Environmental footprint of B2C e-commerce: assessment and comparison of offline and online retailing channels

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Abstract: Environmental sustainability in logistics is among the major issues for practitioners, academia, as well as citizens and municipalities. As technology continues to advance and retailers develop their online sales channels, scholars focused their attention on comparing the environmental impact of traditional and e-commerce purchases. Despite most researchers agree on the lower emissions of online shopping, others discuss potential negative factors that may compromise the environmental friendliness of e-commerce. The aim of this study is therefore to assess and compare the emissions of online and offline purchases in the consumer electronics industry. An analytical model is developed and applied to different areas (urban and rural) considering both Home Delivery (HD) and Click & Collect (C&C) solutions for online retailing. Results prove comparable environmental footprints of HD and C&C solutions, which are significantly lower compared to offline purchases, even if the emission released in the C&C present higher variability depending on the customer trip. While for traditional retailing the highest environmental impact comes from the shops, for the HD and the C&C the most polluting processes are, respectively, last mile delivery and customer trip. The carbon footprint of the three purchasing processes results to be lower in the metropolitan area, while, due to the lower capillarity of hubs and the lower delivery density, the distribution in smaller urban contexts generates higher emissions. Similarly, the lower capillarity of shops in rural areas leads to a higher carbon footprint for traditional retailing. Despite the overall footprint is affected by industry-related incidence of returns, the results obtained can be considered representative even for other sectors. The present research offers contributions to both scholars and practitioners. On the academic side, it provides a deeper understanding of the primary factors contributing to the emissions release across different urban areas. On the managerial side, it may be useful to support environmentally conscious decision-making processes, suggesting proper initiatives aimed at reducing the carbon footprint of the delivery processes, among which influencing customers' decision-making processes and reducing the environmental impacts of their trips.

Keywords: e-commerce, last-mile delivery, logistics, sustainability, environmental impact

1. Introduction

In recent years the Business to Consumer (B2C) e-commerce has significantly grown, and its adoption rate is expected to further increase in the future. To expand the capillarity of their channels and attract a larger customer base, many retailers are developing their e-commerce channels alongside, or in some cases as an alternative to, traditional physical sales channels. Among the most relevant factors for the successful development of the initiatives, logistics play a key role. In particular, special attention should be paid to the delivery phase, which is significantly relevant for three main reasons: efficiency, given the high incidence of costs; effectiveness, since it is the sole physical engagement with customers; environmental sustainability, due to the high impact of the emissions released along the distribution process. According to Brown and Guiffrida (2014), the last-mile delivery is the least efficient stage of the delivery process, responsible for the highest transport costs in the supply chain and, more specifically, it is accountable of up to 28% of the total delivery costs (Ranieri *et al.*, 2018). Several authors, including Perboli *et al.* (2021), highlight the issue of the high costs of the last-mile delivery, mainly due to the difficulties in creating economies of scale when delivering parcels directly to customers' doorstep. In order to reduce the logistics cost and maximise the amount of orders delivered in each tour, alternative drop off points, have been introduced alongside traditional Home Delivery: e.g. lockers, shop, newspaper stand, café and courier shops. Moreover, according to Niemeijer and Buijs (2018), the significant growth of online purchases drew the attention towards the negative externalities generated by online purchases and, in particular, by the last-mile delivery.

The purpose of this study is to measure and compare the carbon footprint generated by different delivery solutions for e-commerce orders, considering both Collection Points and Home Delivery, as well as traditional purchases in physical stores.

The paper is structured as follows: in Section II an overview of the most relevant findings in the existing literature is presented, while in Section III the objectives of the research and the methodology adopted are detailed. Thereafter, the main findings are presented and discussed in Section IV and, finally, the conclusion of the study and possible further research are outlined in Section V.

2. Literature review

Over the last few years, several authors have discussed the environmental impact of purchases made through digital platforms, compared to the traditional physical process. As defined by Brown and Guiffrida (2014), in the traditional purchasing process "the customer themselves pick up the purchased item from the retailer and self-delivers the item to their home using their own vehicle". According to Edwards *et al.* (2010), there are various critical factors affecting the overall carbon footprint generated, including the number of products purchased during the trip, the transport mode, as well as the willingness to combine shopping with other activities and to group purchases into fewer shopping trips. As Edwards, McKinnon and Cullinane (2010) sustain, the higher contribution to the overall emissions generation in the traditional purchasing process come from the customer trip to and from the retail store. Indeed, the way people travel to the shop, the distance covered, the frequency and the volumes of products purchased have a direct impact on the overall carbon footprint generated (J. Edwards *et al.*, 2010).

When considering the most common delivery solution for digital purchases, as defined by Edwards, McKinnon and Cullinane (2010), the Home Delivery process involves, typically, dropping off a single package to an individual address, usually the consumer's home or office. Niemeijer and Buijs (2023) point out that, by consolidating the orders of several customers, personal trips to the shop are replaced by more efficient deliveries performed by the courier, entailing potential reductions of the environmental impact generated. Despite that, as the authors sustain, the advantages gained through the consolidation highly depend on the reference context. Therefore, to increase the efficiency of the direct delivery processes, companies are trying to increase the customer density, by offering incentives in order to shape the demand and concentrate the appointment times for deliveries in a specific area (Boyer *et al.*, 2009). In this way, according to Edwards, McKinnon and Cullinane (2010), the overall distance travelled decreases and, depending on the type of vehicle used, the environmental impact changes. To reduce the carbon footprint of their logistics processes, several companies have thus introduced innovative solutions for the last-mile delivery: the aim is to maximise the drop density (J. B. Edwards *et al.*, 2010) and, at the same time, to reduce the number of failed deliveries (J. Edwards *et al.*, 2010) while providing a satisfactory service to people and improve the efficiency of the processes (Nogueira. *et al.*, 2024). As Edwards *et al.* (2010) report, by designing alternative solutions for delivery and collection, with respect to traditional usage of diesel-fueled vans for Home Delivery, several environmental benefits can be achieved. Among the innovative solutions considered, there are alternative delivery and pick-up points, cargo bikes, city micro-hubs, crowd shipping, drones, ecological means of transport including electric vehicles (Edwards, McKinnon and Cullinane, 2010, Kiba-Janiak *et al.*, 2022) or even mixed fleets (Nogueira *et al.* , 2024).

Defining alternative collection and delivery points turns out to be particularly relevant, offering a viable delivery solution compared with the attended Home Delivery (Niemeijer and Buijs, 2023). In the downstream distribution process, the delivery company can drop a parcel off at the pickup point from where the customer collects the parcel (Niemeijer and Buijs, 2023). Typical pickup points proposed are parcel lockers, supermarkets, railway stations, and post offices. These alternative collection and delivery points may create benefits for customers and, at the meantime, reduce the emissions generated in the traditional delivery process through consolidation advantages, reduction of failed deliveries and a more efficient collection of returned products (J. Edwards *et al.*, 2010).

Indeed, as reported by Boyer, Prud'homme and Chung (2009) and Niemeijer and Buijs (2023), by increasing the number of parcels delivered in collection points and reducing the ones dispatched through the Home Delivery, specialized couriers can perform more efficient routes achieving a higher density of deliveries. Moreover, according to Niemeijer and Buijs (2023) and Sina Mohri *et al.* (2024), a surge in the usage of Pick-Up and Drop-Off points (PUDOs) allows to lower the failed delivery rate and, consequently, to reduce the parcels that have to be included in subsequent routes, thus increasing the overall efficiency of deliveries.

Finally, along with the chances of designing more efficient routes and making a successful first-time delivery, another relevant factor that have a great influence on the carbon footprint released is the products' return process (J. B. Edwards *et al.*, 2010). As the authors report, the online purchasing process is characterised by a higher volume of products returned with respect to the traditional shopping. The environmental impact of these online returns strongly depends on the consumers' preferred habits, as well as on the online retailers' and the couriers' returns policies. Indeed, customers may return products through physical stores or, alternatively, can send the products back to the retailer through courier companies. In the latter case, couriers might collect the parcels in their usual delivery tour, without implying any additional relevant use of resources or, alternatively, they can plan separate collection tours with dedicated vans solely to collect returned items, releasing a greater quantity of negative externalities (J. B. Edwards *et al.*, 2010).

To conclude, as Niemeijer and Buijs (2023) point out, to fairly evaluate the convenience of Click & Collect solutions under an environmental perspective, it is necessary to consider the adoption rates of pickup point in different types of urban areas, as well as the composition of the fleets, both for couriers' delivery vehicles and passenger cars. As a matter of fact, the utilization of parcel lockers is a very relevant factor to take into account. Indeed, Sina Mohri *et al* (2024) argue that there is evidence of poor utilisation of parcel lockers, caused by poor accessibility as a primary barrier. Furthermore, Niemeijer and Buijs (2023) highlight that the main benefits from an environmental perspective can be obtained when pickup points are established in urban settings, since in rural areas the reduction in the carbon footprint release are offset by the carbon footprint associated with customers travels. Indeed, as widely discussed for the traditional purchasing processes, Niemeijer and Buijs (2023) notice that the reduction of distance travelled by the courier might require an additional distance travelled by customers to pick-up their orders. Actually, as Edwards, McKinnon and Cullinane (2010) argue, the emissions generated by the customer personal journey might be greater than the overall carbon footprint released along all upstream logistics activities, irrespectively of the distribution channel considered. Moreover, as reported by Brown and Guiffrida (2014), it is necessary to consider alternative types of transport means for customer shopping trips, such as public transport, cycling or walking.

Therefore, depending on the specific characteristics of the urban context analysed, the composition of the delivery fleet and the customer personal mode of travel, the overall performance and the carbon footprint of the purchasing process might significantly vary.

3. Objectives and methodology

The purpose of this research is to investigate the environmental impact of the last-mile delivery process and assess the carbon footprint released by e-commerce purchases, aiming to quantify and compare the emissions, expressed in CO_2 equivalent (CO_2e). Three alternative purchasing processes for different types of urban areas have been analysed.

The research has been conducted through the development and the application of an activity-based analytical model to assess the emissions released along the different logistics processes and, more specifically, to answer the following research questions:

RQ1: What is the environmental impact of online purchasing processes, including Home Delivery and Click & Collect, compared to offline processes in different urban contexts?

RQ2: For each of the different purchasing and delivery solutions, what are the factors with the highest environmental impact?

In particular, three scenarios have been analysed and compared:

- Home Delivery (HD), where the attended delivery process takes place in a specific address defined by the customer;
- Offline purchasing process, where the customer goes to the shop to make the purchase;
- Delivery in Pick-Up and Drop-Off Points (PUDOs), where the customer goes to collect his order.

The analysis has been focused on the consumer electronics industry for all the three purchasing processes, excluding those product types with singular features which may require particular delivery practices.

The system analysed consists of the network of a generic retailer active in both the online and offline purchasing channels. In particular, the point where the three processes diverge is defined as the origin of the system, i.e. the warehouse from which both online and replenishment orders to the shop are dispatched, without accounting for the emission generated within the facility. For the purpose of the research, it has been assumed that transport to the shop, to the final customer or to the pick-up point is always performed by a specialized courier. Thus, depending on the specific flow being analysed, parcels have been accounted for the emissions related to the courier hubs they pass through. Moreover, for the offline purchasing process, the carbon footprint of the shop has been assessed and similarly, in the process of online purchase and delivery through pick-up points, the emissions released by the infrastructures dedicated exclusively to parcels delivery and pick-up have been estimated. Nevertheless, a relevant assumption of the study is that the emissions related to pick-up points like bars or similar locations have not been considered, as the environmental impact of parcel collection at these locations have been assumed to be negligible. For both the offline purchasing process and Click & Collect the carbon footprint released during the customer journeys to go, and came back, to a shop or pick-up point has been considered. Finally, the emissions from various types of packaging used in the distribution process have been included in the assessment.

The three processes and their use cases have been applied in different urban contexts: a metropolitan area, a medium-populated provincial city, and finally, a more rural area located in a small province. According to the European Classification of Municipalities, which is defined basing on the degree of urbanization (European Union *et al.*, 2021), and referring to the data of report published by ISTAT (Istituto Nazionale di Statistica, 2023), three distinct types of urban areas, characterised by different population densities, have been identified for the Italian context:

- "Cities" or "Densely populated areas" where live almost 35% of Italian population;
- "Towns" or " Areas with intermediate population density", where live almost the 48% of the entire population;
- "Rural areas" o " Scarcely populated areas" where live almost 17% of Italian population.

4. Model application

In this section, the most important assumptions considered for the application of the model are presented. In particular, as shown in E-commerce adoption rate, which decreases according to the population density;

- Distance from couriers' logistics facilities, which increases as population density decreases;
- Average distance travelled by customers, which decreases as the level of urbanization increases.

Table 1, different scenarios have been designed for the three types of urban contexts, with regards to several influencing factors which impact on the delivery performance, both under economic and environmental perspectives:

- E-commerce adoption rate, which decreases according to the population density;
- Distance from couriers' logistics facilities, which increases as population density decreases;
- Average distance travelled by customers, which decreases as the level of urbanization increases.

Table 1: Characteristics of the different urban areas

	City	Town	Rural area
E-commerce adoption rate	High	Medium	Low
Distance from courier's logistics facilities	Low	Medium	High
Distance travelled by customers	Low	Medium	High

For the three types of urban areas analysed, different assumptions of last-mile delivery process have been outlined. As a result of the interviews performed with specialized express couriers, the main characteristics of the delivery tours, such as the total distance travelled in a tour, the number of stops and the number of parcels per stop, have been reported in Table 2.

Table 2: Characteristics of the last-mile delivery process in different urban areas

	City	Town	Rural area
Average distance per tour [km/tour]	60	80	120
Average number of stops per tour [stop/tour]	120	80	65
Average number of parcels per stop in HD [parcel/stop]	1	1	1
Average number of parcels per stop in PUDOs parcel/stop]	15	12	8

For the purpose of this research, it has been assumed that delivery processes are performed through the usage of traditional vehicles. In particular, a different composition of the vehicles fleet used for last-mile delivery has been considered for each urban area. Basing on the report published by the Automobile Club d'Italia (2023), which covers the adoption rates for different fuel sources across different types of vehicles, the composition of the last-mile delivery vehicle fleet was defined as shown in Table 3.

Table 3: Courier fleet composition

	City	Town	Rural area
Diesel	88,72%	88,25%	89,27%
Gasoline	5,83%	3,96%	5,60%
LNG	4,76%	6,99%	4,04%
Electric	0,70%	0,81%	1,10%

Given the high level of uncertainty regarding the final customer's decision, three scenarios were considered to model consumer behaviour when traveling to a retail shop for an offline purchase or to a pick-up point:

- Best case: The customer walks to the shop, or drives along his/her original route;
- Average case: A different mix of transport modes, distance travelled, dedicated/non-dedicated trips to the specific type of facility was considered for each geographical context;
- Worst case: To collect the order, or to purchase the products, the customer makes a dedicated trip, covering a different distance depending on the purchasing solution.

Moreover, for the Home Deliveries, a 5% of unattended deliveries with respect to the overall number of parcels have been considered. As Sina Mohri *et al.* (2024) report, unattended deliveries are those missed first-attempt deliveries, since the customers is not present at the drop off location. Unattended deliveries affect the service level and, at the same time, imply an additional operational cost for couriers, which have to repeat the delivery, releasing negative externalities. Despite several players developed various technological solutions, succeeding in the reduction of the number of deliveries that have to be repeated, there are still second deliveries that have to be performed.

Another factor significantly affecting the e-commerce costs of logistics is represented by the cost of returns. Indeed, the direct and reverse distribution process of products returned by customers represents a relevant cost for companies, both from an economic and an environmental perspective. Analysing customer return rates to retailers, online returns are about twice respect the returns of products purchased in traditional shops. However, for traditional retailing, it is important to consider also the unsold goods that are returned from the purchasing infrastructure to the retailer's warehouse. As shown in Table 4, basing on real context data collected through interviews with practitioners, different return rates were considered, depending on the channel through which products have been purchased.

Table 4: Return rates and modes for the different purchasing channels

	% returns from the customer to the shop	% returns from the shop to the warehouse	% returns from the customer to the warehouse
Offline	3%	5%	-
Online	-	-	6%

Moreover, according to the data collected from the interviews performed with practitioner and shown in Table 5, different solutions to return the goods have been considered for the alternative online distribution channels.

Table 5: Return rates and modes for the different purchasing channels

	% returns in generic C&C points	% returns in parcel lockers	% returns through couriers
Home Delivery	60%	10%	30%
Click & Collect	83%	17%	-

To obtain comparable results, a purchasing profile consisting of 1,5 products per each purchase was considered in all the urban areas and for different types of purchasing processes, i.e. for both online and offline purchases. In addition, to assess the environmental impact of the retailing infrastructure, building-related consumption have been considered, according to the assumptions shown in Table 6, as a result of real context data gathered from interviews with practitioners.

Table 6: Average shop data

	Variable
Average consumption of the infrastructure [(kWh/m²)/year]	250
Average shop surface [m²]	100
Average product flow [products/year]	21.900 Hp: 60 [products/day]

5. Results discussion

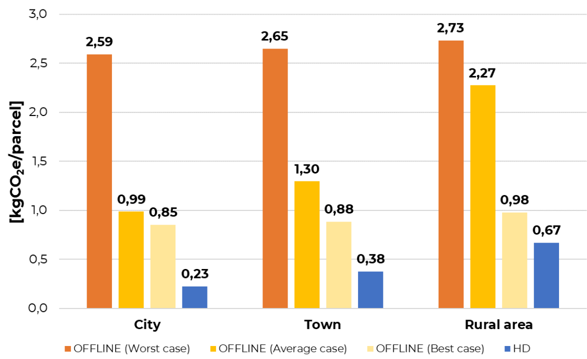
The following section is dedicated to the discussion of the most relevant insights gained from the analysis of the results, obtained by applying the model to the consumer electronics industry, using as reference database data collected by practitioners form various real cases in different areas. To thoroughly assess the carbon footprint and properly address the research questions, an analytical model has been developed. The model's architecture consists of different sections, each delving into a specific part within the system's boundaries. For the various arches and nodes that constitute the network, the consumption of different resources has been assessed, and the related emissions have been expressed in kilograms of carbon dioxide equivalents ($kgCO_2e$) with a global warming potential of 100 years.

The first part of the following section is dedicated to the discussion of the evidence gained from the comparison of the environmental impact of the Home Delivery and the traditional physical purchasing processes. Then, the second part of the section is dedicated to the analysis of the most relevant outcomes obtained by comparing the traditional Home Delivery process to the Click & Collect solution.

5.1 Home Delivery and Offline Purchases

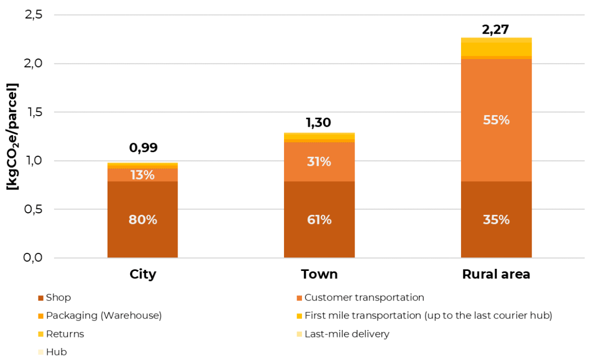
Results show that, in each of the cases analysed, thus for the various urban areas considered, the environmental impact of a purchase performed through the offline channel is significantly higher than the impact of the products bought online and distributed with Home Delivery, regardless of the type of transport mean used by the final customer (Fig. 1). Even if the population density and the e-commerce adoption rate decrease, leading to a rise of the carbon footprint released in the Home Delivery process, it still remains lower than the impact of offline purchases. Indeed, across all the different urban contexts analysed, the carbon footprint of the Home Delivery is consistently lower than the emissions generated in the best-case scenario for traditional shopping, respectively 73% lower in densely populated areas, about 57% lower in an intermediate populated area and about 31% lower in rural area. Even if the emissions related to the customer personal trip are negligible, the higher carbon footprint of traditional shopping is related to the negative externalities released by the point of sale.

Fig. 1: Environmental impact of offline purchases (Best, Average and Worst cases) and Home Delivery



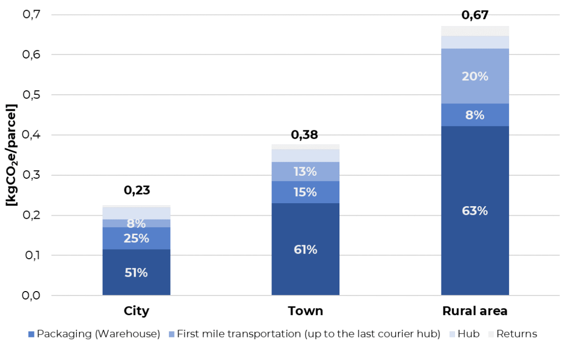
To better understand the incidence of various system components on the overall impact, it has been considered an intermediate scenario regarding the customer behaviour. In particular, assuming that the final customer uses a heterogeneous mix of transport modes to reach the shop and analysing the environmental impact generated in the different urban contexts (Fig. 2), it emerges that in densely populated and intermediate-densely populated areas the retailing infrastructure is responsible for the majority of emissions. In rural areas, instead, the contribution with the highest environmental impact is the one related to the customer's personal journey to the shop, mainly because of the greater distance that has to be covered and the lower use of public transport, due to the limited availability.

Fig. 2: Environmental impact of offline purchases (Average case) in different urban contexts



Considering the different elements responsible for the environmental impact generated in the Home Delivery process, regardless of the type of urban area, the largest carbon footprint is that of the last-mile delivery (Fig. 3). The environmental impact of the deliveries, and in particular that of the last-mile process, increases when moving from a densely populated area to a more rural one. This is due to two main factors: the lower population density and the lower penetration rate of online sales, which leads to a lower delivery density. Indeed, the areas with a lower population density are characterised by delivery tours where a greater number of kilometres are travelled, fewer stops are performed, and fewer parcels delivered. In fact, by considering the carbon footprint released in the last-mile delivery in more rural areas, these are almost three times higher than the emissions of the delivery process in the city.

Fig. 3: Environmental impact of Home Delivery in different urban contextes

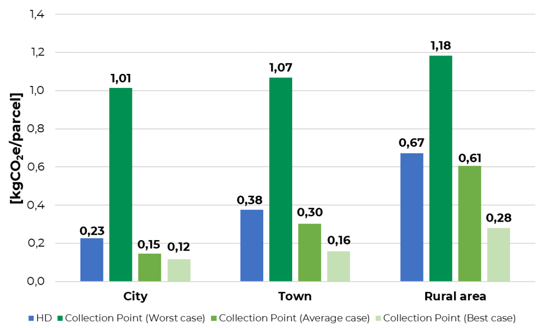


5.2 Home Delivery and Click & Collect

When comparing alternative solutions for online orders' delivery and analysing the environmental impact in a scenario where the final customers use a heterogeneous mix of transport modes, the Click & Collect solution is more sustainable than Home Delivery for all the different types of urban contexts. Specifically, comparing the emissions of a delivery in PUDOs with the ones of the Home Delivery, they are about 35% lower in densely populated areas, about 20% lower in an intermediate populated area and about 10% lower in rural area.

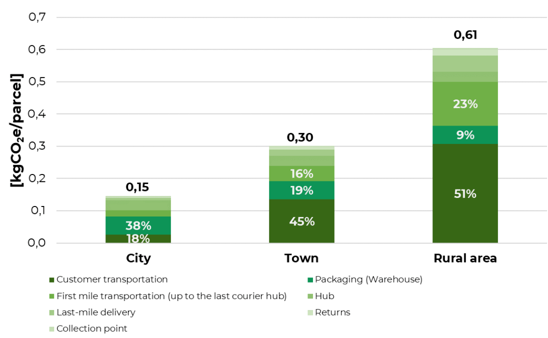
However, the emissions related to the delivery in Click & Collect points are strongly influenced by the way the customer moves to pick up the order. In the best-case scenario, where the customer walks to the facility, the emissions of a Click & Collect delivery are about half of the emissions of Home Delivery for all types of urban areas. However, in the worst-case scenario, where customers move only by car to pick-up the parcel, the environmental impact of an online order picked-up in a collection point can be almost four times greater than that of Home Delivery, as in the case of a densely populated urban area (Fig. 4).

Fig. 4: Environmental impact of Home Delivery and Click & Collect (Best, Average and Worst cases)



When considering the different elements of the distribution process, and their impact on the overall carbon footprint, their relative importance can greatly vary depending on the specific scenario considered for the customer behaviour. Analysing the incidence of the different processes considering the average scenario previously defined for customer behaviour, the main contribution to the environmental impact generated in the different types of urban areas is the customer personal journey. Therefore, this differs respect to the Home Delivery, where the main source of emissions comes from the last-mile delivery. In the case of a Click & Collect delivery the customer transport is that part of the process with the highest carbon footprint, especially in rural areas where it can account for more than 50% of the total emissions. In particular, the emissions of a parcel delivered in a collection point in a rural area are approximately four times those of a delivery in a PUDO established in a densely populated area.

Fig. 5: Environmental impact of Click & Collect (Average case) in different urban contexts



Overall, for both offline shopping and e-commerce purchases involving deliveries to pick-up points, the environmental impact generated is strongly affected by the mode of transport used by the customer, as well as by the distance travelled to go and came back, respectively, to the shop and the pick-up point. Moreover, these factors strongly vary depending on the characteristics of the geographical area considered.

Finally, it is noteworthy to highlight that, although the return rate of online purchases is about twice that of traditional purchases, respectively 6% in online and 3% in offline purchases, the overall carbon footprint increases, but does not change the relative convenience of the processes analysed. Therefore, the e-commerce is proved to be more environmentally friendly compared to the physical purchasing process, especially in the case of delivery to PUDOs.

6. Conclusions

As a result of the research, e-commerce purchases proved to be the greener shopping solution while compared with physical ones, mainly due to the avoidance of the negative externalities released by the shop and the customer's journey to go and came back from the facility. Moreover, results outline higher benefits under an environmental perspective of Click & Collect compared to the traditional Home Delivery, even though the benefit depends on the distance covered and the customer's mode of travel to the pick-up point. In fact, considering the characteristics of the delivery process in different types of urban areas, it is evident that using Collection Points is not always the most efficient solution. Among the main contributions of this research, by analysing the impact of various processes and considering the characteristics of different types of urban areas with a specific focus on Italy, it emerges that in areas characterised by a lower population density and a lower eCommerce penetration rate, delivery to Click & Collect points is not always the most environmentally friendly solution due to the negative externalities related to the customer's personal journey. Indeed, from the analysis of the emissions generated in the different phases of the distribution process, it is noteworthy to highlight the significant impact of customer journey to the shop or the collection point. The mode of transport used by the customer and the distance travelled, to and from the shop or pick-up point, are the factors with a major impact on the overall footprint generated. Therefore, it is evident the key role of customers in affecting and determining the environmental sustainability of their purchases.

To reduce the carbon footprint released in the purchasing process, it is necessary that practitioners develop proper initiatives to inform, support and empower customers to make informed and conscious choices. Indeed, environmental sustainability is a challenge that requires combined efforts of all parties involved: retailers and logistics providers offering alternative delivery solutions to the traditional ones, municipalities and public authorities developing both through cultural and political initiatives, and customers adopting a more conscious purchasing behaviour as well as for the collection of their parcels.

A further development of the research might enlarge the scope of the analysis by assessing the impact of the processes performed within warehouses. Indeed, the emissions related to warehouses, considering both the building-related and process-related consumptions, can be assessed to identify the impacts associated with the specific activities involved in preparing online orders. Nevertheless, another element that can be further analysed is the environmental impact of collection points, which in this study have been assumed to be negligible.

Moreover, future research could analyse the dimension of social sustainability, to deepen the analysis and to enrich the existing knowledge on sustainability issues. Indeed, to support the decision-making process of end-customers and suppliers, aiming to educate and empower customers while promoting sustainable behaviour across all dimensions, it is crucial to include not only the environmental and economic perspectives but also to explore the benefits from a social one.

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