-commerce sales share	Cost van ACI	Home boxes per stop	Home return unitary time	Home delivery unitary time	Return percentage
Delta % Variables	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost
-75%		63%	63%	-26%		-21%	-12%	0%
-50%		28%	28%	-17%		-15%	-10%	-1%
-25%	39%	9%	9%	-9%		-7%	-4%	-1%
0%	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
25%	-16%	-6%	-6%	9%	-6%	5%	2%	0%
50%	-26%	-11%		17%	-11%	13%	9%	-1%
75%	-32%	-14%		26%	-11%	19%	13%	0%
100%	-36%	-17%		34%	-15%	25%	19%	-1%

Table 24: Impact of variables on the Return unitary cost in the traditional scenario (white spaces are due to R limitations in dealing with huge amount of data and unfeasible matches (i.e. boxes per stop cannot drop below 1)

As the conditional format of Table 24 suggests, the variables whose impact is the greatest in module are - in decreasing order – market share courier (+ 63%), e-commerce share (+ 63%), speed (due to R limitations, the maximum variation accounts for +39%; nevertheless, following the trend, it could be assumed a maximum variation similar to the one found for market share courier and e-commerce share (+63%)) and cost van ACI (+34%), while the least important from a magnitude perspective is the return percentage.

Such an analysis is worth some considerations. First of all, market share courier and e-commerce sales share by construction follow the same pattern, although they are different in nature: the first one is dependent on strategical decisions taken by 3PL firms, the second one depends on clients purchasing decision in adopting e-commerce. As explained earlier in this section, the variations in return unitary costs caused by different level of share might be ascribed to economies of scope and scale effects. As far as speed is concerned, it is less likely manageable by the stakeholders involved in parcel transportation: unexpected events (i.e. traffic jams, congestions, strikes, mechanical issues) may interfere with the average speed a van can get in one single tour. A variation in speed value has direct consequences in the bottom line, because extraordinary work will be needed to fill customers' requests. Coming to the variable cost van ACI, it could be improved by the logistics service providers themselves, because dependent on their strategic decisions on the fleet used. Nevertheless, changing the fleet towards less expensive operational configurations (electric vehicles for instance) could be a heavy investment, whose pay-back time should be wisely assessed considering return unitary cost savings. In addition, the variation in the input variable is not steady in return unitary cost: a 75% decrease in the cost van ACI, for example, is worth just a 26% drop in the cost per box returned.

As far as both boxes per stop and return/delivery unitary time, even if the variables differ in term of dependency from a 3PL perspective (boxes per stop is independent on 3PL choices, whereas return/delivery unitary time might be more related to e-tailer/3PL regulations), the influence on return unitary cost is milder.

Finally return percentage variation does not impact on the cost per unit: this takeaway confirms the interviewee consideration that "it does not matter the direction of the flow from a courier perspective".

Scenario 2 and scenario 3 are also represented (Table 25 and Table 26). The reader should be informed that the conclusions made in scenario 1 hold even in these latter settings, plus the influence of locker unitary time and available compartments are not as strong as the one shown by cost van ACI, speed and market share, in line with the consideration formulated above for return/delivery unitary time.

Scenario 2: exclusive

	Variables									
	Speed	Courier market share	E-commerce sales share	Cost van ACI	Home boxes per stop	Home return unitary time	Home delivery unitary time	Return percentage	Locker unitary time	Available compartments
Delta % Variables	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost
-75%				-26%		-21%	-14%	-2%	1%	6%
-50%		27%	27%	-17%		-12%	-11%	0%	1%	2%
-25%	46%	9%	9%	-9%		-9%	-6%	0%	-1%	1%
0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
25%	-16%	-7%	-7%	9%	-6%	5%	5%	0%	3%	0%
50%	-27%	-11%		17%	-10%	10%	8%	0%	2%	0%
75%	-32%	-15%		26%	-10%	18%	13%	1%	0%	-1%
100%	-37%	-18%		35%	-14%	23%	21%	-1%	1%	-1%

Table 25: Impact of variables on the Return unitary cost in the exclusive scenario (white spaces are due to R limitations in dealing with huge amount of data and unfeasible matches (i.e. boxes per stop cannot drop below 1)

Scenario 3: mixed

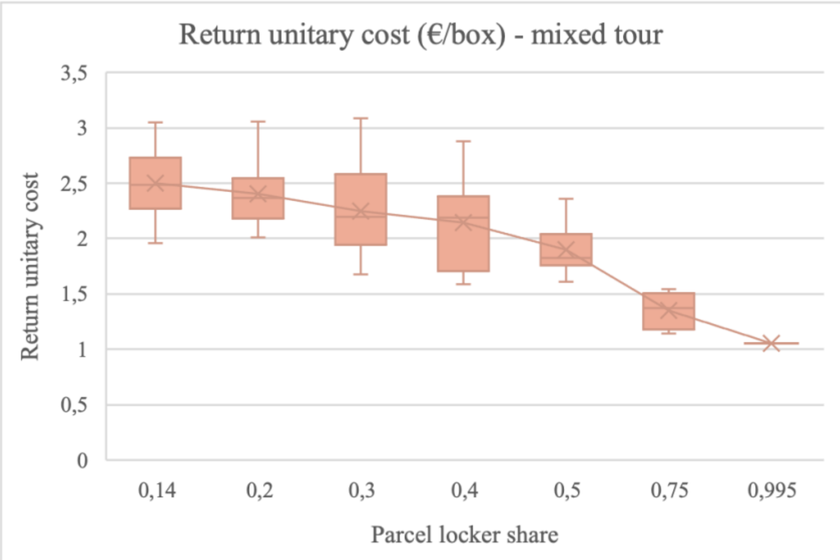
	Variables									
	Speed	Courier market share	E-commerce sales share	Cost van ACI	Home boxes per stop	Home return unitary time	Home delivery unitary time	Return percentage	Locker unitary time	Available compartments
Delta % Variables	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost	Delta % Return Unitary Cost
-75%				-26%		-19%	-13%	2%	0%	0%
-50%		25%	25%	-17%		-13%	-6%	1%	1%	1%
-25%	47%	11%	11%	-9%		-7%	-3%	1%	1%	1%
0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
25%	-15%	-6%	-6%	9%	-5%	10%	5%	1%	1%	1%
50%	-23%	-10%		17%	-5%	16%	12%	1%	1%	1%
75%	-30%	-14%		26%	-8%	20%	18%	2%	1%	0%
100%	-35%	-16%		34%	-11%	30%	23%	4%	2%	1%

Table 26: Impact of variables on the Return unitary cost in the mixed scenario (white spaces are due to R limitations in dealing with huge amount of data and unfeasible matches (i.e. boxes per stop cannot drop below 1)

5.3.3.3 Parcel locker as flow consolidator

Sensitivity analysis are further enriched with a what-if investigation on customer behavioral decisions on the choice of parcel locker as delivery/return mean. Assuming that e-tailers allow clients to choose freely the methodology they prefer, candidates have investigated the extent to which the cost of returning an item differs if the parcel locker share varies. The selected scenario to perform this last piece of analysis is the mixed one. In this regard, readers should be notified that the interviewee claimed that "mixed scenario is the most realistic one", since exclusive tours are not widely implemented, "and powerful one", because mixed setting is the most effective in fulfilling couriers' objective to increase as much as possible drop density and so decreasing cost.

The following chart (Graph 47) represents the variations in return unitary cost due to parcel locker share changes (due to R limitations it has not been possible to map the value of the response at 1 level, so the reason of 0.995 as upper bound).



Graph 47: Parcel locker share and Return unitary cost - mixed scenario

As expected, by addressing more and more customers to parcel lockers, thus increasing the drop density, the return unitary cost decreases: this cost drop is not constant in the x-axis (parcel locker share). The determinant of this pattern can be traced back to the way the algorithm computes the number of lockers needed to fulfil the demand of parcel locker boxes. In fact, lockers number is the next whole number of the variable "boxes locker" divided by the available compartments (steady value equal to 20). If the division yields a value which is slightly greater than the integer, by construction the model considers an additional locker resulting in a sub-optimal saturation of boxes. To clarify the concept, the following example is provided to the reader: considering "boxes locker" equal to 201 and 20 as available compartments, the number of lockers needed will be 11 (10.05 rounded to the upper integer) with an average number of boxes per locker equal to 18.27, whereas assuming an higher parcel locker share which is worth 219 boxes, although the number of lockers needed will be 11 as before (219/20 = 10.95 rounded up to 11), the average number of boxes to be managed per single parcel locker will top 19.9. As exemplified by this instance, by increasing the share of parcel lockers boxes, the number of boxes per single location will increase too: as a consequence, flows of parcels can be better consolidated and return unitary cost will drop. It should also be noted that the same concept can be applied to different CDPs as manned collection and delivery points (post offices, bars, kiosks …) due to their nature of flow consolidator.

In order to remark the benefits beneath the adoption of CDPs, assuming that all customers' requests are managed via flow consolidators, the number of tours/missions (and so express courier vans) to satisfy the demand drops tremendously, as per Table 27 thus decreasing the overall cost an express courier company should bear in managing daily orders.

Parcel locker share	Number of clusters
0.14	20
0.2	19
0.3	17
0.4	16
0.5	14
0.75	6
0.995	1

Table 27: How the number of clusters varies changing the parcel locker share[34]

Graph 47 does not consider that a larger share of clients served via parcel locker might determine huge investments in scaling up the locker infrastructure itself which should cope with a greater amount of orders. The setting chosen as parcel locker location, then, should be capable enough to face the surge of more customers, otherwise criticalities might offset the benefits coming from a drop in the number of vans to be activated. Plus, by increasing the share of parcel lockers, it could happen that the van handling volume was not enough to cope with the large number of parcels to be managed within a single tour, indeed the number of daily orders does not change.

[34] Although it has not been possible to run the algorithm with a parcel locker share of 100%, the outcome of the analysis is definitely straightforward with just one needed cluster at 0.995 parcel locker share level.

6. CONCLUSION

The previous chapters have been instrumental in creating the backbone through which answering the research questions addressed by candidates. In particular, Chapter 4 has described the theoretical framework developed which has then been coded on R, whereas the results obtained have been presented and investigated in Chapter 5.

Relying on this backbone, Chapter 6 will answer exhaustively to the research questions (Section 6.1) with the final objective to generate relevant contribution from a twofold perspective (academic and practical/managerial (Section 6.2)), plus limitations and future developments of this dissertation will be revealed (Section 6.3).

6.1 Answers to the research questions

The main findings this master thesis has revealed takes the form of thorough answers to the two research questions previously formulated. In particular:

RQ1: Which are the elements that impact the most in the cost of returning an item?

To answer this research question, candidates have run the algorithm by varying input variables one at a time while keeping the remaining ones steady performing a sensitivity analysis: the effect of such variations on the summary variable "return unitary cost" has been then benchmarked to the baseline "return unitary cost" value, representative of the baseline case where each input variable assumes the reference value. This approach has been adopted on all of the three selected scenarios aiming at generating fair comparisons.

The following lines depict this piece of analysis for the benchmark scenario: traditional home delivery/pick-up.

The variables which show the greatest impact on "return unitary cost", regardless of the sign, are market share courier and e-commerce sales share: an increase of 63% in the return unitary cost is expected if the values of the input variables drop to 75% in respect to the reference values. Despite these two elements are different by nature and dependency - market share courier relates to the ability of an express courier firm to get larger amount of orders in respect to competitors, while e-commerce sales share is linked to the level of e-commerce requests, thus being proportional to the level of adoption of B2c e-commerce among customers - the effect they generate on the response "return unitary cost" is the same: both of them increase the number of requests (deliveries and/or returns) that has to be managed in the area under investigation. A higher number of customers' requests leads to higher level of drop density, which candidates have studied to be statistically significant in predicting the cost of one returned box. This statistically significant relationship, which holds even in the case of last mile delivery as per existing academic studies, is inverse, meaning that the higher the drop density the lower will be the cost of a box returned. It could be claimed that economies of scale and scope plays a pivotal role in explaining this pattern.

The third variable whose impact is the largest on the summary variable is van speed (+39% in return unitary cost if speed is decreased by a 25%. It should be pointed out that authors have not been able to test -50% and -75% variations because of R limitations in dealing with a huge number of instances). Despite R limitations, it could be claimed that this input variable is the one whose relationship with the summary variable has the largest magnitude considering both a drop and a raise in the speed itself. Indeed, speed directly affects travel time (the higher the speed and the lower the incidence of travel time over operation time and vice versa), and so the ability to answer more customers' requests in the form of more packages handled within one mission. In this regard, authors have tested that the number of boxes within a tour is inversely proportional to cost of a returned box and the effect is statistically significant, as for the drop density. Therefore, the joint effect of "speed-boxes per tour" and "speed-travel time" relationships makes van speed the input variable whose role is the most effective one in modifying "return unitary cost".

The variations in the operative cost of the vehicle used to perform delivery/pick-up mission (cost van ACI), fourth variable by effect on the representative variable "return unitary cost", are constant in the effect they provide to the summary variable meaning that a -x% in the cost per km marks a +y% in the cost of a returned box, while a +x% yields a corresponding -y%. Such a pattern derives from the nature of the variable itself, which is used as a multiplicative coefficient, with no links with the other variables. It has to be noted, however, that modifications in cost per van are not worth the same outcome in return unitary cost variation: this is to say that if an express courier firm decides to change the fleet used to perform its tasks with a cheaper one, the expected variation in the cost per single returned box is not as the variation in the cost per km derived from a different vehicle. As an example, if the cost per van drops by 25%, the cost per single box returned will be just 9% lower compared to reference values. The determinant of this patter can be found in the relationship between the cost per van and the summary variable itself, since cost per van relates with just one component of return unitary cost, namely the cost van unitary.

As far as both delivery and return unitary time, the effect they provide to the cost of a single box returned is less severe than the ones abovementioned, due to the lower incidence of the operation time (one third) over the total time. Notwithstanding, the effect of return time unitary delta are slightly more powerful than the one caused by delivery unitary time: the reason may lie in the higher absolute figures entailed by return unitary time due to the longer time needed to manage returns at customer's place in respect to deliveries.

The variable boxes per stop is worth an attentive discussion, since by doubling the number of boxes from 1.23 to 2.46 boxes per home location (under the assumption that one box equal one customer's request, regardless of the type), the summary variable drops just by 15%. It could be claimed that the low incidence of operation time over travel time caused by different level of parcels to be managed per single location leads to a mild variation in return unitary cost, indeed by averaging clusters results in terms of operation and travel time, operation time share over the total time goes from 31% (computed at the benchmark value of 1.23) to just 36% (100% increase in the boxes per stop level which yields 2.46 boxes per stop), other else being equal. By construction, in addition, the number of locations to be visited decreases as the number of boxes per location increases, so the benefits in terms of return unitary cost reduction are offset by the higher km travelled to visit the n-location. To support this line of reasoning, the following example comes handy: supposing to double the value of boxes per stop, the overall number of addresses to be visited to fulfil customers' request will be halved, thus the distance travelled within each tour will increase covering a wider area. This means that, keeping the overall demand steady, a positive variation in the number of boxes per stop relates in a marginal way to the drop density: indeed, this variation will affect in the same direction both the numerator and denominator of drop density formula, boxes per tour and surface respectively. Wrapping all up, higher values of boxes per stop would influence consistently drop density and so return unitary cost only if combined with higher level of demand. As a support of this final statement, recalling that return unitary cost is mostly driven by travel time incidence, the reader should be notified that the share of travel time over the total time goes from a 69% (benchmark value of 1.23 units per box) to just 64 %, thus the mild variation in the summary variable is justified. To conclude this argumentation, market share courier and e-commerce sales share variation proves to be more powerful than the boxes per stop in changing the level of drop density within the delivery/pick-up area, because more customers' requests will have to be managed in the area under investigation.

The last input variable to deal with is the return percentage: this element does not impact in a meaningful way the summary variable "return unitary cost", therefore the model supports the line of reasoning expressed by the expert manager candidates had the chance to talk with, who stated that from a logistic service provider point of view, the one this dissertation follows, the direction of the flow (return/delivery) does not affect the bottom line.

As an additional piece of information to strengthen this formal answer, it is worth mentioning that the effects just presented for scenario 1 (traditional) hold even in the case of scenario 2 (exclusive) and scenario 3 (mixed), even if the magnitude of the effect caused by home-related variables, namely return/delivery unitary time and boxes per stop, slightly changes. The different number of boxes to be managed in the traditional fashion – home delivery/pick-up – is the determinant beneath this condition.

For the sake of completeness, both scenario 2 and scenario 3 own two specific variables, locker unitary time and available compartments, which are linked to the parcel locker handling methodology scenarios exclusive and mixed makes us of. Keeping all the variables steady as for the other input variables, nothing can be inferred about locker unitary time due to a very weak variation on the summary variable "return unitary cost". Such a pattern could be explained by the low level of parcel locker share (14% benchmark value) combined with the low weight of operation time, the one mostly affected by a variation in the time needed to handle a box via parcel locker, over the total time. Coming to available compartments, even though the variations in the summary variable are mild as in the case of the previous variable, it is worth the following consideration: by construction, the number of lockers needed is the result of the number of parcels to be managed via parcel locker methodology (parcel locker share) over available compartments. In case of high values of compartments, the number of lockers needed will drop (vice versa in the opposite case), with a consequent low parcel locker density within the drop-off/pick-up area. A low parcel locker density will increase the likelihood to have a not-fully saturated cluster (the van would not have enough time to visit the next n-parcel locker location, because by construction there need to be enough time to handle all the parcels within one parcel locker: the model does not allow a partial fulfilment request). Nevertheless, this latter condition is valid only in the case of the exclusive scenario, indeed in the mixed setting the saturation is forced by swapping the n-parcel locker location, which cause time constraint violation, to lower "time consuming" home locations.

To conclude this formal answer, it should be added that variations in input variables might be achieved with different levers depending on the actors which could control the variable, if possible. Table 28 justifies this statement providing suggestions on how to modify input variables with the ultimate goal to drive down costs and maximize the bottom line.

Number	Input Variable	Actor/s involved	Comment
1	Courier market share	3PL	Couriers might invest more to gain higher market share in respect to competitors. They could increase the service level both in the sight of customers (i.e. possibility to reschedule deliveries/returns, on time services, warranties, tracking services …) and e-tailers (i.e. frequent load batches, tracking services, flexibility …). In this way, 3PL might be more appealing in the light of e-merchants, thus gaining trust and consequentially more market shares.
2	E-commerce sales share	e-tailers	e-tailers could find more appealing policy to attract more customers (like online-only shopping discount).
3	Speed	Policy makers + 3PL	Regulators play a fundamental role in this regard: the more the area under investigation is developed from an infrastructural point of view the higher the expected value of the speed (assuming no congestions). 3PL might include in tour design the minimization of congestions (real-time model), so at optimizing deliveries and returns.
4	Cost van ACI	3PL	Different vehicles imply different cost per km travelled, depending on the key features of the van used.
5	Home delivery time	3PL & e-tailers	Different delivery policies defined by both 3PL and e-merchants might be used as levers to modify the home delivery time (i.e. proof of delivery not requested).
6	Home return time	3PL & e-tailers	As above.
7	Locker delivery/return time	3PL & e-tailers	As above.
8	Boxes per stop	-	The number of boxes per stop is strictly related to the urban layout of the area under investigation, so any discussion would be useless.
9	Available compartments	3PL	The owner of the parcel lockers network should define not only the right sizing in terms of typology of locker and so the number of total compartments, but also the access policy (i.e. in case of demand peaks and considering customers' point of view, allowed time windows for parcel collection and return should be reduced).
10	Parcel locker share	3PL & e-tailers	Partnerships among merchants and 3PL could increase the usage rate of parcel lockers.
11	Return Percentage	(e-tailers)	By definition, there will be always a certain percentage of returns to be managed, even if new technologies (AI, VR) might decrease the likelihood to have returns.

Table 28: Possible room for improvements for the input variables

RQ2: To what extent the cost of returning an item differs from one return methodology to another?

To answer this research question, the comprehensive summary variable, “return unitary cost”, identified by authors comes handy, indeed by considering the same input variables as defined in Chapter 5, the three selected scenarios can be easily compared one to each other.

In particular, “return unitary cost” is worth 2.78 €/unit in scenario 1 (baseline), 2.82 €/unit in scenario 2 (considering traditional part and parcel locker part) and 2.50 €/unit in scenario 3.

Bearing in mind the input variables used as well as the perspective considered by the theoretical framework (e.g. the cost of one single returned parcel is assessed from customers’ place/parcel locker location to logistic service provider’s first hub), the fundamental insight coming from these figures is that the least expensive scenario is the mixed one. Although the expert manager interviewed by candidates has already claimed that mixed configurations are the most frequent ones employed by logistic service providers in managing customers’ requests (regardless of the type, both returns and deliveries), the novelty of this master thesis lies in the capability to test via a mathematical modelling and simulation approach that mixed configurations are truly the most efficient ones in dealing with returns.

The determinants of this finding must be traced back to the role of the parcel locker as flow consolidator. First of all, the reader should be aware that drop density and boxes per tour are statistically significant in predicting the response return unitary cost in all of the three scenarios, as shown in the previous chapter (Chapter 5). The relationship is inverse, meaning that for higher values of drop density (and boxes per tour), the cost per each returned box drops. By using parcel lockers, the number of boxes within a single tour could be increased as well as the drop density, thus leading to more efficiencies as suggested by lower cost per unit. In addition, the operation time variability beneath the usage of an automatic delivery/return methodology is lower than in the case of home traditional delivery-pick up, since no human interactions are involved, therefore efficiencies could be further enhanced.

Willingly to remark the importance of the so-called “flow consolidator” role as in the case of parcel lockers, candidates have tested how the return unitary cost changes in relation to different level of parcel locker share. In this regard, it should be noted that the rate of adoption of the parcel locker might be due customers’ behavioral decisions (in case parcel locker is available as return/delivery method), but also e-tailers ones who should put parcel lockers at client’s disposal. The key finding is that by increasing the number of boxes to be managed via lockers, the return unitary cost drops consistently. More in detail, from the benchmark value of 14%, a small positive variation in the parcel locker share increases parcel locker saturation without modifying the number of lockers needed, thus slightly lowering the return unitary cost. Whereas, if the increase in the parcel locker share is consistent, new parcel lockers should be activated thus reducing the number of vans needed to fulfil the daily demand: arguably this tendency could derive from economies of scale and scope effects.

Coming to the conclusion of this answer, despite the single return unitary cost values, as presented earlier in this section, are affected by the input data gathered, there is strong and analytical evidence that the mixed scenario, where different return methodologies are employed within a single tour, offers the lowest level of return unitary cost, plus the higher the adoption rate of parcel lockers the greater the benefits.

6.2 Contribution

The current work is willing to develop new knowledge on the reverse logistic procedures in B2c e-commerce from both a theoretical, thus mostly targeting academia, and a managerial point of view, providing a greater degree of understanding of the topic among practitioners. The two perspectives are in a certain way linked one to each other because the academic perspective, in the form of the theoretical framework developed within this master thesis, could be deployed by practitioners who always strive to perform better.

First of all, this dissertation extends the current literature in reverse logistic B2c e-commerce as no instances of models which specifically address return unitary cost quantification could be found. Despite the broad attention placed on last-mile delivery solutions among scholars, the reverse process in B2c e-commerce field is worth to be investigated, knowing that e-commerce cannot be developed without an efficient an effective way of returning items to be integrated in the forward logistics.

Candidates have also been able to specify the variables which impact the most on the cost of returning an item alongside with the correspondent "owner" of them and a complete and detailed description on the determinants beneath the different relationships among them.

The reader should also be aware that the process mapping derived from the literature review is not for its own sake, meaning that it should be intended as a first attempt to map all the existing return methodologies and enhance the understanding via a graphical representation on how reverse logistics in B2c e-commerce works.

As far as the managerial insights coming from this master thesis are concerned, practitioners, logistics service providers above all, might understand weaknesses, criticalities but also room for improvements in their procedures: dependent input variables (i.e. cost van ACI, return unitary time, delivery unitary time, locker unitary time), indeed, are discussed in the light of the effects, magnitude included, they might cause to the summary variable "return unitary cost". In this regard, they could map their as-is situation and simulate different scenarios, thus assessing, for instance, if a certain investment could be worth or not.

The key feature of the model has to be found in its dynamic, modular and scalable nature. Thanks to its dynamic feature, the algorithm could be employed not only in mapping the as-is situation, but also in generating new scenarios with a minimum effort, bearing in mind that the higher the reliability of input data, the more precise and useful the outcome. The modular shape of the algorithm allows practitioners, express courier companies in particular, to consider their peculiar processes, which might imply different return methodologies than the ones investigated by authors. Finally, the model is easily scalable, meaning that minor adjustments should be put in place to extend the reference area of the model, which could be stretched to different phases of e-commerce B2c with the possible final objective to represent both reverse and forward logistics.

6.3 Limitations and future developments

Although candidates have strived to investigate the topic in a detailed, precise and meaningful way, this work is far from being completely faultless: limitations will be detailed shedding the light on the corresponding future developments that might be put in place.

- *input data quality:* candidates gathered data from a broad array of trustworthy sources (both primary and secondary), which were considered as the best snapshot of the current e-commerce-related process. Nevertheless, the ever-changing e-commerce sector could lead to rapid development that might impact the reliability of input data (i.e. different return policy may increase/decrease the time needed by an express courier worker to perform his/her tasks or again the urban layout could be changed by policy makers with huge impact on the performance of a single delivery/pick-up mission). By increasing the timeliness of input data gathering, the outcome will be enhanced, keeping in mind that the higher the quality of input data, the greater would be the outcome.
- *geographical boundaries and drop density:* the model developed has been coded and tested on the municipality of Milan for both a matter of availability of geolocated addresses and time, therefore the numerical results concerning the return unitary cost cannot be generalized

to cover all the possible drop-off/pick-up areas: it would have been necessary to test the model on different zones (i.e. different cities, municipalities, provinces and regions both in the Italian soil and abroad). In line with this, it must be noted that the framework lacks to consider the link between the input variables and the area under investigation. Such a connection could have been found in the population density of the area by means of more precise population-density dependent input data that could have yield better outcomes.

- *volume constraints, time windows and deliveries/returns failure rates:* as detailed in the assumption of the model, volume constraints, time windows and failed deliveries/returns rates have not been considered, due to the willingness to keep under control the degree of complexity of the framework. For what concerns volume constraints, although in e-commerce last mile delivery (and reverse logistics) the scarce resource is usually the time, the model could have considered the volume as per the time. By including time windows, then, the model could have better fit the real world, knowing that current high service level required by both e-merchants and e-customers cannot prescind from scheduled deliveries/pick-ups. Lastly, deliveries and returns failure rates in traditional home delivery/pick-up handling methodology have not been taken into account: while for deliveries it is reasonable not to consider this rate given the authors' objective to come up with the cost of a returned box, failed returns rate could have been addressed. However, it has deemed reasonable not to include them since the magnitude of its effect is way lower than the one experienced by couriers in the case of last-mile delivery: the underlying assumption is that customers who are willing to return items will schedule the service whenever they are available at home.
- *overtime:* by construction, the algorithm does not allow the chance to schedule overtime, because the clusters are constrained to 8 hours as length of a shift. Although this approach was needed to decrease the complexity of the framework, the resulting flaw is that, most of the time, the cluster coming from the last iteration of the algorithm is prone to unsaturation. By spreading customers' requests which flow into the last cluster among the other clusters through overtime activation, it could have been possible to decrease the number of clusters to fulfil clients' demand, thus reducing the overall cost of the daily tours and get more reliable results.
- *return methodologies*: the scenarios under investigation in model deployment relates to just two return means, namely traditional home delivery/pick-up and parcel locker. In the sight of the candidates, this choice was considered viable in generating insightful contributions, since too many handling means mapped could have increased by far the complexity of the algorithm and the risk to miss connections among the response "return unitary costs" and the input

variables. However, the modular and scalable nature of the framework could be further developed so at including all the return methodologies, thus better fitting real world features.

- *focus on environmental consumption:* even if the gap addressed by authors revolves around both the lack of monetary and environmental cost assessment, the choice has been to focus on just one side, monetary, of the gap. Aware of the importance of environmental issues in e-commerce B2c last-mile delivery/reverse logistics, which relates by large to sustainability topics, candidates' choice has been guided by the willingness to get a straightforward measure, cost per unit, to compare in a more representative way different scenarios, thus generating more insights. For the sake of precision, the environmental dimension, in the form of C02 emissions, could be easily introduced into the framework since it relates just to the distance travelled and the typology of van used. Once again, the modular and scalable features of the model come handy in this possible modelling upgrade.
- *employees cost:* in Chapter 5, the return unitary cost has been investigated by varying input variables once at a time. In this regard the reader could have noted that the employees cost has been kept constant: for a matter of fairness and ethic, it would have not made any sense to investigate how to reduce costs by lowering the wage of operators.

To wrap up this section, the limitations described above are mainly due to the need of decreasing the complexity of the process under investigation, however some improvements would have made the results more robust. Once again, the final aim of this dissertation is not to provide an extremely precise cost per single box returned which could be prone to input data misalignment, but to enhance the understanding of a process, reverse logistics in e-commerce, without whom e-commerce logistics cannot work, and to shed the light on the pivotal input variables and the differences among handling means.

(this page intentionally left blank)

(this page intentionally left blank)

Bibliography

ACI, 2017. *Costi chilometrici.* [Online]
Available at:
http://www.aci.it/fileadmin/documenti/servizi_online/Costi_chilometrici/CKI_web_dicembre_2017.pdf

AGCOM, 2019. *Osservatorio sulle comunicazioni N.1/2019.* [Online]
Available at: https://www.agcom.it/documents/10179/14467561/Documento+generico+24-04-2019/0ef5a32e-0870-412e-b596-c1ef3f775fd9?version=1.0

Agrawal Saurabh, S. R. K. M. Q., 2018. Reverse supply chain issues in Indian electronics industry: A case study. *Journal of Remanufacturing,* 8(3), pp. 115-129.

Albastroiu, I., Dina, R., Vasiliu, C. & Dina, I., 2016. *Approaches regarding the return policy of online retailers.* Bucharest, Romania, s.n.

Alvarez, E., 2019. *Nike uses AR to help you find the right fit for your sneakers.* [Online]
Available at: https://www.engadget.com/2019-05-09-nike-fit-augmented-reality-right-fit-size-shoes.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAJvR_FGqEKltZVsPn03MDX5DaqeH150t2Tb3XMqsUFQ0h1e8Mq2sKPkqjbfc2-LUcxOGW_7BmiyL_MyayHZ99
[Accessed 24 August 2020].

Amazon, n.d. *Prime Air.* [Online]
Available at: https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011
[Accessed 1 August 2020].

Anderson Eric T., H. K. S. D., 2009. The Option Value of Returns: Theory and Empirical Evidence. *Marketing Science,* 28(3), pp. 405-423.

Anon., 2019. [Online].

Bowes, P., 2019. *2019 REPORT Online Shopping Study.* [Online]
Available at: https://www.pitneybowes.com/content/dam/pitneybowes/us/en/ecommerce/shopping-study/2019-global-ecommerce-report-v3-web.pdf
[Accessed 3 August 2020].

Buldeo Rai Heleen, V. S. M. C., 2019. The "next day, free delivery" myth unravelled. *International Journal of Retail & Distribution Management*, 47(1), pp. 39-54.

Cardenas, I. D. et al., 2017. The E-Commerce Parcel Delivery Market and the Implications of Home B2C Deliveries Vs Pick-Up Points. *International Journal of Transport Economics*, pp. 235-256.

Casaleggio Associati, May 2020. *E-commerce in Italia 2020 - Vendere online ai tempi del Coronavirus*, s.l.: s.n.

Chang Qun-Qun, Z. H.-Z., 2014. *An effective strategy for non-defective reverse logistics.* Hailar, IEEE.

Chen Chao, P. S. W. Z. Z. R. Y., 2017. Using taxis to collect citywide E-commerce reverse flows: a crowdsourcing solution. *International Journal of Production Research,* 55(7), pp. 1833-1844.

Chiranjib, B. & Walid, A.-K., 2018. *Reverse Logistics Challenges in e-Commerce.* Washington DC, IEOM society.

Council, R. L. E., n.d. *The definition of the Reverse Logistics Executive Council.*, s.l.: s.n.

De Araújo Ana Carolina, M. E. M. U. J. E. M. A. S. M., 2017. An exploratory study on the returns management process in an online retailer. *International Journal of Logistics Research and Applications*, Volume 21, pp. 1-18.

eshopworld, 2018. *Global ecommerce Market Ranking 2019,* s.l.: eshopworld.

Feng Changli, X. L., 2006. *A Study on Returns Logistics Operating Mode in E-business Environment.* Shanghai, IEEE.

Formica, F., 2018. *Amazon espelle chi fa troppi resi: ecco i casi italiani.* [Online]
Available at: https://www.repubblica.it/economia/diritti-e-consumi/diritti-consumatori/2018/06/01/news/amazon_anche_in_italia_diverse_espulsioni_contestate_gli_utenti_poca_trasparenza_-197808777/
[Accessed 24 August 2020].

Gevaers, R., Van de Voordea, E. & Vanelslander, T., 2014. Cost Modelling and Simulation of Last-mile Characteristics in an. *Social and Behavioral Sciences*, pp. 398-411.

Guo Jianquan, W. X. F. S. G. M., 2017. Forward and reverse logistics network and route planning under the environment of low-carbon emissions: A case study of Shanghai fresh food E-commerce enterprises. *Computers & Industrial Engineering,* Volume 106, pp. 351-360.

Hübner Alexander, H. A. K. H., 2016. Distribution systems in omni-channel retailing. *Business Research,* Volume 9, pp. 255-296.

Hahsler, M. & Hornik, K., 2020. *Package 'TSP'.* [Online]
Available at: https://cran.r-project.org/web/packages/TSP/TSP.pdf

Hahsler, M., Piekenbrock, M., Arya, S. & Mount, D., 2019. *Package 'dbscan'.* [Online]
Available at: https://cran.r-project.org/web/packages/dbscan/dbscan.pdf

Hjort Klas, H. D. ,. S. O. P., 2019. Typology of practices for managing consumer returns in internet retailing. *International Journal of Physical Distribution & Logistics Management,* 49(7), pp. 767-790.

Jin Delong, C.-D. O. C. F. (. H. M., 2020. Omnichannel retailers' return policy strategies in the presence of competition. *International Journal of Production Economics,* Volume 225.

Kedia Ashu, K. D. N. A., 2017. Acceptability of collection and delivery points from consumers' perspective: A qualitative case study of Christchurch city. *Case Studies on Transport Policy,* 5(4), pp. 587-595.

Khan, A. G., 2016. Electronic Commerce: A Study on Benefits and Challenges in an Emerging Economy. *Global Journal of Management and Business Research: B Economics and Commerce,* Volume 16 Issue 1 Version 1.0, pp. 19-22.

Kulach, K., 2018. *Ecommerce in Italy: the definitive guide.* [Online]
Available at: https://www.webinterpret.com/au/blog/ecommerce-italy-definitive-guide/#:~:text=In%20terms%20of%20return%20rates,to%20offer%20easy%20returns%20solutions
[Accessed November 2020].

Kulach, K., 2018. *Ecommerce in Italy: the definitive guide.* [Online]
Available at: https://www.webinterpret.com/au/blog/ecommerce-italy-definitive-guide/#:~:text=In%20terms%20of%20return%20rates,to%20offer%20easy%20returns%20solutions
[Accessed November 2020].

Kunst, A., 2020. *Returns of online purchases by category in Italy 2020.* [Online]
Available at: https://www.statista.com/forecasts/1000695/returns-of-online-purchases-by-category-in-italy
[Accessed 18 August 2020].

Lewis, P. H., 1994. Attention Shoppers: Internet Is Open. *The New York Times*, 12 August, p. 1.

Li Guogang, L. W., 2015. *The Analysis of Return Reverse Logistics Management Strategy Based.* s.l., Atlantis Press.

Mahar Stephen, W. P. D., 2017. In-Store Pickup and Returns for a Dual Channel Retailer. *IEEE Transactions on Engineering Management,* 64(4), pp. 491-504.

Mangiaracina Riccardo, P. A. S. A. T. A., 2019. Innovative solutions to increase last-mile delivery efficiency in B2C e-commerce: a literature review. *International Journal of Physical Distribution and Logistics Management.*

McLeod, F. N. et al., 2020. Quantifying environmental and financial benefits of using porters and cycle couriers for last-mile parcel delivery. *Transportation Research Part D: Transport and Environment.*

Melacini, M. & Perego, A., 2018. *Distribution network design - design methodology and policies PART II*, s.l.: s.n.

Mentzer, J. T., DeWitt, W., Keebler, J. S. & Min, S., 2011. Defining supply chain management. *Journal of Business Logistics* , 22(2).

MH&L, 2018. *Consumers Are Changing E-Commerce Preferences.* [Online]
Available at: https://www.mhlnews.com/technology-automation/article/22055220/consumers-are-changing-ecommerce-preferences
[Accessed 1 August 2020].

Mohsin, M., 2020. *10 Ecommerce Trends That You Need to Know in 2020 [Infographic].* [Online]
Available at: https://www.oberlo.com/blog/ecommerce-trends
[Accessed 19 8 2020].

Mollenkopf Diane A., R. E. L. T. M. B. K. K., 2007. Managing Internet Product Returns: A Focus on Effective Service Operations. *Decision Sciences,* 38(2), pp. 215-250.

Muir A. William, G. S. E. W. J. M., 2019. A Simulation Model Of Multi-Echelon Retail Inventory With. *Journal of Business Logistics,* 40(4), pp. 322-338.

Orendorff, A., 2019. *The Plague of Ecommerce Return Rates and How to Maintain Profitability.* [Online]
Available at: https://www.shopify.com/enterprise/ecommerce-returns
[Accessed 31 July 2020].

Osservatorio eCommerce B2c, 2020. *LA RISPOSTA DELL'ECOMMERCE B2C ALL'EMERGENZA COVID-19.* [Online]
Available at: https://www.osservatori.net/it/prodotti/formato/video/ecommerce-b2c-covid19-video
[Accessed 14 August 2020].

Perboli, G., Rosano, M., Saint-Guillain, M. & Rizzo, P., 2018. Simulation–optimisation framework for City Logistics: an application on multimodal last-mile delivery. *IET Intelligent Transport Systems,* pp. 262-269.

Perego Alessandro, P. S. M. R., 2011. ICT for logistics and freight transportation: a literature review and research agenda. *International Journal of Physical Distribution & Logistics Management,* 41(5), pp. 457-483.

qapla, n.d. *Resi e percentuali: un confronto tra i Paesi Europei.* [Online]
Available at: https://www.qapla.it/blog/ecommerce/confronto-resi-tra-i-paesi-eu
[Accessed October 2020].

R Core Team and contributors worldwide, n.d. *The R Stats Package.* [Online]
Available at: https://stat.ethz.ch/R-manual/R-devel/library/stats/html/stats-package.html
[Accessed 2020].

Robinson, A., 2014. *How to set up an E-commerce Reverse Logisitcs Framework Strategy for the Industrial Space as Proven by the Retail World.* [Online]
Available at: https://cerasis.com/e-commerce-reverse-logistics/
[Accessed 19 8 2020].

Saleh, K., n.d. *E-commerce Product Return Rate – Statistics and Trends [Infographic].* [Online]
Available at: https://www.invespcro.com/blog/ecommerce-product-return-rate-statistics/#:~:text=E%2Dcommerce%20Product%20Return%20Rate%20%E2%80%93%20Statistics%20and%20Trends%20%5BInfographic%5D,-

By%20Khalid%20Saleh&text=Did%20you%20know%20at%20least,brick%2Dand%2Dmorta [Accessed 4 August 2020].

Seghezzi Arianna, M. R. T. A. P. A., 2020. 'Pony express' crowdsourcing logistics for last-mile delivery in B2C e-commerce: an economic analysis. *International Journal of Logistics Research and Applications.*

Serrano, R., 2019. *E-Commerce VS. Traditional Commerce.* [Online]
Available at: https://enebfaculty.com/2019/05/14/e-commerce-vs-traditional-commerce/
[Accessed 30 July 2020].

statista, June 2020. *eCommerce Report 2020,* s.l.: Statista Digital Market Outlook – Market Report .

Taylor Daniel, B. S. K. A. M. M. P., 2019. Omnichannel fulfillment strategies: defining the concept and building an agenda for future inquiry. *The International Journal of Logistics Management,* 30(3).

Vakulenko Yulia, H. D. H. K., 2018. What's in the parcel locker? Exploring customer value in e-commerce last mile delivery. *Journal of Business Research,* Volume 88, pp. 421-427.

Vakulenko Yulia, S. P. H. D. H. K., 2019. Service innovation in e-commerce last mile delivery: Mapping the e-customer journey. *Journal of Business Research,* Volume 101, pp. 461-468.

Vasiliu Cristinel, A. I. D. R. D. I., 2016. *Approaches Regarding the Return Policy of Online Retailers.* s.l., s.n.

Velazquez R., C. S. M., 2019. *Environmental Impact of Last Mile Deliveries and Returns in Fashion E-Commerce: A Cross-Case Analysis of Six Retailers.* Macao, IEEE.

W.J., W. J., 2008. B2c e-commerce logistics: the rise of collection-and-delivery points in The Netherlands. *International Journal of Retail & Distribution Management,* 36(8), pp. 638-660.

Wang Qingjun, L. Y., 2014. *Returns Reverse Logistics Management Strategy in E-commerce B2C Market.* Shenyang, Atlantis Press.

Wang Ziping, Y. D.-Q. H. P., 2007. A new location-inventory policy with reverse logistics applied to B2C e-markets of China. *International Journal of Production Economics,* Volume 107, pp. 350-363.

Wikipedia, n.d. *dbscan.* [Online]
Available at: https://it.wikipedia.org/wiki/Dbscan
[Accessed 2020].

Wikipedia, n.d. *k-means clustering.* [Online]
Available at: https://en.wikipedia.org/wiki/K-means_clustering
[Accessed 2020].

Wu Yu, Z. B. H. S., 2019. A Dynamic Strategy for Home Pick-Up Service with Uncertain Customer Requests and Its Implementation. *Sustainability,* Volume 11, pp. 1-21.

Xu Xun, J. J. E., 2019. Investigating the influential factors of return channel loyalty in omni-channel retailing. *International Journal of Production Economics,* Volume 216, pp. 118-132.

Yu Yanan, K. H.-S., 2019. Online retailers' return policy and prefactual thinking: An exploratory study of USA and China e-commerce markets. *Journal of Fashion Marketing and Management,* 23(4).

Zaiqiu, T. Z. a. G., 2010. *A Preliminary Analysis Of Reverse Logistics in B2C.* s.l., 3rd International Conference on Information Management, Innovation Management and Industrial Engineering.

Zenezini Giovanni, L. A. ,. P. R. D. M. A. G. R., 2018. The Collection and Delivery Points Implementation Process from the Courier, Express and Parcel Operator's Perspective. *IFAC-PapersOnLine,* 51(11), pp. 594-599.

Zhang Juzhi, X. Q. H. Y., 2018. Omnichannel retail operations with consumer returns and order cancellation. *Transportation Research Part E: Logistics and Transportation Review,* Volume 118, pp. 308-324.

Zhang Rong, L. J. H. Z. L. B., 2019. Return Strategies and Online Product Customization in a Dual-Channel Supply Chain. *Sustainability,* 11(12).

Zhenleong, T. & Zaiqiu, G., 2010. *A Preliminary Analysis of Reverse Logistics in B2C.* Kunming, IEEE.

(this page intentionally left blank)

RINGRAZIAMENTI

Un doveroso ringraziamento al team che ci ha guidato nel corso di questi mesi: i Professori Mangiaracina e Tumino e le Dottoresse Seghezzi e Siragusa. Grazie per averci messo alla prova con un argomento così stimolante e attuale, la vostra guida è stata preziosa per portare a termine il lavoro di tesi. Abbiamo davvero apprezzato la vostra presenza e umanità nonostante il periodo difficile per tutti.

Ringraziamo anche il Politecnico di Milano per essere stato una palestra di vita che ci ha fatto crescere dandoci l'opportunità di coltivare i nostri interessi e i nostri rapporti personali.

Ringraziamenti di Elena

Al termine di questo percorso ci tengo a ringraziare chi ha reso la scalata più leggera. In primis voglio rivolgermi al mio compagno di tesi, Claudio. Sono felice tu abbia accettato "alla cieca" di portare avanti questo progetto con me: ho avuto la conferma che con il lavoro di squadra si possono superare presunti limiti e raggiungere risultati oltre le aspettative. Ti ringrazio per il tempo, la dedizione, la professionalità e la costanza che hai sempre dedicato a questo lavoro, insegnandomi a rafforzare i miei punti di debolezza e spronandomi a puntare sempre più in alto.

Voglio ringraziare anche chi è stato al mio fianco in questi anni. Non farò nomi perché so che saprete sentirvi i diretti destinatari di questi ringraziamenti: chi per il supporto morale, chi per la pazienza infinita nel rispondere alle mie mille domande spesso stupide, chi per la determinazione e l'esempio, chi per aver alleggerito tutte le imprese che sembravano impossibili. Grazie a chi ormai è da tanto tempo che cammina al mio fianco rappresentando una certezza sotto ogni punto di vista: nonostante le nostre strade stiano prendendo direzioni diverse so che ci sarà sempre un punto di incontro caratterizzato da affetto forte e incondizionato. Grazie anche a chi, invece, ho avuto la fortuna di conoscere negli ultimi anni e che mi ha riempito di novità e freschezza insegnandomi a guardare e a guardarmi da nuove prospettive.

Per concludere, voglio ringraziare tutta la mia famiglia, in particolare Mamma, Papà ed Elisa. Credo sia arrivato il momento di esprimere nero su bianco, per la prima volta, la mia riconoscenza. Sono infinitamente grata per l'amore con cui mi avete cresciuta, prima tenendomi per mano e accompagnandomi passo dopo passo, poi lasciandomi l'autonomia e l'indipendenza di proseguire con le mie gambe. Grazie per l'educazione e i valori che mi avete trasmesso: sono fiera della persona che sono e spero, un giorno, di sapere insegnare tanto come voi avete insegnato a me.

Ringraziamenti di Claudio

Con questa tesi porto a termine un capitolo importante della mia vita fatto di soddisfazioni e gioie, ma anche fatiche e rinunce. Se potessi tornare indietro però, rifarei ancora tutto: in questi anni, infatti, sono sicuro di essere maturato molto e di essere diventato una persona migliore. Non posso quindi non ringraziare chi mi ha accompagnato in questo fantastico viaggio.

Grazie mamma Carmen e papà Angelo. Vi voglio un mondo di bene, siete davvero incredibili! Non mi avete mai fatto mancare nulla e vi siete sempre fatti in quattro per me, dalle piste da sci ai banchi di scuola. Spero di avervi reso orgogliosi di me!

Grazie Ely per sopportarmi e supportarmi in ogni situazione. Non avrei potuto chiedere una sorella migliore!

Grazie nonna Elena per avermi allevato con sani e semplici principi: spero che questo mio traguardo possa alleviare almeno in parte le sofferenze che hai passato nella tua vita. Grazie nonna Silvana, instancabile lavoratrice, per avermi insegnato che il duro lavoro paga sempre.

Grazie zia Angela per avermi ospitato in questi anni e avermi sempre spronato ad andare avanti e a migliorarmi.

Grazie Marco, mio fedele amico, per aver condiviso con me gli anni dell'università. Chi avrebbe resistito a Saronno senza la tua compagnia!?

Un grazie anche a tutti i miei amici, vicini e lontani, che hanno reso questo percorso ancora più bello.

Non posso ovviamente non ringraziare la mia fantastica compagna di tesi Elena! Mai e poi mai avrei immaginato di conoscere una ragazza come te, semplice, dolce e laboriosa. Ho imparato davvero tanto dal tuo modo di essere e lavorare. Sono estremamente orgoglioso di quanto abbiamo fatto insieme in questi mesi: che squadra che siamo stati! Un grosso in bocca al lupo per la tua vita, ti auguro ogni bene!

Concludo con la frase che accompagnava sempre i miei allenamenti di sci, perché ancora una volta si è dimostrata vera: "*Il duro lavoro ha fatto sì che fosse facile. Questo è il mio segreto. Questo è il motivo per cui ho vinto.*".