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Investigating the Return Cost for B2C e-commerce

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Purpose: *Online sales have significantly increased, especially in the realm of the COVID emergency. For B2C e-commerce, reverse logistics is critical: it strongly impacts the willingness of customers to buy online, but it is very expensive for online players, who are striving to find ways to reduce the associated costs. This work aims to define a measure of the return cost and to investigate the main factors affecting it.*

Methodology: *This work combines analytical modelling and simulation. The model allows to represent the reverse logistics process and to define the associated cost; simulation is used in testing the model and analysing different scenarios. The used data were collected from both primary and secondary sources.*

Findings: *The return cost includes three main components (usage of the van, time spent by the driver to travel and to perform collection activities). The application of the model to Milan (Italy) resulted in an average unitary return cost of 2.78€. The variables impacting the most on this cost are the collection density and the travel speed.*

Originality: *This research is a first attempt to propose a measure for the cost of B2C e-commerce returns, and to analytically investigate the variables having the greatest impact in determining such cost.*

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1 Introduction

B2C e-commerce is on the rise: online sales have been increasing in many industries and different countries, and this trend is expected to continue also in the future. According to the B2C e-commerce observatory (2021), Italian online sales in 2020 were worth €32.4 billion, with €25.9 billion generated by products. Also due to the effects of the COVID sanitary emergency, those values will be boosted in 2021, when e-commerce sales should increase up to €38.6 billion. On a global scale, Statista (2020) forecasted a continuous and significant e-commerce diffusion, with US$3,299.5 billion revenues for 2024, signing a +71% growth rate if compared to 2019.

Despite this increasing trend, different barriers still make some customers favour offline traditional brick and mortar retailing to the online one. Among them, the main element is the lack of "physical interaction" with the product, which may result in customers' dissatisfaction in case of the wrong fit of ordered items, unmatching features with the description provided online or lower quality than expected (Zhenleong & Zaiqiu, 2010). In this direction, one of the main solutions that increase the customers' willingness to buy online is the possibility to easily (and typically for free) return products they are not satisfied with. Accordingly, most of the players operating online are trying to optimise return processes.

As a result, the product return rate (i.e., the percentage of products returned over the total number of items bought) is very high in the online channel. Focussing on the Italian scenario, product return rates in e-commerce account for 5% in the case of general goods, 15% for electronics and over 40% for fashion. Since e-commerce sales are growing, online returns are expected to increase as well. Hence reverse logistics, intended as the set of processes that move physical products from the final customer back to the retailer, is no longer to be considered an afterthought. It should not be managed as an additional service offered by retailers to clients but as the "New Normal".

These being the premises, reverse logistics is very critical for online players, as it strongly impacts the willingness of customers to buy online. Nonetheless, it may be very expensive, and operators are striving to find ways to reduce the associated costs. Despite its significance, there seems to be a shortage of academic contributions aimed to measure the cost of reverse logistics. As a result, this work defines a measure of the return cost and investigate the main factors affecting it.

The remainder of this paper is organised as follows: Section 2 presents the results of the literature review, section 3 defines the research objective and the methodology, section 4 displays the developed model, section 5 illustrates the model application and the deriving results, and section 6 summarises the main conclusions stemming from the work.

2 Literature review

In line with the overall goal of the paper, the objective of the literature review is to systematise extant academic knowledge dealing with reverse logistics for B2C e-commerce. The searching process performed on Scopus led to 44 articles, which have been examined to identify relevant patterns in the reverse logistics field, if any. In this regard, in line with the approach followed by Perego et al. (2011), the 44 papers were first classified according to their descriptive characteristics (i.e., source, country of the main author, and addressed sector); second, the research method used by authors was identified, alongside with a content-based analysis.

Concerning the source, they are quite broad, with journals belonging to domains ranging from marketing to computer science; this result allows to state that the field of reverse logistics for e-commerce is interesting for scholars from different disciplines. From a country perspective, China and the USA are the main contributors in the field of online reverse logistics: the presence of e-commerce giants as Alibaba and Amazon, as well as the penetration of internet retailing in those countries, have a key role in determining this pattern (Wang et al., 2007). Concerning the industry, scholars do usually not focus on a specific sector, probably due to their willingness to provide a generalisable contribution to current academic knowledge. While it could be expected to find a higher number of papers addressing the most return-inclined sector – namely the fashion one, where return rates are above the average (Velazquez and Chankov, 2019)– this was not confirmed by the literature analysis.

Switching to the content-based analysis, the reverse logistics process for B2C e-commerce is usually debated as a side topic of more general works addressing forward logistics. 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 consider forward logistics in B2C e-commerce at least partially similar to reverse one, accordingly assuming forward logistics studies as good proxies of reverse logistics ones (Hübner et al., 2016).

In most of the cases, analysed papers have the aim of understanding which variables have an impact on the number of returned products. In this sense, surveys play a relevant role, since these allow to better understand the behaviour of customers concerning e-commerce and returns management (e.g. Lin et al. (2020), Wang et al. (2020), Li et al. (2021), Rintamäki et. al. (2021), Stöcker et al. (2021)).

A further step was performed aimed to systematise the papers by considering the analysed phases of the process of reverse logistics. Following the approach proposed by De Araùjo et al. (2017), the B2C reverse logistics process can be synthesised based on the following phases: (i) pre-receipt, (ii) collection, (iii) transport, (iv) processing of returns and (v) shipment to the final destination. The role of the different actors involved in a typical e-customer journey - i.e., customers, logistics service providers and merchants (Vakulenko et al., 2019) – may vary, based on the peculiar activities they carry out. By considering these units of analysis, the literature proves to be quite scarce in insightful contributions: in most of the cases, the collection and the transport are the only phases described in detail by scholars, whereas very little attention is devoted to both the return processing and the shipment to the final destination.

The content-based analysis also allowed to identify the different ways that are implemented to allow customers to return products in B2C e-commerce. The literature displays three different options from a consumer perspective, namely the traditional return – based on the home pick-up made by the courier – (Röllecke et al., 2018), the collection points option – both attended and unattended – (Kedia et al., 2017) and the cross-channel option – which encompasses the possibility to buy goods online and return them to the merchants' physical store – (Hjort et al., 2019). Referring to the last-mentioned option, it has recently received particular attention by Huang et al. (2020) and

Jin et al. (2021), investigating competing e-tailers' BORS adoption strategies. Crowdsourcing logistics is another interesting discussed way to return products, with an example provided by Upadhyay et al. (2020).

Among the papers having the returns as a core topic, it is worth mentioning the innovative mathematical model approach followed by Chen et al., (2017). The author proposes an innovative model to collect e-commerce reverse flows utilising a network of taxis and CDPs (i.e. collection and delivery points), leveraging on the crowdsourcing paradigm. The proposed model moves 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 if compared to traditional return management. Considering instead the work by Chang and Zheng (2014), it presents an effective strategy of non-defective reverse logistics. The authors develop a model according to which online players can choose another consumer's delivery address as the client's return address to reduce the distance of non-defective return transportation. In such a case, the integrity checking process is delegated to a third-party logistics service provider.

As shown by these two works, logistics service providers (LSPs) play a fundamental role in managing reverse logistic flows, since online players are not used to managing internally last mile and reverse logistics. Such behaviour is expected: in most of the case, it would not be cost-efficient for an online player to manage transport internally, mainly for a matter of missing economies of scale and experience effects. In Wang et al. (2021), the importance of choosing the right LSP is underlined, and a decision support system is developed.

By the way, the lack of papers on reverse logistics cost assessment should be underlined: despite some articles addressing the theme of prices customers have to pay given the different cost components (Difrancesco et al. (2020), Nageswaran et al. (2020)), sources address this aspect with conceptual frameworks (Nel et al. (2020)) or choosing the preferable channel considering variations in costs (Mandal et al. 2020). Shah et al. (2021) developed a model including cost components, validating it with real case studies. However, the paper focus stays on proposing collaborative buffering between LSP and e-retailer, to reduce the storage and distribution efforts. In this sense, no instances on how much is the reverse logistics process 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.

Nevertheless, the low incidence of “core” papers dealing with the return methods in e-commerce B2C is in line with the statement by Hjort et al. (2019), who have been recently claiming that “literature on return management (i.e. reverse logistics) is still underdeveloped”. So far, scholars have widely discussed optimisation 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): fewer sources quantify and suggest new frameworks which consider forward and reverse logistics at the same time, or solely the latter one.

Based on the analysis of the literature and the emerging findings, the following three main research gaps were uncovered.

- Despite different scholars recognise how reverse logistics for e-commerce is very critical in terms of efficiency, there is a lack of models aimed to assess the cost of returning products in a B2C e-commerce environment
- The state-of-art description of the different options e-commerce clients might use to return products is incomplete (as additional innovative options could be exploited, e.g., relying on parcel lockers).
- While different works target specific phases of the return process, an holistic description of the overall return management process, concerning both the various return methods and the role of the actors in the different phases, is not present in academic literature.

Among the gaps identified, this paper focusses on the first one, addressing the following research questions:

- RQ1: What is the average cost for returning an item?
- RQ2: What are the elements impacting the return costs most?

3 Objectives and methodology

To answer the research questions, this work adopts an analytical approach, combining mathematical modelling and simulation. The model allows to depict the reverse logistics process, and to define the formulas needed to estimate the associated cost; simulation is instead used to get numerical insights, in applying and testing the model, and analysing different scenarios. The data used in the application phase have been collected from both primary (i.e., interviews and direct observation) and secondary sources (reports and logistics practitioners' journals), following the approach of Latte et al. (2020).

As far as the approach embedded into modelling and simulation is concerned, this can be described as follows. Following the scheme proposed by Seghezzi et al. (2020), firstly, great emphasis has been placed on the problem setting phase, where relationships among variables have been investigated and introduced, and a basic scheme of the model has been built. Later on, data to be plugged into the algorithm have been collected. Afterwards, the problem-solving phase has taken place, and two different approaches have been tested for the definition of the delivery tours (further details are presented in the following section): a clustering algorithm based on the k-means approach and a "constrained" methodology. Similar approaches have been used by Ahmed et al. (2017), to determine optimal resources required (vehicles, field executives) to operate a city-logistics network with a given distribution of sellers and customers. Both of them hold pros and cons, therefore the final decision has been to merge the two approaches in a sort of "time-constrained k-means clustering" algorithm, which makes use of k-means clustering as a baseline with time correction/constraint. Once the final model has been defined, it has been applied to a representative case in Milan (Italy), to gain numerical results and accordingly derive managerial considerations.

4 Model

Figure 1 represents the architecture of the model, which was developed in R.

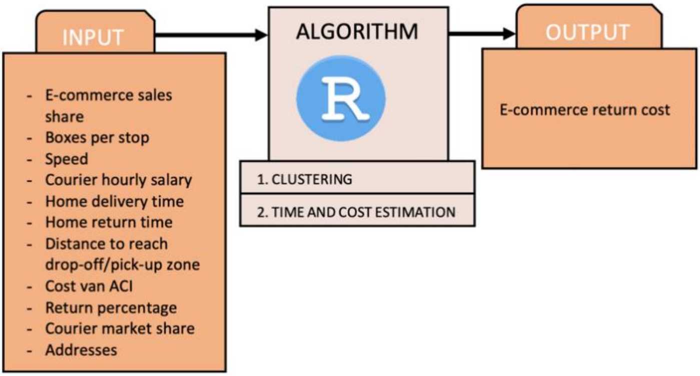

Figure 1: Model architecture

The "**Input**" variables describe the implementation context. Some concern the deliveries (e.g., Home delivery time) because in the tested scenario, both deliveries and returns are managed in the same tour, meaning that the express courier van travels each day to the different customers' homes either to drop-off or pick-up packages. They are defined as follows:

- E-commerce sales share: ratio between the number of locations to be visited daily on the total number of eligible locations in the considered geographical area.
- Boxes per stop: number of boxes to be delivered at/returned from a single address.
- Speed: average travelling speed of the van.
- Courier hourly salary: hourly salary of an express courier driving a van.
- Home delivery time: time needed to deliver a parcel once the home location has been reached (e.g., ring the doorbell).
- Home return time: time needed to collect a parcel to be returned once the home location has been reached.

- Distance to reach drop-off/pick-up zone: distance between the departure point (i.e, the hub of the courier) and the delivery area.
- Cost van ACI: cost per travelled kilometre for the usage of the van (including fuel).
- Return percentage: ratio of returns on the total number of boxes managed per tour (deliveries + returns).
- Courier market share: percentage of orders managed by a specific courier over the total number of orders to be managed daily in the same area.
- Addresses: set of candidate addresses for customers' delivery/pick-up locations in terms of geographical coordinates.

The "**Output**" is expressed in terms of "return unitary cost"; it represents a sort of summary variable which encompasses the costs of all the elements needed to handle return requests in B2C e-commerce, from the customer's location to the first hub of the courier.

The "**Algorithm**" is the set of processes and computations needed to estimate the return unitary cost based on the considered input values. It works according to two main steps: (i) clustering and (ii) time and cost estimation.

In the (i) clustering step, the considered delivery/pick-up locations are grouped, via a time-constrained clustering method, in clusters, where each cluster is associated with a tour performed by a single van. The k-means clustering approach is applied to a set of addresses within the considered area (in the case of this research the municipality of Milan), which are net of the daily e-commerce requests, courier market shares and the average number of orders (boxes per stop) each address might account for. Different input variables are plugged into the algorithm to let R generate the optimal number of clusters to satisfy the demand (namely the average speed of the van, the unitary operation time and the distance to be travelled outside the delivery area, from the drop-off/pick-up area to first couriers' hub). It should also be noted that the model is dynamic, meaning that depending on the customers' requests (e.g. e-commerce sales) and the relative market share of the express courier, a different number of clusters is activated.

In the (ii) time and cost estimation step, the time spent by the van driver and the associated cost are estimated for each delivery tour, and the return unitary cost is subsequently derived as follows.

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

The Return Unitary cost is found – as shown in the previous formula – by summing three cost voices (please note that "unitary" indicates that the cost refers to one single returned box):

Cost Van Unitary: the cost for the van is computed as the cost per kilometre related to a specific typology of a van – which includes fuel, maintenance, taxes, insurance and other indirect costs (ACI, 2017) – multiplied by the total distance travelled by the van within and outside the delivery area. The cost of the van is then split on the total number of boxes managed in a specific tour regardless of the percentage of deliveries and returns (since such cost does not depend on the type of service to be performed).

$$Cost\ Van\ Unitary = \frac{(Din + Dout) \cdot Cfi}{Boxes\ per\ tour}$$

Cost Driver Travel Unitary: this value accounts for the cost related to the time spent by the courier travelling. It is obtained by multiplying the travel time by the hourly salary of the courier, and – also in this case – dividing it by the total number of managed boxes.

$$Cost\ Van\ Unitary = \frac{Travel\ time \cdot SC}{Boxes\ per\ tour}$$

Cost Driver Return Unitary: it is the cost related to the time spent by the courier performing pick-up and delivery activities. In this case, it only considers returns (since the time spent to perform deliveries does not contribute to the return cost). It is obtained by multiplying the time spent to perform the activities related to one return, by the courier hourly salary

$$Cost\ Driver\ Return\ Unitary = truh \cdot SC$$

For sake of simplicity, some assumptions were made concerning the model development. First, the courier delivers/picks up only one box from one customer. If a customer orders different products in the same online order, these items are included in the same box (1 box = 1 customer). Second, time windows are not taken into considerations when scheduling the tours. This is in line with most of the "generic" last-mile deliveries, which are not managed by appointment. Third, there are not tours dedicated to deliveries only and returns only: in each tour, there is a certain percentage of deliveries and a complementary percentage of returns. This reasonable assumption has been justified by the interviewed express-courier. According to what emerged during the interview, managing returns with dedicated tours is not an option due to the low volumes at stake. Fourth, the input database with the candidate delivery/pick-up destinations does not only include residential addresses, but also other locations like commercial activities or offices. The assumption is that customers can schedule deliveries and pick-ups also in these alternative locations, as it happens in real life.

5 Model application and results

This section of the work is devoted to presenting the application of the model to a realistic case in an Italian city, Milan. The considered base scenario is described in Table 1, which reports the values assigned to all the different input variables and parameters previously presented in Figure 1. These input data, retrieved from both primary and secondary sources, were validated by an express courier senior manager interviewed in October 2020.

Table 1: List of input variables with values

Input variable	Value
E-commerce sales share	27 %
Boxes per stop	1.23 boxes/stop
Speed	10.21 km/h
Courier hourly salary	20 €/h
Home delivery time	1.5 minutes
Home return time	2 minutes

Input variable	Value
Distance to reach drop-off/pick up zone	15 km (one way)
Cost van ACI	1.6 €/km
Return percentage	10 %
Courier market share	12.5 %
Geolocated addresses	Longitude and latitude

This scenario was used to answer both the proposed research questions.

As far as RQ1 is concerned, the model was applied to such values, to obtain an average return cost for the presented scenario. As anticipated in section 4, after the identification of the delivery/pick-up customer destinations to be reached, the solving algorithm groups such locations in clusters, and assigns each of them to one van. Figure 2 shows the result of the k-means clustering (a different colour is assigned to different tours).

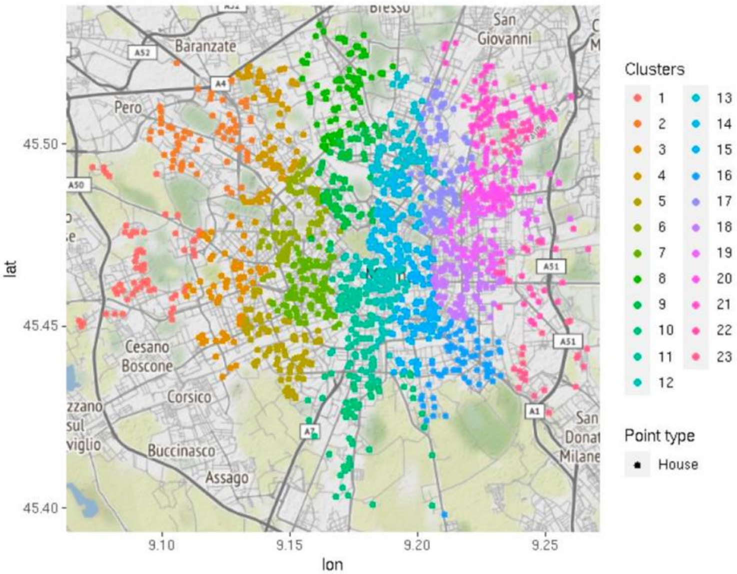

Figure 2: Result of the clustering – Delivery tours

The return unitary cost was then derived according to the formulas presented in section 4, resulting in the outcome shown in Figure 3. The average return unitary cost accounts for 2.78 €/box returned. The highest incidence in the final cost among the three illustrated cost components is represented by the "cost driver travel unitary" (42%), followed by the "cost van unitary" (34%) and finally, the "cost driver return unitary (24%). Considering instead the time components, the incidence of the travel time on the total is more than double if compared to the operation time (69% vs. 31%). It should be noted that the travel time might also be affected by a higher degree of uncertainty: urban congestions, for instance, could decrease the vehicle speed, thus requiring couriers to reschedule delivery/pick-up missions and/or to activate the overtime with a consequent cost increase.

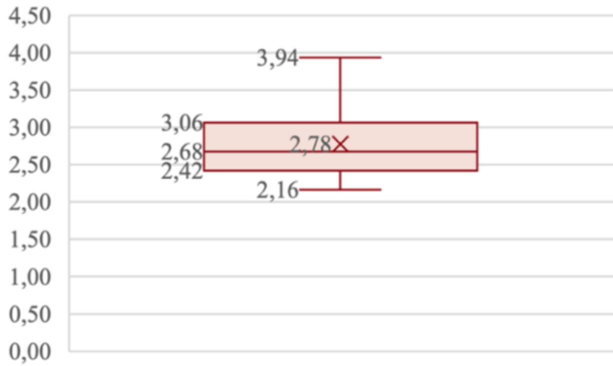

Figure 3: Return unitary cost

Switching to RQ2, which aims at identifying the elements affecting the most return cost, it has been addressed employing some sensitivity analyses run on the different input variables. More specifically, the effects on the return unitary cost caused by the same variations for the different inputs (considering their benchmark value as a reference starting point) have been investigated. The results of this analysis are displayed in Table 2.

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

	Variables							
	1	2	3	4	5	6	7	8
	Speed	Courier market share	E-commerce sales share	Return percentage	Cost van ACI	Home boxes per stop	Home return unitary time	Home delivery unitary time
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%	0%	-26%		-21%	-12%
-50%		28%	28%	-1%	-17%		-15%	-10%
-25%	39%	9%	9%	-1%	-9%		-7%	-4%
0%	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
25%	-16%	-6%	-6%	0%	9%	-6%	5%	2%
50%	-26%	-11%		-1%	17%	-11%	13%	9%
75%	-32%	-14%		0%	26%	-11%	19%	13%
100%	-36%	-17%		-1%	34%	-15%	25%	19%

These outcomes allow deriving different considerations.

First, the variables that show the greatest impact – whether positive or negative – on the "return unitary cost" are the market share courier and e-commerce sales share (+63% in return unitary cost for a 75% drop in the input variables). The determinant of this pattern may be found in the relationship between these two inputs and the drop density, which is defined as the number of packages to be managed in a drop-off/pick-up zone divided by the covered surface. The higher the e-commerce sales share (and/or the higher the market share of the courier), the higher the number of customers' houses to be visited in the same area (as represented in Figure 4).

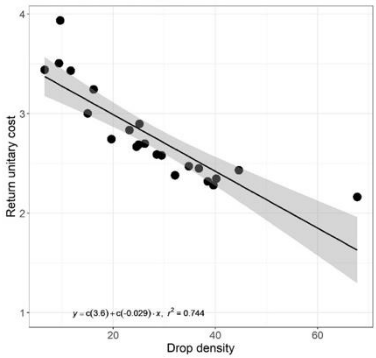

Figure 4: Drop density VS Return unitary cost

The drop density is statistically significant in predicting the return unitary cost, as it may be noticed from the results of the test shown in Figure 5. Above all, economies of scale and scope phenomena play a pivotal role in explaining the abovementioned figures.

```
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 5: Output of the regression analysis for Drop density vs. Return unitary cost

The third variable in terms of the highest impact on the return cost is the **speed**: if the speed decreases by 25%, a 39% increase in the return unitary cost is expected. The determinants of this strong interaction can be found in the way the speed relates to both the “travel time” and the number of “boxes per tour”. More in detail, the speed affects the travel time negatively, and thus the higher the average speed the lower the incidence of the travel time over the 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). Also, in this case, a test has been made to support the statement that the number of boxes per tour is inversely proportional to the cost of a returned box and that such an effect is statistically significant. Therefore, the joint effect of the “speed-boxes per tour” and “speed-travel time” relationships attribute the speed of the van to a key role in modifying “return unitary cost”. Considering the effect of speed on the return unitary cost, it is worth noticing that it is not constant, but it assumes the pattern shown in Figure 6. The decreasing tendency is due to the relationships between the speed and the number of boxes per tour, which implies that for high numbers of boxes per tour a lower number of tours needs to be activated by the single express courier to fulfil the demand. Considering instead the horizontal asymptote, this is caused by fixed components (i.e. fixed distance to reach the drop-off/pick-up area) which have to be beared in any case.

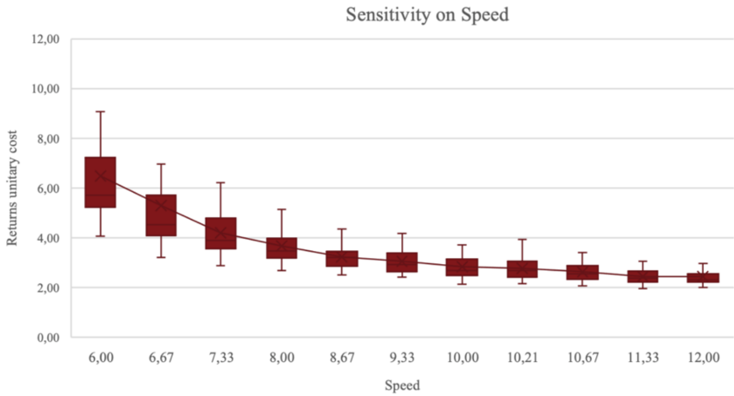

Figure 6: Output of the regression analysis for Drop density vs. Return unitary cost

The variable **Cost van ACI**, expressing the cost per km ascribed to the use of the vehicle to perform deliveries-pick-ups, causes slight variations in the return unitary cost: this variable is present in the formula to compute the cost as a multiplicative coefficient, with no links to other variables. Its direct relationship with the travelled kilometres implies that the effects caused by variations in the cost of the van on the return unitary cost have the same entity in both negative and positive cases (meaning that a 25% decrease in the cost causes a 9 % decrease in the return unitary cost, as well as a 25% increase causes a 9% increase). As noticeable, a drop/rise in the cost per van does not causes the same percentage variation in the return unitary cost, because this latter does not only include vehicle operations costs, but also labor ones (and the effect is thus mediated).

Coming to the number of **boxes per stop**, differently from what could be expected, by doubling the number of boxes to be managed in a single location, the return unitary cost decreases by just 16%. The reason behind this result can be find in the way the analysis is set: in order to be able to analyse the impact of each variable, one variable at a time is modified in the what-if analysis. As a result, changing the number of boxes per stop without changing the overall demand implies that – since the driver spends more time at each customer's home to perform delivery/pick-up activities – a lower number of addresses will be visited in a single tour (since less time will be left to travel). As a result, the drop density – being defined as the ratio between the number of boxes and the surface of the tour itself – is not strongly affected because both the numerator and the denominator increase. In other words, while both the market share of the courier and the e-commerce sales have a pivotal role in changing the drop density (and thus reducing cost), the number of boxes per drop by itself does not.

As far as both the **home return unitary time** and the **home delivery unitary time** are concerned, the impact that variations in their values have on the "return unitary cost" is even lower than the previous ones. These two elements solely affect the operation time, which accounts for one-third of the total time of 8 hours.

Finally, the input variable having the lowest impact on the return unitary cost is the **return percentage**. The reason behind this result is that the considered tours manage both returns and deliveries. As a result, in case the percentage of returns decreases, the number of managed boxes does not change, and the mix simply shifts towards a predominance of deliveries.

The presented results have been discussed with the interviewed manager, who has confirmed their reliability and agreed with the derived considerations.

6 Conclusions

B2C e-commerce has been increasing in the last years, especially in the realm of the COVID emergency, which has boosted the online sales of products. For e-commerce, reverse logistics is critical in a twofold direction. On the one hand, it strongly impacts the willingness of customers to buy online; on the other hand, it is very expensive for online players, who are striving to find ways to reduce the associated costs. This work is a first attempt to propose a measure for the cost of B2C e-commerce returns and to analytically investigate the variables having the greatest impact in determining such cost.

This research answers the defined research questions identifying the main components of the return cost (usage of the van, time spent by the driver to travel and to perform collection activities). Thanks to the application of the model to Milan (Italy), it provides an estimation of such cost, which resulted in an average unitary return cost of 2.78€. Moreover, it identifies the variables impacting the most on the return cost, i.e., the collection density and the travel speed.

This work has both academic and managerial implications. From an academic perspective, this work is a first attempt to propose a measure for the cost of B2C e-commerce returns and to analytically investigate the variables having the greatest impact in determining such cost. From a managerial perspective, the dynamic, scalable and modular model developed could help practitioners, especially express couriers, to gain a deeper understanding of the variables driving the return cost. More specifically, some remarks can be drawn stemming from the mentioned analyses, and potential managerial implications and suggestions may be derived about all the studied variables if considering the perspective of the courier service.

- Courier market share – Couriers might invest more in trying to gain higher market shares if compared to competitors. They could increase the service level considering the perspective of both customers (e.g., offering the possibility to reschedule deliveries/returns, providing on-time services, warranties and tracking services ...) and online players (i.e. offering frequent load batches, tracking services, flexibility ...).
- Speed – 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). The active role couriers may have in this direction is including in the tour definition the analysis of aspects linked to the congestions (which should be real-time modelled).
- Cost Van – Different vehicles may entail different costs per km travelled, depending on their features. Additional considerations could also be made concerning electrical or green vehicles, which in some countries could allow benefiting from national incentives.
- Home delivery time – Different delivery policies could be defined by both couriers and merchants aimed to reduce the home delivery time (e.g., proof of delivery not required, delivery in the garden/courtyard…).
- Number of boxes per stop – The number of boxes per stop is more related to demand issues. Nonetheless, some initiatives could be implemented aimed at increasing the delivery/return density, such as relying on dynamic pricing policies.

- Return percentage – There will always be a certain percentage of returns to be managed, even if new technologies (AI, VR) might decrease their likelihood.

Despite its contribution, this research has some limitations, which offer sparks for future research efforts. First, the data validation. Despite data from primary and secondary sources have been confirmed by an express courier senior manager, validation by more than one sources could be included. Second, the context of application. The model has been applied to the municipality of Milan. Future works could enlarge the scenario, applying the model also to additional areas, with different characteristics. Third, the return mode. The model focusses on the traditional return mode, in which the parcel is collected at the customer's home. Nonetheless, it could be interesting to evaluate how the cost would change if considering alternative return modes (e.g., returns at collection points, in parcel lockers). Fourth, the focus on the economic aspect. This research addresses the economic aspect estimating the return cost. It would be interesting to consider also the environmental perspective, addressing the emissions associated with reverse logistics processes.

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