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How Does Consumers' Omnichannel Shopping Behaviour Translate into Travel and Transport Impacts? Case-Study of a Footwear Retailer in Belgium

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Abstract: Retailers and consumers are increasingly "omnichannel". This means that retailers offer multiple integrated offline and online channels to their customers, while consumers use multiple offline and online channels throughout their shopping journeys. In these shopping journeys, consumers can travel for researching, testing, receiving and returning activities related to a purchase, next to the purchasing itself. It is unclear how such omnichannel consumer behaviour materialises in practice. This information is important for practitioners from retail as well as for society, not in the least because of the environmental impact that shopping trips generate. Existing environmental assessments of retail-related transport and logistics do not account for consumers' omnichannel shopping and travel behaviour. To fill this gap in research, we set up a case-study collaboration with an omnichannel footwear retailer in Belgium. We collected data on logistics and consumer flows and analysed this data to determine the CO_2 footprint. Our research results in six profiles, of which "the online shopper" that shops online and receives its purchase at home or at a collection point generates the lowest impact. However, when online shoppers travel to stores prior to their e-purchase and become "showroomers", the external CO_2 costs double compared to "traditional shoppers" that carry out all shopping activities in-store and are more than eight times higher compared to "online shoppers". Although the case-study context should be taken into account (e.g., in terms of product type, retailer type and geography), a sensitivity analysis demonstrates the robustness of our results.

Keywords: sustainability; omnichannel retail; e-commerce; consumer behaviour; transport; case-study; survey; external transport cost

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1. Introduction

Online retail has pushed traditional retailers to reinvent themselves by adding an online store to their offline activities. Also e-retailers have opened up stores and showrooms, or developed partnerships to create an offline presence [1,2]. These developments resulted in a retail model that has been termed "omnichannel retail", which implies that retailers offer various online (e.g., web and mobile shop) and offline (e.g., physical stores) channels. These channels are integrated, allowing consumers to combine different channels throughout their shopping journey and use these channels simultaneously and interchangeably. Accordingly, consumers can create a flexible, convenient and dynamic path-to-purchase that fits their preferences and needs [3].

The omnichannel path-to-purchase distinguishes five phases, reflecting the different activities that consumers carry out. These phases cover researching, testing, purchasing and receiving products, and potentially returning them [4,5]. In the process model for customer journeys developed by Lemon and Verhoef [6], researching and testing belong to the "pre-purchase stage", purchasing and receiving converge in the "purchase stage", and returning is part of the "post-purchase stage". Various channels can be used for each activity. In fact, Frazer and Stiehler [7] state that "a true omnichannel experience means that one transaction spans over more than one channel".

Omnichannel environments in which consumers shop online and offline at the same retailer are increasingly ubiquitous and omnichannel purchase experiences are now the norm [1,8]. Consumer surveys demonstrate that about 38% of US consumers [9] and 64% of Belgian consumers [10] shop in fact omnichannel. Although the omnichannel retail environment theoretically facilitates a wide variety of shopping journeys, how consumers' path-to-purchase materialises in practice is largely unclear. Hence, several researchers stressed the need to obtain better knowledge and thorough understanding of consumers' behavioural patterns and characteristics [7,11,12]. What is more, understanding these patterns allows to gain insight in the transport flows related to shopping, that induce significant environmental consequences [13–16], both locally (e.g., air pollution, congestion, noise) and globally (e.g., climate change emissions) [17]. Accordingly, environmental assessments of transport that compare the impacts of online and offline shopping do not account for the complexities created by consumers' omnichannel shopping behaviour.

To address this gap in knowledge and contribute to both research and practice, our objective is to identify (1) consumers' most common omnichannel behavioural patterns, (2) related travel behaviour by consumers and transport operations by retailers and their logistics partner and (3) the transport-related CO_2 emissions generated by the purchase. To this end, we set up a case-study with an omnichannel footwear retailer in Belgium. Data from the consumer side is collected through customer surveys, while data from the logistics side is collected through interviews and information exchange and generated by an agent-based simulation model. By combining this information, our goal is to determine the environmental impact of several omnichannel shopping journeys, by explicitly accounting for consumer behaviour as well as retail logistics.

This paper covers a review of the literature in the second section, covering consumers' omnichannel shopping behaviour as well as studies that report on the environmental impact of retail-related transport and logistics. The third section elaborates on the case-study context and our methodological approach, while the fourth section reports results. In the final section, conclusions are drawn.

2. Literature

Over the past ten years, there has been debate among researchers as to whether traditional shopping has a lower environmental impact than e-commerce or not. The environmental sustainability of retail supply chains largely depends on logistics activities [18] and transport is believed to have the biggest impact [19,20]. Although transport by both end-consumers and logistics service providers is important in such analysis [14], Van Loon et al. [21] report that consumer trips are often excluded. Moreover, virtually all studies fail to incorporate consumers' contemporary omnichannel shopping behaviour.

In this section, we review literature on environmental assessments of transport and logistics activities related to shopping, as well as literature on omnichannel consumer behaviour. On 9 January 2019, the combination of keywords "online retail", "environmental impact", "transport" and "logistics" yielded 477 results in the Google Scholar database. The combination of keywords "omnichannel retail" and "consumer behaviour" yielded 752 results. The most relevant research reports are discussed in this section. Section 2.1 discusses 21 peer-reviewed journal articles that comprehensively deal with transport and logistics related to the purchase of physical products. Section 2.2 covers a review of 24 journal and conference articles on omnichannel retail developments and how they affect consumer behaviour.

2.1. Environmental Assessment of Retail-Related Transport and Logistics

We reviewed 21 articles reporting on the environmental impact of retail-related transport and logistics. While the oldest study dates back to 2005 [22], the majority of studies was published in 2009 [23–27] and 2015 [20,21,28,29]. Apart from conceptual studies reflecting on available knowledge and literature on the topic [20,23,27,30–32], the product-specific case-study approach is common. In particular, clothing [22,33–35] and electronics [25,28,36] are investigated most. Specifically analysed in these studies are greenhouse gas emissions, carbon emissions or CO_2 emissions [19,21,26–31,33,34,36–39] and energy consumption, energy usage or energy demand [32]. Some studies analysed both [22,25,35]. All studies reflect to some extent on a combination of online and offline channels, except for two studies that consider an offline retail supply chain only [22,37].

Next to logistics transport by retailers and their logistics partners, trips made by consumers are considered in all reviewed studies. Earlier research includes trip characteristics of consumers' travel to stores, e.g., trip distances, transport modes, vehicle types (e.g., fuel mix) and trip chaining behaviour (i.e., in which travel to stores was combined with other types of travel) [22,25]. In response, Velásquez et al. [27] suggest to incorporate consumer habits and Cullinane [23] stresses the importance of taking complex and dynamic human behaviour and household travel patterns into account, particularly when analysing the environmental impact of online retail. The author refers to four effects on travel as a consequence of e-commerce: modification, generation, additional and substitutional effects, and highlights the direct effects (i.e., first order effects on travel patterns) and indirect effects (e.g., changes in household travel, residential relocation) that are in play. Weltevreden and Rotem-Mindali [24] are the first to do a combined analysis of both personal and commercial transport induced by e-commerce, to determine its net mobility effect. The authors build on a nationwide sample of e-shoppers in the Netherlands and find that online retail creates additional demand. The result is an increase in freight trips that outweighs the reduction in personal trips. When focusing on trip distance, however, the net increase of freight transport is significantly smaller than the net decrease in personal travel.

Later, researchers started to consider several side-effects of consumers' online ordering behaviour. Such side-effects include delivery failures, product returns, collection of failed deliveries [20,21,33,35,38] and even "browsing-only" shopping trips, in which consumers travel to stores for the sole purpose of product research [19,26,28,30]. Van Loon et al. [31] explicitly refer to consumer delivery preferences, in terms of speed and frequency, as a factor of importance in such studies, while the process of re-delivery as a consequence of failed delivery gained ground as well [31,32]. Yet, while knowledge of consumer behaviour grew throughout years of research, not all environmental impact studies integrate crucial travel information as introduced in this literature review [29,34,36,37,39]. Nevertheless, all studies highlight the importance of including consumer transport to the overall comparison of retail systems.

2.2. *Omnichannel Consumer Behaviour*

Five phases are distinguished in today's omnichannel path-to-purchase. These phases reflect different activities that consumers carry out and cover researching, testing, purchasing and receiving products, and potentially returning them as well [4,5]. In the omnichannel environment, various channels can be used for each activity, which is illustrated in Figure 1. Some activities are fixed, so inherent to all purchases (visualised in solid lines), while other activities are flexible and can be carried out multiple times, in the reverse order or neglected overall (visualised in dotted lines) [12].

Gathering and investigating product information can be done in-store, but today's consumers make most use of the wealth of information that is available online [40], e.g., product reviews, user testimonials, location details and pricing information. Mobile devices in particular allow to obtain pricing and product information in an easy way, whenever and wherever consumers need it [40,41].

Testing activities are traditionally associated with physical stores only. In delivering information about "non-digital attributes" (e.g., the feel of a shirt, the look of a pair of glasses), stores have a definite edge [42]. While this is true in most cases, new solutions have been created to carry out this shopping activity at home, e.g., through "test at home" or "home sampling" programs [1]. For example, when shopping for eyewear, consumers can try out several pairs using a dedicated test set and place an order for the pair they like. Also more technologically advanced solutions are gaining ground, enabling "virtual try-on" [43]. Building further on the example of eyewear, consumers can upload their picture to test out various pairs, employ digital avatars for fitting [43,44] or make use of options created by augmented reality [45].

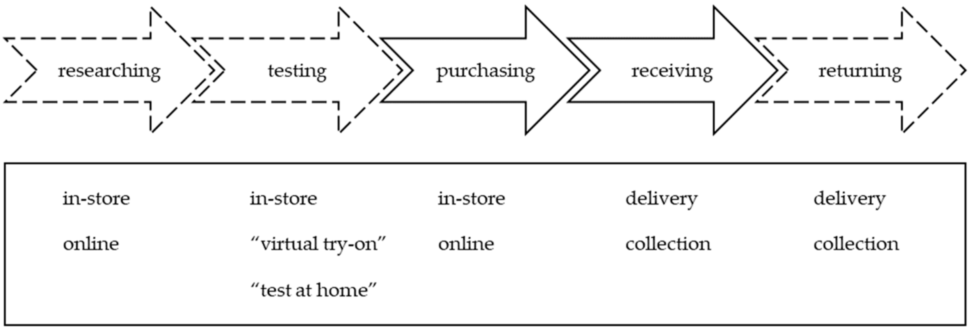

Figure 1. Five phases of the omnichannel path-to-purchase, adapted from Schoutteet et al. [4]. Arrows in solid lines represent fixed phases, arrows in dotted lines represent flexible phases.

In the omnichannel environment, retailers observe consumers' research shopping with great attention. Research shopping means that consumers research and test in one channel and purchase in another [46], and materialises in two phenomena: "showrooming" and "webrooming". When showrooming, consumers carry out research activities in-store using their smartphone, specifically looking for lower priced items online. Fulgoni [40] reports that one third of consumers have showroomed. Half of them declared that their intention always was to purchase online because of higher in-store prices, but they wanted to see the product first. The showrooming practice is critiqued widely, accusing consumers and e-retailers of free-riding [43]. Contrary, webrooming implies online research activities, while still making the actual purchase in-store [46]. Compared to showrooming, webrooming is the most common practice [9,10,47].

Purchases can be made in-store or online. In the omnichannel retail environment, the concept of "store" includes traditional shops, next to innovative initiatives, e.g., pop-up stores [48] and "showrooms" (or also termed "zero-inventory stores" or "guide shops") [8,49]. In case of shopping online, computers and tablets are common, but also smartphones have become ubiquitous, enabling shopping anytime and anywhere [45]. Responding to this on-the-go shopping behaviour, retailers implemented "virtual stores" [44], in which images of store shelves are attached in public spaces, e.g., near public transport. Consumers can scan each item using their smartphone, creating a virtual shopping cart that is delivered to their homes. Next to in-store and online shopping, purchases can also be made through a combination of both, using in-store screens [50]. Omnichannel retailers place such screens as a means of bridging their online and offline presence, extending their offline assortment with online items (also termed "virtual shelf extension") and eliminating consumers' frustration when an item is out of stock [51]. Next to screens, retailers are introducing other advanced technologies, e.g., self-service kiosks equipped with radio frequency identification (RFID) systems, digital signage, informative touch points and contactless technologies for mobile payments [52].

Consumers receive their purchases in retailers' stores when the product is purchased offline, but stores also serve as collection points for online purchases. This practice has been termed "click-and-collect" [53] or "BOPS", which stands for "buy-online-and-pickup-in-store" [43]. Omnichannel retailers can use their store network as collection point in two ways: via "site-to-store" in which the online order is supplied from the distribution centre and sent to the store, or via immediate pick-up in-store in which the online order is picked from the store's shelves or stock [51]. However, when products are bought online, the majority of consumers prefers delivery to home or work, making last mile transport a vital part of consumers' shopping journey [2]. These deliveries can be sourced from three types of location: retailers' distribution centre, retailers' supplier by means of drop-shipping and retailers' store [53,54]. Logistics service providers that carry out these home (or work) deliveries offer collection points as well. Such collection points are either attended or unattended. Attended collection points are existing local stores following a shop-in-shop concept, while unattended collection points are automated lockers that are accessed through quick response (QR) codes, or similar solutions [51]. Because of this variety of reception options, adequate and efficient distribution systems are key in omnichannel retail [53,55].

Depending on the product type, a significant share of orders are returned. Product returns, often approaching 30%, and as high as 40% for clothing retailers, are a major burden for retailers [49]. Accordingly, returns management has become a top priority for many retailers [56]. Returns can be collected at consumers' homes or workplaces. In most cases, however, consumers take faulty or unwanted products to drop-off points like attended collection points, lockers or retailers' stores. Particularly when omnichannel retailers have a limited coverage of stores, they partner with logistics service providers with a dense network of collection points to extend their reach [57].

In the omnichannel environment, consumers pass through consecutive path-to-purchase activities, particularly in case of well-considered purchases, such as electronics or "fit critical" fashion items. This leads to highly personal and tailored shopping journeys, on which limited knowledge exists. Accordingly, transport induced by such omnichannel consumer behaviour is not or hardly incorporated in existing studies that assess the environmental impact of shopping [19,33]. Nevertheless, whether traditional shopping has a lower environmental impact than e-commerce or not, largely depends on the trade-off between consumer and commercial transport flows [58]. Our aim is to contribute to literature and practice, by investigating omnichannel shopping and travel behaviour across all phases of the path-to-purchase and explicitly incorporating this knowledge into an environmental impact assessment of retail-related transport and logistics.

3. Materials and Methods

3.1. Case-Study

To address our research objective, we set up a case-study with an omnichannel footwear retailer. This retailer is leading the omnichannel development in Belgium (as acknowledged by several achievement nominations and awards), while also actively pursuing a sustainability agenda that includes both people and planet focused initiatives. In terms of omnichannel retail, the Belgian market stands out. Together with the UK and the Nordic regions, these markets show the most advanced use of mobile channels, channel integration and data analytics [59]. Footwear is a "considered purchase" or "experience good", where consumers feel the need to touch and feel before buying [32]. It is also a homogeneous product category, meaning that several physical characteristics, such as size and packaging, are shared among the products. According to Edwards et al. [30], "the more homogeneous the category, the easier it will be to compare channels on a consistent basis". The case-study method, as applied in this research, is a comprehensive research strategy [60], suitable when "how" and "why" questions are asked in emerging fields of research [60,61]. In omnichannel retail research, the case-study approach is common. See for example [1,8,42,43,48].

The footwear retailer launched its online store in 2012 and evolved towards an advanced, integrated omnichannel model in the following years. Currently, the retailer disposes of about seventy stores, spread across the north of Belgium (i.e., Flanders). Each store serves as collection point for pick-up and return of online orders, holds inventory for in-store customers and offers in-store virtual screens that extend its assortment. Next to providing store information, the retailer's website features a web-shop. This web-shop offers the possibility to check product availability in-store as well. Delivery options for online orders are in accordance with offerings from leading online-only retailers: free, next day delivery to any address in Belgium, any of the collection points offered by the retailer's last mile logistics partner and any of the retailer's stores. Evening and weekend deliveries are optional at a surcharge. At the time of research, the retailer allocates 15% of its turnover to online sales, processes on average 2200 parcels a day and deals with a product return rate of 20%.

3.2. Data Collection

We collected logistics data by means of an exploratory semi-structured interview with the retailer's logistics manager and sales manager (on 9 September 2017) and consecutive information exchange with the logistics manager and a representative of their last mile logistics partner (in June 2018, July 2018 and January 2019). In this way, we gained insight in the retailer's omnichannel performance (e.g., online sales, last mile options, return policy) and logistics operations (i.e., fulfilment, internal transport, last mile transport). We set our system boundaries accordingly, starting from the retailer's centralised and integrated distribution centre as point of divergence to consumers' homes, while ending back at the distribution centre in case of returns.

We collected consumer data by means of an online survey, preceded by a meeting with the retailer's e-commerce manager and chief digital officer (on 8 August 2019). The survey was designed in Qualtrics software and spread among 80,000 customers who made a purchase after 15 August 2018. The retailer sent out the survey invitation with link to the software on 31 October 2018 (to 20,000 customers) and 13 November 2018 (to 60,000 customers).

As secondary data sources (e.g., household surveys) provide only limited information on consumer behaviour, surveys are essential to understand and map consumers' shopping journeys [6,30]. To this end, the survey consists of seven parts: an introduction, questions about their last product purchase, questions about reception of that purchase, questions about related research activities, questions about related testing activities, questions about a potential return and several socio-demographics. In the introduction, we briefly introduce the scope and purpose of our study and notify the estimated time to complete the survey (i.e., approximately ten minutes). Socio-demographic questions include age, gender, household situation, education, income, vehicle access and a five-point Likert-type scale on the extent to which environmental impact is considered when purchasing. The remaining five parts survey each activity of the omnichannel path-to-purchase. For each activity that is executed offline (if any, in case of researching and testing), we ask for the location by means of a drop-down store selection or postal code text box and query related travel details. Requested travel details are time and day of transport, transport mode and trip chaining. The latter is presented as a list of activities derived from the Belgian Daily Mobility study (http://www.beldam.be/). For each activity selected as part of the chained trip, we ask for the postal code as well.

In total, 707 surveys were completed, resulting in a response rate of 0.88%. Low response rates are not uncommon in scientific research, especially for surveys administered online [62]. Several factors that impact on response rates are discussed in literature, including survey length, respondent contacts, compensation and salience [62]. Although most respondents filled in our survey in less than ten minutes (six minutes on average), parts of the survey made it demanding to complete (e.g., postal code questions). Moreover, customers only received the invitation once and were not offered any kind of compensation. Nonetheless, it has been demonstrated that nonresponse rate by itself is inadequate in predicting response bias [63]. When comparing our sample to the population of customers, both are spread in terms of age and geography, while women are overrepresented (90.2% in sample and 92% in population).

3.3. Data Analysis

Analysing the data, we aimed to identify (1) consumers' most common omnichannel behavioural patterns, (2) related travel behaviour by consumers and transport operations by retailers and their logistics partner and (3) the transport-related CO_2 emissions generated by the purchase. For consumers' omnichannel shopping and travel behaviour, we applied statistical package SPSS using simple statistics (e.g., frequencies, cross-tabulation, chi-square tests). Based on literature and survey results, we allocated all respondents into six omnichannel shopping behaviour profiles and determined typical travel behaviour for each profile, focusing on trip distance covered and transport mode used. In line with literature, we calculated trip distance on the basis of home-based trip chains, in which trips start and end at home [64]. When the shopping activity trip was complemented with other activities, only a share of total trip distance should be allocated to the shopping activity [30]. Different approaches are found in literature to determine this share. Browne et al. [22], for example, assume that trips have two purposes and allocate half of the trip's energy use to the shopping activity. Edwards and McKinnon [26] allocate a quarter of total distance to shopping and Wiese et al. [33] include only trips in which shopping was the main reason. A commonly accepted approach lacks [64,65]. In this research, total trip distance was determined by respondents' home postal code, store location and activity postal code. Similarly to Brown and Guiffrida [38], Google Maps was used to route the quickest trip between addresses and postal codes. Total trip distance for the shopping activity is determined by dividing total trip distance by the number of activities accomplished in that trip. Consumers walking or cycling do not generate CO_2 emissions but are relevant shopping trips and are therefore included in the analysis. Trips taking place within the same postal code zone ("intrazonal trips") allow only limited precision and lead to significant inaccuracies [66]. In this research, we allocated a distance of two kilometres to intrazonal trips (four kilometres round-trip), based on the average size of postal code zones in Flanders.

Then we assess the environmental impact. Generally, such assessments were derived from a conversion of distances into greenhouse gas emissions (mainly CO_2) or pollutants (e.g., NOx and PM10) [67]. In this research, we focused on external transport costs generated by CO_2 emissions, the common approach in this stream of research (see literature review). As stated by Bickel and Friedrich [68], "an external cost arises when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted or compensated for, by the first group". We calculate this externality based on best practices for marginal external cost calculations currently available in economic literature.

For consumer trips, we derive transport distances from the survey and apply spreadsheet software Excel for calculations. Logistics trips were simulated via the TRABAM freight transport model [69]. This Transport Agent-BAsed Model uses the open-source software MATSim [70] and is based on the work of Schröder and Liedtke [71] and Schröder et al. [72]. It optimises the daily transport operations from a carrier perspective via an iteration process that differentiates departure time, vehicle choice, routing and stop sequence. Two agents are addressed: the retailer that optimises its store-bound transport and its logistics partner that performs the transport flows towards collections points and homes. The following information is known for each agent: vehicle fleet, volume per destination and distribution centre locations. Agents make day-plans that aim to deliver all goods at their destinations. To this end, agents choose vehicle(s), departure time per vehicle, stop sequence per vehicle and routing. They perform their plan on the transport network, simultaneously with other agents and passenger cars, which allows to include congestion. Then, day-plans are scored according to their economic success. This information is saved and used to adapt next day-plans. A new iteration starts, is scored and compared to previous scores. Continuing this process allows agents to learn from previous iterations and plan towards a near optimal day-plan. This output is used for analysis.

Three types of logistics flows are simulated. First, the deliveries of parcels to the retailer's stores. They account for 20% of the online volume and are consolidated on the same vehicle that is supplying the stores with replenishment stock. These transport operations are done by truck, delivering on average seven shops per roundtrip. We assumed that all shops represented equal volumes. The second flow consists of parcels going to collection points and individual homes. They account respectively for 20% and 60% of the online volume. The parcels in these flows are transported from the retailer's distribution centre to the logistics partner's distribution centres first, which is assumed to be dedicated transport by truck. From the four logistics distribution centres of the logistics partner, parcels are consolidated and transported to local distribution centres, also by truck. The last mile to collection points and homes, starts from these local distribution centres and is performed by vans. The retailer's volume represents less than 1% of the entire volume of the logistics partner. Therefore, the logistic partner consolidates this volume with volume from other retailers to perform optimised local delivery tours. In our analysis, logistics transport is included for products bought and picked-up in-store, as well as for products delivered to consumers' home, neighbour, work or collection point.

It is an approximation to calculate CO_2 emissions based on road distance, though Carling et al. [28] demonstrated that it is a fairly good one. CO_2 emission factors and monetary values are derived from international reports [73–75]. In this way, we estimate the external transport cost for several omnichannel shopping journeys, reflecting in a comparative way on the environmental burden generated by each journey.

4. Results

The following section describes the case-study findings in three parts: first we discuss the results from the survey that reflect on consumers' omnichannel shopping behaviour. We create six path-to-purchase profiles in which we subdivided our sample of consumers. Second, we complemented each profile with travel information, including trip distances, trip chains and modal choice. Combining consumers' travel information together with logistics data from the retailer and the retailer's logistics service provider allows to calculate comprehensive transport impacts for each profile, which we reflect on in the third part.

4.1. Omnichannel Shopping Behaviour

Combining literature and survey results, we derived six omnichannel shopping behaviour profiles, as visualised by Figure 2. Although there is no such thing as "typical" shoppers [19], specific multichannel segments can be identified that differ in terms of consumer characteristics [6]. Segmentation among consumers is essential in this type of research [30]. Our profiles are structured based on two axes: whether consumers address only one channel type (single channel) or multiple channel types (omnichannel) throughout their shopping journey and whether consumers purchase their product online or offline.

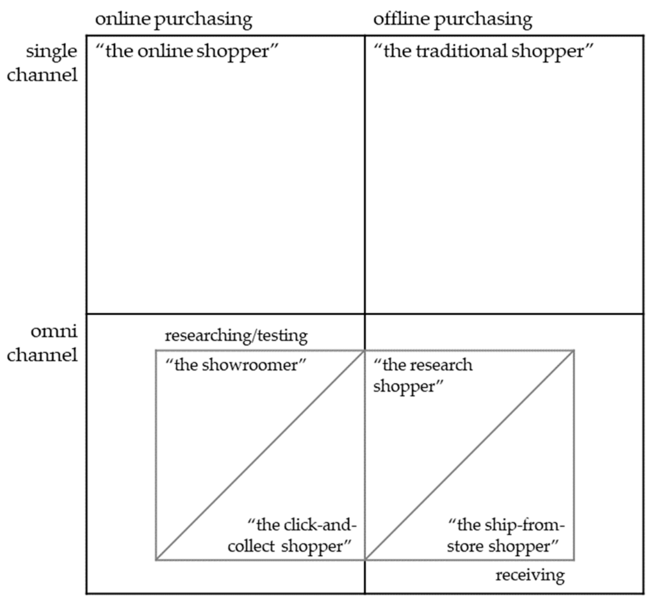

Figure 2. Six omnichannel shopping behaviour profiles.

Single channel shoppers are captured in "the online shopper" profile that buys online and "the traditional shopper" profile that buys offline. Any pre-purchase activities "online shoppers" engage in are solely on the internet, while "traditional shoppers" research and test in the store of purchase. "Online shoppers" receive their order at a location of choice, while "traditional shoppers" take their purchase home from the store in which they bought it. In case of omnichannel shopping, we separated pre-purchase activities from receiving activities [6]. Specifically, online purchases complemented with offline researching and/or testing activities are captured in "the showroomer" profile, while online purchases that are picked up in-store are captured in "the click-and-collect shopper" profile. Offline purchases in-store that are complemented with online research belong to "the research shopper" profile, while in-store purchases that are delivered to consumers instead of taken home belong to "the ship-from-store shopper" profile.

Whether consumers actually returned their purchase or not, is not taken into consideration in this analysis. Sold products can be returned within fourteen days. As some respondents received the survey closer to the day of purchase, we did not include it as a question in our survey (although we did probe for their intentions in terms of return location and transport mode in case of return).

Classifying all consumers into the six identified omnichannel shopping behaviour profiles, indicates large differences among the profiles. Figure 3 illustrates the shares of consumers belonging to each of these profiles.

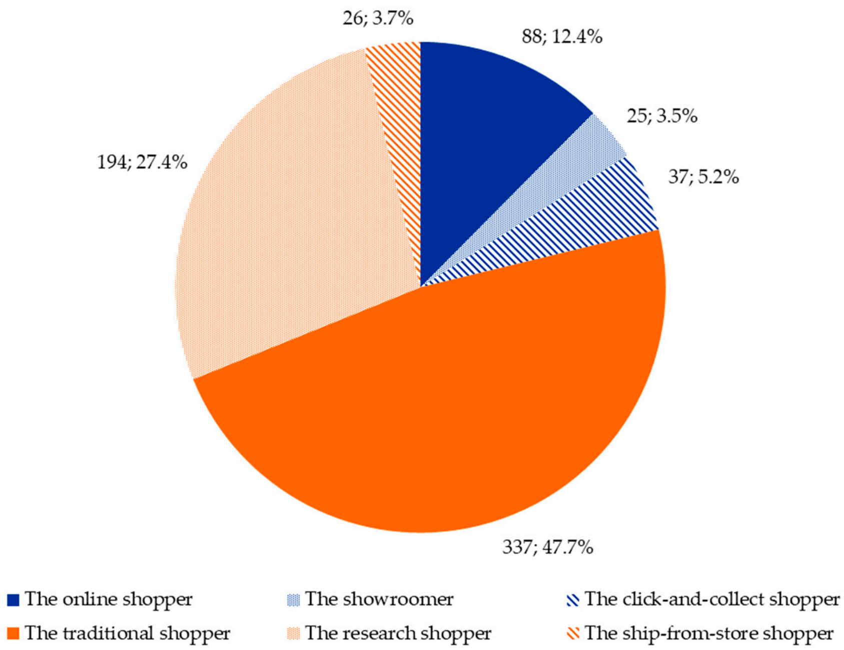

Figure 3. Classification of consumers into omnichannel shopping behaviour profiles.

What is clear from the analysis, is that stores are still by far the most popular location for purchasing, despite strong e-commerce developments. While 78.8% (n = 557) of consumers went to a store, 21.2% (n = 150) made their purchase online. Among the "traditional shoppers", the majority (71.5% or n = 241) did not do any research activities in-store but did engage in testing activities (60.8% or n = 205). Among all "online shoppers", almost half (43.2% or n = 38) did not perform research activities. From the ones that did, the majority (72% or n = 36) mentioned the retailer's website. Only 4% (n = 2) refers to another website and 24% (n = 12) did not specify. Most "online shoppers" received their order at home (76.1% or n = 67) or alternatively at work (9.1% or n = 8), at a collection point (13.8% or n = 12) or at a collection point after an unsuccessful delivery attempt at home (1.1% or n = 1). More than "traditional shoppers", "online shoppers" prefer a collection point over stores for potential product returns: half (48.9% or n = 43) of "online shoppers" compared to 7.4% (n = 25) of "traditional shoppers". In comparison, 92.6% (n = 312) of "traditional shoppers" would return their product in one of the retailer's stores.

Most shoppers in our sample are single channel shoppers: 60.1% (n = 425) of consumers reported to have used only one channel type during their shopping journey, while 39.8% (n = 282) referred to multiple channel types. Among the omnichannel shoppers, most common was to combine an in-store purchase with pre-purchase activities in another store or online. Accordingly, approximately one fourth (27.4% or n = 194) of consumers identified as "research shoppers". Of these consumers, 20.1% (n = 39) travelled to a store for research and 20.6% (n = 40) travelled to a store for testing prior to travelling to the retailer's store to make the final purchase. Most (89.2% or n = 173) "research shoppers" prefer to return their purchase in one of the retailer's stores, when needed. Next to pre-purchase activities, consumers can add channels to their shopping journey for post-purchase activities as well. For "ship-from-store shoppers", this entails buying a product in-store but receiving it another time, instead of taking it home after purchase. This profile represents 3.7% (n = 26) of consumers and typically occurs when consumers used the retailer's in-store screen (80.8% or n = 21). To obtain their product, most of these consumers pick it up in-store (57.7% or n = 15) or get it delivered at home (30.8% or n = 8). Also "ship-from-store shoppers" prefer in-store returns over return at collection points (84.6% or n = 22).

Omnichannel shoppers that buy online but travel for pre-purchase or receiving activities include "showroomers" that represent 3.5% (n = 25) and "click-and-collect shoppers" that represent 5.2% (n = 37). From all "showroomers", three-quarters (76% or n = 19) visited an additional store for research activities and the majority (68% or n = 17) for testing. Almost half (44% or n = 11) of the "showroomers" declared to have made separate trips for both researching and testing. The majority (68% or n = 17) of "showroomers" prefers to return their product in-store, while one-third (32% or n = 8) preferred a collection point. All "click-and-collect shoppers" made their purchase online and picked up their product in-store. Most of them (97.3% or n = 36) would also opt for a store to return the product, if needed.

We used cross-tabulation and chi-square tests to determine whether there were significant differences between specific omnichannel shopping behaviour profiles. In terms of socio-demographic information (i.e., age, gender, household situation, education, income, and vehicle access), we found no significant differences among the six profiles. We also checked for socio-demographic differences between single channel and omnichannel shoppers and between online buyers and offline buyers but found only weak associations at best. Possibly, omnichannel behaviour was determined more by situational factors (e.g., product type, specific need, available time) than by socio-demographic characteristics. Significant differences were found at a more general level. Analysis of survey responses shows that consumers that purchased online are more likely to visit stores for researching (p = 0.003) and testing (p = 0.004) activities, as compared to consumers that purchased in-store. This is important, as it challenges the notion that online shopping and home delivery replace consumer trips. Online buyers are also more likely to use the internet for searching product-related information (p = 0.000). In case of returns, e-purchases are more likely to be returned at a collection point, while in-store purchases are more likely to be returned at the retailer's stores (p = 0.000).

4.2. Omnichannel Travel Behaviour

We collected travel information for all shopping activities and for all omnichannel shopping behaviour profiles. The distance that consumers travel proved to be highest for purchasing trips (median = 18.5 km), followed by researching (median = 15.0 km), testing (median = 14.4 km) and receiving trips to stores or collection points (median = 10.1 km). Distance for returning trips is the lowest (median = 9.9 km). These distances are in line with similar research, e.g., Browne et al. [22] apply a distance of 11 kilometres for the UK and 15 kilometres for France (covering shopping and another activity), and Edwards et al. [19] assume dedicated car-trips of 12.8 miles or approximately 20 km for the UK. Indeed, trips do not consist of shopping activities only. On average and across all shopping activities (except for returning), 66.7% of consumers chain other activities to shopping. Purchasing trips combine most activities (mean = 3.2; median = 2), followed by receiving (mean = 3.0; median = 2) and researching (mean = 2.4; median = 2) trips. Testing trips are combined with the lowest number of activities (mean = 2.0; median = 2). Significant differences were only found between purchasing trips and pre-purchase trips, using the Wilcoxon signed rank test (p = 0.008 for researching and p = 0.010 for testing). Activities that are most popular to combine with pre-purchase and purchase activities are leisure shopping and grocery shopping. Receiving activities, in which orders are picked-up in-store or at a collection point, are combined most with travel for groceries and home–work commute.

To allocate a specific distance to the shopping activities considered in this research, each respondent's total trip distance was divided by the number of additional activities. The result was a different picture than presented at the beginning of this section. Distance differences among shopping activities are less articulate. Researching (median = 5.7 km), testing (median = 7.9 km), purchasing (median = 8.2 km) and receiving (median = 6.0 km) activities cover similar distances, while returning activities' distance were now the highest (median = 9.9 km). The latter is due to the fact that no trip chaining information could be collected for this activity. While the Wilcoxon signed rank test demonstrated significant differences between trip distances without taking trip chains into account, now only differences in distance between returning activities on the one hand and purchasing (p = 0.000) and receiving (p = 0.005) activities on the other hand are found significant.

Most trips are done by car. On average, 81.6% of consumers use cars for their shopping activities, which is in line with related European studies [19,23]. Bikes are the second most used transport mode, representing 12.4% on average. These findings hold for all shopping activities, although a significant difference was found between purchasing and returning activities: cars were used more for purchasing and less for returning (p = 0.001 using the Wilcoxon signed rank test).

When looking more closely to the identified omnichannel shopping behaviour profiles, we detect differences among shopping distances that each profile covers, although no statistically significant differences could be found. Table 1 provides an overview of mean (μ), median (Q2) and quartile (Q1, Q3) distances and transport modes. For receiving and returning activities, we added information on location as well.

Table 1. Travel information for all omnichannel shopping behaviour profiles.

	The Traditional Shopper	The Online Shopper	The Research Shopper	The Ship-from-Store Shopper	The Showroomer	The Click-and-Collect Shopper
Researching						
Mode			Car 87.2% Bike 10.3% Foot 2.6%		Car 78.9% Bike 15.8% Foot 5.3%	
Distance			μ = 12.1 km Q1 = 2.5 km Q2 = 4.6 km Q3 = 16.9 km		μ = 12.4 km Q1 = 2.6 km Q2 = 7.7 km Q3 = 13.1 km	
Testing						
Mode			Car 80% PT 5% Bike 12.5% Foot 2.5%		Car 82.4% Bike 11.8% Foot 5.9%	
Distance			μ = 13.6 km Q1 = 4.0 km Q2 = 8.4 km Q3 = 21.5 km		μ = 7.9 km Q1 = 4.0 km Q2 = 6.5 km Q3 = 14.1 km	
Purchasing						
Mode	Car 81% Van 0.3% PT 2.4% Moped 0.6% Bike 11.3% Foot 4.5%		Car 87.1% PT 1% Bike 10.3% Foot 1.5%	Car 92.3% Bike 7.7%		
Distance	μ = 13.3 km Q1 = 3.9 km Q2 = 8.1 km Q3 = 16.5 km		μ = 11.8 km Q1 = 4.1 km Q2 = 8.0 km Q3 = 15.4 km	μ = 10.8 km Q1 = 4.4 km Q2 = 8.8 km Q3 = 15.5 km		

Table 1. *Cont.*

	The Traditional Shopper	The Online Shopper	The Research Shopper	The Ship-from-Store Shopper	The Showroomer	The Click-and-Collect Shopper
Receiving						
Location		Home 76.1% Work 9.1% CP 14.7%		Home 30.8% Work 3.8% CP 7.7% Store 57.7%	Home 68% Work 16% CP 16%	Store 100%
Mode		Car 76.9% Bike 7.7% Foot 15.4%		Car 82.4% Bike 17.6%	Car 75% Bike 25%	Car 81.1% Van 2.7% Bike 10.8% Foot 5.4%
Distance		μ = 5.3 km Q1 = 2.0 km Q2 = 4.0 km Q3 = 7.8 km		μ = 10.8 km Q1 = 2.8 km Q2 = 8.5 km Q3 = 15.1 km	μ = 3.8 km Q1 = 2.0 km Q2 = 3.0 km Q3 = 6.4 km	μ = 9.7 km Q1 = 2.9 km Q2 = 7.1 km Q3 = 11.7 km
Returning						
Location	Store 92.6% CP 7.4%	Store 51.1% CP 48.9%	Store 89.2% CP 10.8%	Store 84.6% CP 15.4%	Store 68% CP 32%	Store 97.3% CP 2.7%
Mode	Car 77.2% Van 0.3% PT 2.1% Moped 0.3% Bike 14.8% Foot 5.3%	Car 72.7% PT 2.2% Bike 19.3% Foot 5.7%	Car 82% PT 2.5% Bike 12.9% Foot 2.6%	Car 84.6% Bike 15.4%	Car 80% Bike 12% Foot 8%	Car 78.4% Van 2.7% Bike 10.8 Foot 8.1%
Distance	μ = 14.3 km Q1 = 4.2 km Q2 = 10.2 km Q3 = 19.7 km	μ = 9.3 km Q1 = 4.0 km Q2 = 4.0 km Q3 = 12.2 km	μ = 13.3 km Q1 = 4.7 km Q2 = 11.0 km Q3 = 19.0 km	μ = 12.2 km Q1 = 4.0 km Q2 = 8.9 km Q3 = 19.7 km	μ = 10.0 km Q1 = 4.0 km Q2 = 6.8 km Q3 = 12.6 km	μ = 11.5 km Q1 = 5.4 km Q2 = 8.8 km Q3 = 14.9 km

μ = mean distance. Q2 = median distance. Q1 and Q3 = quartile distances. PT = public transport (i.e., bus or tram). CP = attended or unattended collection point.

4.3. Omnichannel Travel Impacts

This section reflects on the external CO_2 costs caused by all transport activities. These calculations are built on consumer trips and logistics transport. We use median distances for consumer trips, as mean distances are impacted by outliers. Such outliers are created by recreational trips in which shopping is assumed to be a secondary activity (e.g., visits to friends, daytrips to the seaside). In this way, we include transport flows from the retailer's distribution centre to consumers' homes, and back in case of returns. Accordingly, Figure 4 reports the external cost for CO_2 emissions for one purchase, generated by the shopping journeys of each omnichannel shopping behaviour profile. Costs due to return are added as well, although only 20% of purchases were returned.

In line with common findings in literature [32], "the online shopper", that buys online and receives its purchase at home or at a collection point, generates the lowest environmental impact. Taking only logistics trips into account, collection points are most favourable from an environmental point of view. This is, however, counterbalanced by consumers' collection trips, which are done by car in the majority of cases. This finding holds as well for "the ship-from-store shopper" and "the showroomer". The difference in external CO_2 costs between "the online shopper" and "the click-and-collect shopper" stands out. This profile shops online as well but visits one of the retailer's stores for product reception. In this way, the analysis confirms that passenger trips are less efficient and thus more harmful as compared to logistics trips. Several aspects are of essential importance to this result. First, efficiency and size of the logistics partner that carries out these last mile deliveries, as Kellner and Igl [37] found. The retailer in this research collaborates with the largest logistics player in the Belgian business-to-consumer parcel market. Switching to another player most likely increases external last mile transport costs. Second, consumers' attitude towards home delivery, as delivery failure was reported only twice in our sample (0.3%). This figure is in contrast with percentages found in literature on product deliveries that fail, e.g., 25% in the Netherlands [76] and 2% to 30% in the UK [77].

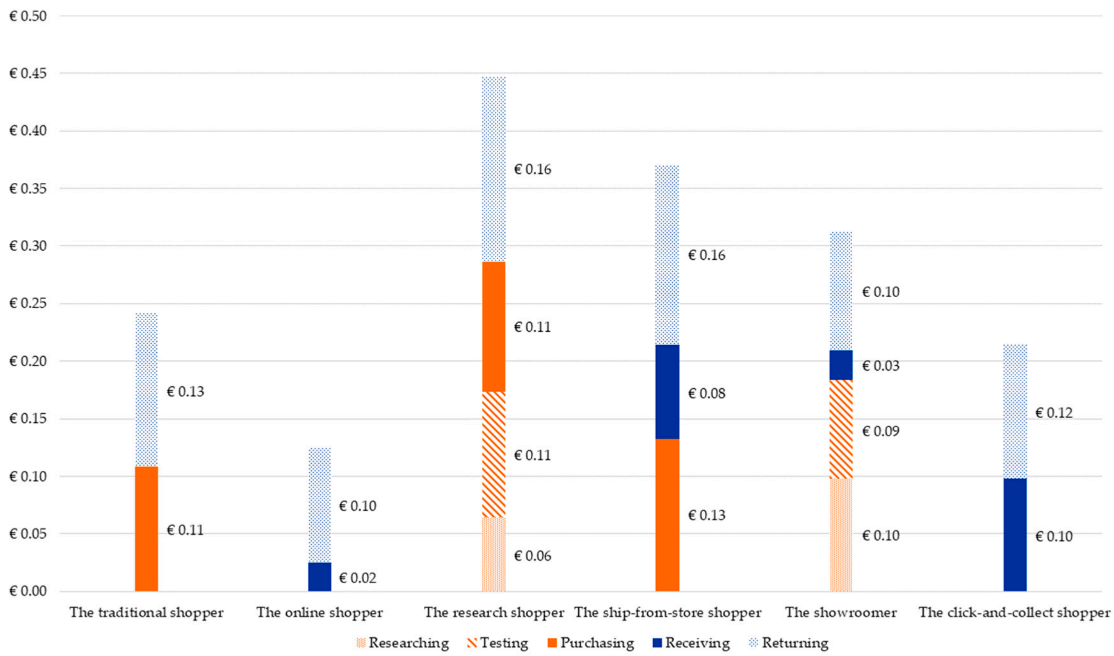

Figure 4. Total external transport cost for CO_2 emissions per omnichannel shopping behaviour profile.

Comparing the environmental impacts of "the online shopper" and "the showroomer" demonstrates the importance of considering consumers' pre-purchase trips, supporting the claim we put forward in this research. Both profiles shop online and receive their purchase at home or at a collection point but "the showroomer" makes additional trips for researching the market and testing available products. Therefore, the external CO_2 costs generated are more than eight times higher than the costs generated by "the online shopper" and double those generated by "the traditional shopper" (excluding returns). These findings nuance common claims that online shopping outperforms offline shopping in terms of environmental impact. In fact, it shows that when stores serve as "one-stop-shops", in-store shopping is preferred over e-shopping with additional pre-purchase and/or receiving trips to stores. Such "one-stop-shops" allow consumers to carry out all activities of the shopping path-to-purchase. Evidently, the contrary is true when in-store shoppers carry out additional trips for researching, testing and receiving, as demonstrated by "the research shopper" and "the ship-from-store shopper" profiles. "Research shoppers" make the most trips and accordingly generate the highest external CO_2 costs, while "ship-from-store shoppers'" impact is high because the retailer's store is often visited twice.

Differences in external CO_2 costs due to potential returns are explained by consumers' return location of preference. Profiles that prefer collection points, such as "the online shopper" (48.9%) and "the showroomer" (32%), cover shorter distances then profiles that prefer stores for returning products (e.g., "the traditional shopper" (92.6%) and "the click-and-collect shopper" (97.3%)). Nevertheless, we have no information on trip chaining behaviour for the return activity. Combining several activities on longer trips could outbalance the large differences between distances covered for each return location.

Distances covered by consumers greatly influence the outcome of the analysis. In this research, we determined the distances based on store locations and respondents' stated activities and postal codes. For intrazonal trips (i.e., trips within the same postal code), we assumed a round-trip of four kilometres. To shed light on how this situational factor influences the outcome of our comparison, we perform a sensitivity analysis. This analysis extends the findings reported in Figure 4, that are based on median distances (Q2), with lower quartile (Q1) and upper quartile (Q3) distances. Figure 5 visualises the result of the sensitivity analysis.

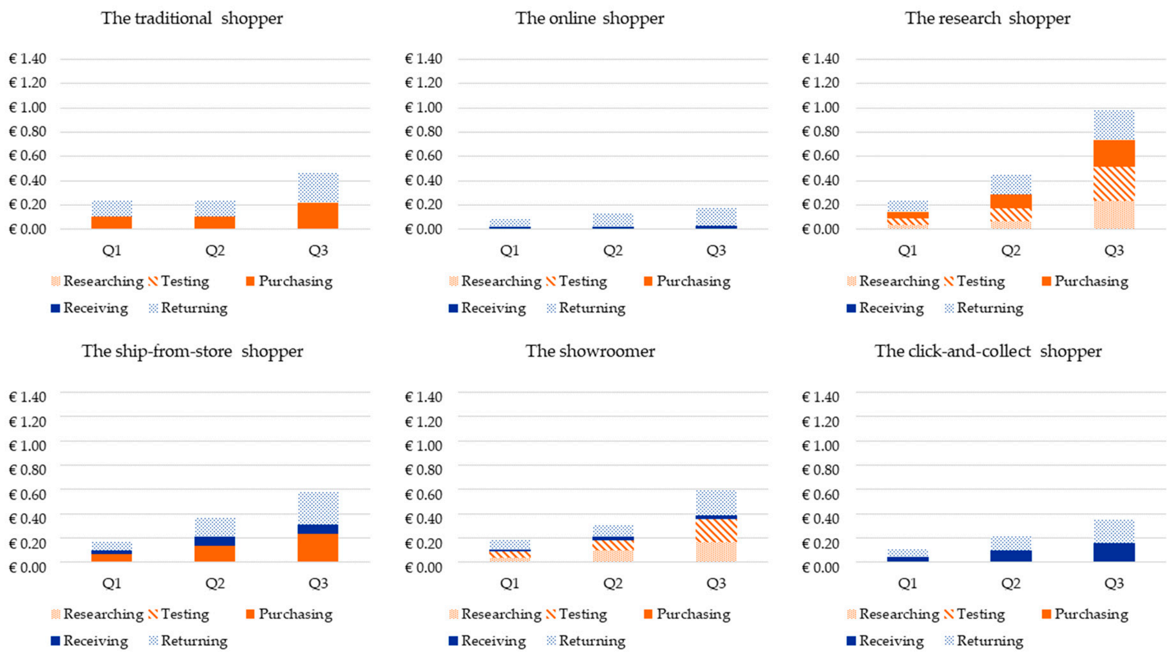

Figure 5. Sensitivity analysis on total external transport cost for CO_2 emissions per omnichannel shopping behaviour profile.

The sensitivity analysis confirms and supports the conclusions that can be derived from Figure 4. In line with these results, we find that "the online shopper" produces the lowest external CO_2 costs, followed by "the traditional shopper" and "the click-and-collect shopper", while "the research shopper" generates the highest impact. Overall, receiving trips remain similar across all scenarios because logistics trips and distances covered to and from collection points are stable. In comparison, distances for store-bound trips are subject to a lot more variation. This is true for all types of shopping activity.

The results from this case-study are based on data from an omnichannel retailer, its logistics partner and customers, and are tested through a sensitivity analysis. While our results are robust, it is important to consider the case-study context, in which we focus on a specific product type (i.e., shoes), a specific geographical situation (i.e., north of Belgium), a specific retailer (i.e., established Belgian omnichannel retailer that developed from a store-based model), a specific logistics partner (i.e., largest logistics service provider in the Belgian business-to-consumer parcel market) and a specific point in time (i.e., 2018). Previous research has found such contextual factors to be important [2,12,25,30,57]. Accordingly, these factors outline the generalisability of our research results. Moreover, indirect impacts arising from online and omnichannel retail developments, e.g., changes in supply chain configuration, retail structure and net transport effects, are excluded from the analysis. Nevertheless, some key learnings emerge from this case-study research that reflect on reducing the environmental impact of omnichannel retail transport. These learnings are listed in Table 2 as opportunities for retailers, consumers and logistics service providers. Conflicts with business goals are, however, possible: e.g., attracting consumers to stores instead of collection points, locations that are attractive for soft modes allow less storage space for enabling "one-stop-shops" while locations that allow more storage space attract car-based travel.

Table 2. Opportunities to reduce the environmental impact of omnichannel retail transport.

Retailers	Consumers	Logistics Service Providers
Adapt store infrastructure and store locations to facilitate sustainable transport modes.	Use sustainable transport modes for all shopping activities, especially for shorter trips.	Increase use of sustainable vehicle types.
Stimulate stores as “one-stop-shops” for all pre-purchase and purchase activities.	Chain activities to shopping trips.	Increase delivery efficiency.
Enhance online channels to facilitate pre-purchase activities online.	Combine shopping activities in one trip.	Increase collection point density and flexibility.
Provide and stimulate longer delivery terms to foster consolidation.	Avoid short delivery terms.	Create programmes to avoid delivery failure.
Encourage reception and return in collection points.	Select collection point delivery.	
Collaborate with the most efficient logistics partner for last mile deliveries.	Avoid product returns.	

5. Conclusions

Retailers and consumers are increasingly “omnichannel”. This means that retailers offer multiple integrated offline and online channels to their customers, while consumers use multiple offline and online channels throughout their shopping journeys. Next to making a purchase and receiving it, such shopping journeys cover trips for researching, testing and returning activities as well. How this omnichannel shopping behaviour materialises in practice, is unclear. As a result, it is largely omitted in studies assessing the environmental sustainability of retail supply chains, despite its importance. This study aims to fill this gap in research. Our objective is to determine the environmental impact of several omnichannel shopping journeys, by explicitly accounting for consumer behaviour as well as retail logistics. To this end, we set up a case-study with an omnichannel footwear retailer in Belgium. This case-study enables us to calculate the CO_2 footprint for several omnichannel shopping journeys, by combining information on consumer behaviour (collected through an online survey) and logistics information (collected through interviews and information exchange with the retailer and its logistics partner and generated by an agent-based simulation model).

From our analysis, we derived six omnichannel shopping behaviour profiles: two types of single channel shoppers (“the online shopper” and “the traditional shopper”), two types of omnichannel shoppers that purchase in-store (“the research shopper” and “the ship-from-store shopper”) and two types of omnichannel shoppers that purchase online (“the showroomer” and “the click-and-collect shopper”). Yet, single channel in-store shoppers still comprise the majority of consumers. “Online shoppers” generate the lowest environmental impact, which confirms existing research. Nevertheless, e-shoppers are more likely to visit stores for researching and testing activities prior to their purchase, as compared to consumers that purchase in-store, which considerably increases the external CO_2 costs they produce. “Research shoppers’” impact is the worst, as they make separate trips for pre-purchase and purchase activities.

A sensitivity analysis demonstrates the robustness of our results, yet it remains important to take the case-study context into account, e.g., in terms of product type, geography and characteristics of retailer, logistics service provider and consumer base. Moreover, indirect impacts arising from online and omnichannel retail developments are excluded from the analysis. The research gives rise to several opportunities for the involved stakeholders that allow to reduce the environmental impact of omnichannel retail transport.

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References

1. Bell, D.R.; Gallino, S.; Moreno, A. Inventory Showrooms and Customer Migration in Omni-Channel Retail: The Effect of Product Information. *SSRN Electron. J.* **2013**, 1–33. [CrossRef]
2. Rosengren, S.; Lange, F.; Hernant, M.; Blom, A. Catering to the Digital Consumer: From Multichannel to Omnichannel Retailing. In *Managing Digital Transformation*; Andersson, P., Movin, S., Mähring, M., Teigland, R., Wennberg, K., Eds.; Stockholm School of Economics Institute for Research: Stockholm, Sweden, 2018; ISBN 9789186797317.
3. Peltola, S.; Vainio, H.; Nieminen, M. Key Factors in Developing Omnichannel Customer Experience with Finnish Retailers. In Proceedings of the HCI in Business, Los Angeles, CA, USA, 2–7 August 2015; Springer International Publishing: New York, NY, USA, 2015; Volume 9191, pp. 437–445.
4. Schoutteet, P.; Vanhaverbeke, L.; Buldeo Rai, H.; Verlinde, S.; Macharis, C. A consumer behavior typology based on temporal and spatial characteristics in an omnichannel retail environment. In Proceedings of the INFORMS 2017 Marketing Science Conference, Los Angeles, CA, USA, 7–10 June 2017.
5. Cook, G. Customer experience in the omni-channel world and the challenges and opportunities this presents. *J. Direct Data Digit. Mark. Pract.* **2014**, *15*, 262–266. [CrossRef]
6. Frazer, M.; Stiehler, B.E. Omnichannel Retailing: The Merging of the Online and Off-Line Environment. In Proceedings of the Global Conference on Business and Finance Proceedings, Honolulu, Hawaii, 6–9 January 2014; pp. 655–657.
7. Lemon, K.N.; Verhoef, P.C. Understanding Customer Experience Throughout the Customer Journey. *J. Mark.* **2016**, *80*, 69–96. [CrossRef]
8. Bell, D.R.; Gallino, S.; Moreno, A. Offline Showrooms in Omni-Channel Retail: Demand and Operational Benefits. *Manag. Sci.* **2018**, *64*, 1629–1651. [CrossRef]
9. UPS. *UPS Pulse of the Online Shopper*; UPS: Atlanta, GA, USA, 2016.
10. Bpost. *Explaining the Omnichannel Path to Purchase*; Bpost: Brussels, Belgium, 2017.
11. Lazaris, C.; Vrechopoulos, A. From Multichannel to "Omnichannel" Retailing: Review of the Literature and Calls for Research. In Proceedings of the 2nd International Conference on Contemporary Marketing Issues, Athens, Greece, 18–20 June 2014.
12. Park, J.; Kim, R.B. A new approach to segmenting multichannel shoppers in Korea and the US. *J. Retail. Consum. Serv.* **2018**, *45*, 163–178. [CrossRef]
13. Comi, A.; Nuzzolo, A. Exploring the Relationships Between e-shopping Attitudes and Urban Freight Transport. *Transp. Res. Procedia* **2016**, *12*, 399–412. [CrossRef]
14. Russo, F.; Comi, A. A classification of city logistics measures and connected impacts. *Procedia Soc. Behav. Sci.* **2010**, *2*, 6355–6365. [CrossRef]
15. Arnold, F.; Cardenas, I.; Sörensen, K.; Dewulf, W. Simulation of B2C e-commerce distribution in Antwerp using cargo bikes and delivery points. *Eur. Transp. Res. Rev.* **2018**, *10*, 2. [CrossRef]
16. Hagberg, J.; Holmberg, U. Travel modes in grocery shopping. *Int. J. Retail Distrib. Manag.* **2017**, *45*, 991–1010. [CrossRef]
17. Browne, M.; Allen, J.; Nemoto, T.; Patier, D.; Visser, J. Reducing social and environmental impacts of urban freight transport: A review of some major cities. *Procedia Soc. Behav. Sci.* **2012**, *39*, 19–33. [CrossRef]
18. McKinnon, A.; Cullinane, S.; Whiteing, A.; Browne, M. *Green Logistics: Improving the Environmental Sustainability of Logistics*; Kogan Page Publishers: London, UK, 2010.
19. Edwards, J.; McKinnon, A.; Cullinane, S. Comparative analysis of the carbon footprints of conventional and online retailing: A "last mile" perspective. *Int. J. Phys. Distrib. Logist. Manag.* **2010**, *40*, 103–123. [CrossRef]
20. Mangiaracina, R.; Marchet, G.; Perotti, S.; Tumino, A. A review of the environmental implications of B2C e-commerce: A logistics perspective. *Int. J. Phys. Distrib. Logist. Manag.* **2015**, *45*, 565–591. [CrossRef]
21. Van Loon, P.; Deketele, L.; Dewaele, J.; McKinnon, A.; Rutherford, C. A comparative analysis of carbon emissions from online retailing of fast moving consumer goods. *J. Clean. Prod.* **2015**, *106*, 478–486. [CrossRef]

22. Browne, M.; Rizet, C.; Anderson, S.; Allen, J.; Keïta, B. Life cycle assessment in the supply chain: A review and case study. *Transp. Rev.* **2005**, *25*, 761–782. [CrossRef]
23. Cullinane, S. From Bricks to Clicks: The Impact of Online Retailing on Transport and the Environment. *Transp. Rev.* **2009**, *29*, 759–776. [CrossRef]
24. Weltevreden, J.W.J.; Rotem-Mindali, O. Mobility effects of b2c and c2c e-commerce in the Netherlands: A quantitative assessment. *J. Transp. Geogr.* **2009**, *17*, 83–92. [CrossRef]
25. Weber, C.L.; Hendrickson, C.T.; Matthews, H.S.; Nagengast, A.; Nealer, R.; Jaramillo, P. Life cycle comparison of traditional retail and e-commerce logistics for electronic products: A case study of buy.com. In Proceedings of the 2009 IEEE International Symposium on Sustainable Systems and Technology, Phoenix, AZ, USA, 18–20 May 2009.
26. Edwards, J.; McKinnon, A. Shopping trip or home delivery: Which has the smaller carbon footprint? *Focus (Madison)* **2009**, *11*, 20–24.
27. Velásquez, M.; Ahmad, A.-R.; Bliemel, M. State-of-the-Art in E-commerce Carbon Footprinting. *J. Internet Bank. Commer.* **2009**, *14*, 1–21.
28. Carling, K.; Han, M.; Håkansson, J.; Meng, X.; Rudholm, N. Measuring transport related CO2 emissions induced by online and brick-and-mortar retailing. *Transp. Res. Part D* **2015**, *40*, 28–42. [CrossRef]
29. Laghaei, J.; Faghri, A.; Li, M. Impacts of home shopping on vehicle operations and greenhouse gas emissions: Multi-year regional study. *Int. J. Sustain. Dev. World Ecol.* **2016**, *23*, 381–391. [CrossRef]
30. Edwards, J.; McKinnon, A.; Cullinane, S. Comparative carbon auditing of conventional and online retail supply chains: A review of methodological issues. *Supply Chain Manag. Int. J.* **2011**, *16*, 57–63. [CrossRef]
31. Van Loon, P.; McKinnon, A.; Deketele, L.; Dewaele, J. The growth of online retailing: A review of its carbon impacts. *Carbon Manag.* **2014**, *5*, 285–292. [CrossRef]
32. Pålsson, H.; Pettersson, F.; Winslott Hiselius, L. Energy consumption in e-commerce versus conventional trade channels—Insights into packaging, the last mile, unsold products and product returns. *J. Clean. Prod.* **2017**, *164*, 765–778. [CrossRef]
33. Wiese, A.; Toporowski, W.; Zielke, S. Transport-related CO_2 effects of online and brick-and-mortar shopping: A comparison and sensitivity analysis of clothing retailing. *Transp. Res. Part D Transp. Environ.* **2012**, *17*, 473–477. [CrossRef]
34. Mangiaracina, R.; Perego, A.; Perotti, S.; Tumino, A. Assessing the environmental impact of logistics in online and offline B2C purchasing processes in the apparel industry. *Int. J. Logist. Syst. Manag.* **2016**, *23*, 98–124. [CrossRef]
35. Hischier, R. Car vs. Packaging—A First, Simple (Environmental) Sustainability Assessment of Our Changing Shopping Behaviour. *Sustainability* **2018**, *10*, 3061. [CrossRef]
36. Melacini, M.; Tappia, E. A Critical Comparison of Alternative Distribution Configurations in Omni-Channel Retailing in Terms of Cost and Greenhouse Gas Emissions. *Sustainability* **2018**, *10*, 307. [CrossRef]
37. Kellner, F.; Igl, J. Estimating the effect of changing retailing structures on the greenhouse gas performance of FMCG distribution networks. *Logist. Res.* **2012**, *4*, 87–99. [CrossRef]
38. Brown, J.R.; Guiffrida, A.L. Carbon emissions comparison of last mile delivery versus customer pickup. *Int. J. Logist. Res. Appl.* **2014**, *17*, 503–521. [CrossRef]
39. Belavina, E.; Girotra, K.; Kabra, A. Online Grocery Retail: Revenue Models and Environmental Impact. *Manag. Sci.* **2016**, *63*, 1781–1799. [CrossRef]
40. Fulgoni, G.M. "Omni-Channel" Retail Insights and The Consumer's Path-to-Purchase—How Digital Has Transformed the Way People Make Purchasing Decisions. *J. Advert. Res.* **2014**, *54*, 377–380. [CrossRef]
41. Hoehle, H.; Aloysius, J.A.; Chan, F.; Venkatesh, V. Customers' tolerance for validation in omnichannel retail stores: Enabling logistics and supply chain analytics. *Int. J. Logist. Manag.* **2018**, *29*, 704–722. [CrossRef]
42. Bell, D.R.; Gallino, S.; Moreno, A. Showrooms and Information Provision in Omni-channel retail. *Prod. Oper. Manag.* **2014**, *24*, 360–362. [CrossRef]
43. Gao, F.; Su, X. Omnichannel retail operations with buy-online-and-pickup-in-store. *Manag. Sci.* **2016**, *63*, 2478–2492. [CrossRef]
44. Rigby, D. The Future of Shopping. *Harv. Bus. Rev.* **2011**, *89*, 65–76.
45. Brynjolfsson, E.; Hu, Y.J.; Rahman, M.S. Competing in the Age of Omnichannel Retailing. *MIT Sloan Manag. Rev.* **2013**, *54*, 23–29.

46. Verhoef, P.C.; Kannan, P.K.; Inman, J.J. From Multi-Channel Retailing to Omni-Channel Retailing. Introduction to the Special Issue on Multi-Channel Retailing. *J. Retail.* **2015**, *91*, 174–181. [CrossRef]
47. Lazaris, C.; Vrechopoulos, A.; Fraidaki, K.; Doukidis, G. Exploring the "Omnichannel" Shopper Behaviour. In Proceedings of the AMA SERVSIG International Service Research Conference, Thessaloniki, Greece, 13–15 June 2014.
48. Picot-Coupey, K.; Huré, E.; Piveteau, L. Channel design to enrich customers' shopping experiences—Synchronizing clicks with bricks in an omni-channel perspective—The Direct Optic case. *Int. J. Retail Distrib. Manag.* **2016**, *44*, 336–368. [CrossRef]
49. Bell, D.R.; Gallino, S.; Moreno, A. The Store Is Dead—Long Live the Store. *MIT Sloan Manag. Rev.* **2018**, *59*, 59–66.
50. Piotrowicz, W.; Cuthbertson, R. Introduction to the Special Issue Information Technology in Retail: Toward Omnichannel Retailing. *Int. J. Electron. Commer.* **2014**, *18*, 5–16. [CrossRef]
51. Melacini, M.; Perotti, S.; Rasini, M.; Tappia, E. E-fulfilment and distribution in omni-channel retailing: A systematic literature review. *Int. J. Phys. Distrib. Logist. Manag.* **2018**, *48*, 391–414. [CrossRef]
52. Savastano, M.; Barnabei, R.; Ricotta, F. Going Online While Purchasing Offline: An Explorative Analysis of Omnichannel Shopping Behaviour in Retail Settings. In Proceedings of the International Marketing Trends Conference, Venice, Italy, 21 January 2016.
53. Hübner, A.; Holzapfel, A.; Kuhn, H. Distribution systems in omni-channel retailing. *Bus. Res.* **2016**, *9*, 255–296. [CrossRef]
54. Bayram, A.; Cesaret, B. Ship-from-Store Operations in Omni-Channel Retailing. In Proceedings of the Proceedings of the 2017 Industrial and Systems Engineering Conference, Pittsburgh, PA, USA, 20–23 May 2017.
55. Hübner, A.; Wollenburg, J.; Holzapfel, A. Retail logistics in the transition from multi-channel to omni-channel. *Int. J. Phys. Distrib. Logist. Manag.* **2016**, *46*, 562–583. [CrossRef]
56. Daugherty, P.J.; Bolumole, Y.; Grawe, S.J. The new age of customer impatience: An agenda for reawakening logistics customer service research. *Int. J. Phys. Distrib. Logist. Manag.* **2019**, *49*, 4–32. [CrossRef]
57. Bernon, M.; Cullen, J.; Gorst, J. Online retail returns management: Integration within an omni-channel distribution context. *Int. J. Phys. Distrib. Logist. Manag.* **2016**, *46*, 584–605. [CrossRef]
58. Rizet, C.; Cornélis, E.; Browne, M.; Léonardi, J. GHG emissions of supply chains from different retail systems in Europe. *Procedia Soc. Behav. Sci.* **2010**, *2*, 6154–6164. [CrossRef]
59. Omnichannel Retail in Europe. Available online: https://ecommercenews.eu/omnichannel-retail-europe/ (accessed on 28 April 2019).
60. Yin, R.K. *Case Study Reserach—Design and Methods*; SAGE Publications: Thousand Oaks, CA, USA, 1984; Volume 5, ISBN 9781412960991.
61. Seuring, S. Case study research in supply chains. An outline and three examples. In *Research Methodologies in Supply Chain Management*; Springer: Berlin, Germany, 2005; pp. 235–250.
62. Sheehan, K.B. E-mail Survey Response Rates: A Review. *J. Comput. Commun.* **2001**, *6*. [CrossRef]
63. Wåhlberg, A.E.; Poom, L. An Empirical Test of Nonresponse Bias in Internet Surveys. *Basic Appl. Soc. Psychol.* **2015**, *37*, 336–347. [CrossRef]
64. Primerano, F.; Taylor, M.A.P.; Pitaksringkarn, L.; Tisato, P. Defining and understanding trip chaining behaviour. *Transportation (Amst)* **2008**, *35*, 55–72. [CrossRef]
65. Reumers, S.; Polders, E.; Janssens, D.; Declercq, K.; Wets, G. *Onderzoek Verplaatsingsgedrag Vlaanderen 5.1 (2015–2016)— Verkeerskundige Interpretatie van de Belangrijkste Tabellen (Analyserapport)*; Universiteit Hasselt: Hasselt, Belgium, 2016.
66. Boussauw, K. *Aspects of Spatial Proximity and Sustainable Travel Behaviour in Flanders: A Quantitative Approach*; Ghent University: Ghent, Belgium, 2011.
67. Gonzalez-Feliu, J. *Sustainable Urban Logistics: Planning and Evaluation*; John Wiley & Sons: Hoboken, NJ, USA, 2018; ISBN 1786301792.
68. Bickel, P.; Friedrich, R. *ExternE. Externalities of Energy. Methodology 2005 Update*; Office for Official Publications of the European Communities: Luxembourg, 2005.
69. Mommens, K.; Lebeau, P.; Verlinde, S.; van Lier, T.; Macharis, C. Evaluating the impact of off-hour deliveries: An application of the Transport Agent-BAsed model. *Transp. Res. Part D Transp. Environ.* **2018**, *62*, 102–111. [CrossRef]

70. MATSim MATSim: Multi-Agent Transport Simulation. Available online: https://www.matsim.org/ (accessed on 28 January 2019).
71. Schröder, S.; Liedtke, G. Modeling and Analyzing the Effects of Differentiated Urban Freight Measures—A Case Study of the Food Retailing Industry. In Proceedings of the Transportation Research Board 93rd Annual Meeting, Washington, DC, USA, 12–16 January 2014.
72. Schröder, S.; Zilske, M.; Liedtke, G.; Nagel, K. Towards a Multi-Agent Logistics and Commercial Transport Model: The Transport Service Provider's View. *Procedia Soc. Behav. Sci.* **2012**, *39*, 649–663. [CrossRef]
73. Otten, M.; Hoen, M.; den Boer, E. *STREAM Goederenvervoer 2016. Emissies van Modaliteiten in Het Goederenvervoer*; CE Delft: Delft, The Netherlands, 2017.
74. Otten, M.; 't Hoen, M.; den Boer, E. *STREAM Personenvervoer 2014. Studie naar TRansportEmissies van Alle Modaliteiten Emissiekentallen 2011*; CE Delft: Delft, The Netherlands, 2015.
75. Delhaye, E.; De Ceuster, G.; Vanhove, F.; Maerivoet, S. *Internalisering van Externe Kosten van Transport in Vlaanderen: Actualisering 2016*; Vlaamse Milieumaatschappij: Leuven, Belgium, 2017.
76. Van Duin, J.H.R.; De Goffau, W.; Wiegmans, B.; Tavasszy, L.A.; Saes, M. Improving home delivery efficiency by using principles of address intelligence for B2C deliveries. *Transp. Res. Procedia* **2016**, *12*, 14–25. [CrossRef]
77. Edwards, J.; McKinnon, A.; Cullinane, S. *Modelling the Environmental Impacts of Conventional and Online Non-Food Shopping*; Green Logistics Report; Heriot-Watt University: Edinburgh, Scotland, 2009; pp. 109–116.