Environmental sustainability of the last mile in omnichannel retail

Buldeo Rai, Heleen

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The retail sector has changed radically in the last years, driven by possibilities created by the internet. Consumers adapted their behaviour accordingly, purchasing online as well as in-store and combining several retail channels for a single purchase. This type of behaviour is called “omnichannel” and spurred the development of retail models accommodating this behaviour, by integrating physical stores with web-shops and mobile shops. Transport associated with retailing is investigated with great attention, particularly because it is a significant contributor to climate change and air polluting emissions, among others. An unresolved yet crucial question remains which retail model is more sustainable from an environmental point of view: online retail or retailing in-store. While research has focused mostly on retail logistics to address this matter, this PhD advocates to consider the broad omnichannel retail context, explicitly including consumers’ purchase, travel and choice behaviour.

Heleen Buldeo Rai investigated the “last mile” of the retail supply chain, in which purchases reach their final delivery destination, under supervision of prof. dr. Cathy Macharis and dr. Sara Verlinde. The aim was to understand how the last mile is impacted by omnichannel retail and what that implies for the last mile’s environmental sustainability. The results of her research are bundled in this doctoral thesis.
Environmental sustainability of the last mile in omnichannel retail

Heleen Buldeo Rai

ENVIRONMENTAL SUSTAINABILITY OF THE LAST MILE IN OMNICHANNEL RETAIL

Thesis submitted in fulfilment of the requirements for the degree of PhD in Business Economics

August 2019

Promotors
Prof. dr. C. Macharis (Vrije Universiteit Brussel)
Dr. S. Verlinde (Vrije Universiteit Brussel)

Jury
Prof. dr. T. Crispeels (Vrije Universiteit Brussel)
Prof. dr. L. Vanhaverbeke (Vrije Universiteit Brussel)
Prof. dr. M. Browne (University of Gothenburg)
Prof. dr. A. Goodchild (University of Washington)
I always read the acknowledgements section first when I come across a doctoral thesis. More than often, it says: “I never expected to pursue a PhD, but here it is”. The same goes for me, and I have a number of people to thank for what I experienced as an exciting, challenging and important journey.
Starting a master’s programme at the Vrije Universiteit Brussel felt a bit like homecoming and I’m grateful to have met my professor and masterthesis supervisor professor Caroline Pauwels and her team. Thank you for sharing your enthusiasm for research and for passing it on to me. After that, getting to know MOBI and leading lady professor Cathy Macharis was the little jump-start I needed. Thank you, Cathy! The open, constructive and trustful way you lead the team and supervise your researchers is a true inspiration and I’m grateful to have been able to learn from you. Many, many “thank you’s” as well to Sara. I would not have been able to present this thesis with the majority of chapters published if it wasn’t for your day-to-day commitment to provide profound and constructive feedback, brainstorm with me and share your critical eye. I’m happy to have been part of the city logistics team!
Sincere acknowledgements go out to my jury: professor Michael Browne, professor Anne Goodchild, professor Lieselot Vanhaverbeke and professor Thomas Crispeels. I greatly appreciate your interest in my work, critical review of the thesis and valuable feedback. Thank you Thomas for chairing my jury and Lieselot for substituting as chair during the public defence. A special word of thanks to Mike, for showing me all things city logistics in Gothenburg during my VREF research stay (and the Swedish-style visit to the archipelago).
The research presented in this thesis was realised in the course of different projects. I’m grateful for the many occasions I had the chance to meet and exchange ideas with inspiring people from academia, policy and industry during this time. A warm thanks to the BOARD team and to Innoviris for funding our project. Thank you to Penelope Schoutteet, Lieselot Vanhaverbeke, Jan Merckx and Koen Mommens for the fruitful collaborations and co-authoring the outputs thereof.
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All the fun aside, this thesis results from countless hours of work and there were many times I was overwhelmed with doubt, stress and occasional symptoms of

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IV

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<td>Carbon dioxide</td>
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<tr>
<td>PM</td>
<td>Particulate matter</td>
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<tr>
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<td>Nitrogen oxides</td>
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<td>SO₂</td>
<td>Sulphur dioxides</td>
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<td>MAMCA</td>
<td>Multi-actor multi-criteria analysis</td>
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Abstract

The retail sector has changed radically in the last years, driven by possibilities created by the internet. Consumers adapted their behaviour accordingly, purchasing online as well as in-store and combining several retail channels for a single purchase. This type of behaviour is called “omnichannel” and spurred the development of retail models accommodating this behaviour, by integrating online channels (e.g. web shop, mobile shop) with offline channels (e.g. physical stores). Omnichannel retail enables highly personal purchase journeys, which call for diverse, tailored and dynamic transport options to deliver purchases to consumers and drive logistics complexity. How this so-called “last mile” to consumers materialises in omnichannel retail is unclear. As transport is a major contributor to climate change and air polluting emissions that negatively affect our global and local environment, the environmental impact of omnichannel retail is unclear as well. This knowledge is needed to drive sustainable decision-making by the stakeholders involved (i.e. consumers, retailers and logistics service providers) and is key in determining which retail model is most sustainable. Therefore, the objective of this PhD is to understand the impact of omnichannel retail on the last mile, and on the last mile’s environmental sustainability. To this end, a threefold approach is adopted. First, the last mile options in omnichannel retail are identified by means of literature reviews and expert-interviews. Second, consumer preferences for these options are assessed by means of surveys. Third, the impact of these options is determined by means of case-study based external transport cost calculations. Findings show that omnichannel retailers outsource the last mile to logistics service providers, although insourcing (for e-grocery) and crowdsourcing (for ship-from-store) strategies are qualified for specific situations. To most consumers, free, next-day delivery to an address of choice is the preferred last mile option, yet they are making trade-offs: when delivery and return are free, consumers are willing to wait longer for their orders to arrive or collect their orders themselves. Collection points are most beneficial from an environmental perspective, but only when consumers walk, bike or are en route of a multi-purpose trip. To this end, local crowdsourced neighbourhood relays are of interest. Deliveries at home have the second to lowest environmental impact. However, this largely depends on whether consumers travel for pre-purchase activities (i.e. product research and testing), which online shoppers are significantly more inclined to than store-shoppers. It also depends on the party executing the deliveries. In this respect, crowdsourced deliveries are unfavourable. As the crowd makes dedicated trips, the environmental impact of deliveries multiplies as compared to deliveries by logistics service providers.

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Samenvatting

Aangestuurd door het internet onderging de retail sector een radicale transformatie. Consumenten pasten hun gedrag aan, door zowel online als in winkels te kopen en verschillende retail kanalen te combineren voor eenzelfde aankoop. Dergelijk “omnichannel” gedrag is de sturende kracht achter nieuwe retail modellen waarin online (vb. webshop, mobiele shops) en offline kanalen (vb. fysieke winkel) geïntegreerd worden. Omnichannel retail laat consumenten toe om hoogstpersoonlijke aankooptrajecten te creëren. Zo’n trajecten vergen diverse en dynamische transportopties op maat om de aankopen bij consumenten te krijgen en brengen een logistieke complexiteit met zich mee. Het is echter onduidelijk hoe deze spreekwoordelijke “laatste kilometer” naar consumenten toe tot uiting komt in omnichannel retail. Aangezien transport in belangrijke mate bijdraagt tot klimaatsverandering en luchtvervuilende emissies, is ook de milieu-impact van omnichannel retail onduidelijk. Deze kennis is nodig om alle betrokken stakeholders (consumenten, retailers, logistieke dienstverleners) te navigeren richting duurzamere beslissingen, maar ze is ook essentieel om het meest duurzame retail model te identificeren: online of “offline”. De doelstelling van dit doctoraat is om de impact van omnichannel retail op de laatste kilometer, en op de ecologische duurzaamheid van deze laatste kilometer te begrijpen.

Een drieledige aanpak werd geïmplementeerd: de afhaal- en leveropties in omnichannel retail identificeren aan de hand van literatuur en expert-interviews; de voorkeuren van consumenten voor deze opties nagaan via enquêtes; de impact van deze opties evalueren aan de hand van externe transportkost berekeningen in specifieke casussen. De bevindingen tonen aan dat omnichannel retailers de laatste kilometer grotendeels uitbesteden aan logistieke dienstverleners, hoewel alternatieve strategieën gelden in bepaalde situaties: voor boodschappen wordt de laatste kilometer zelf georganiseerd, voor bestellingen verzonden vanuit het winkelpunt wordt de “crowd” overwogen. Het merendeel van de consumenten wil zijn bestellingen gratis en de volgende dag ontvangen op een adres naar keuze, maar ze maken compromissen: in het geval van gratis levering en retour, zijn consumenten bereid langer te wachten op hun bestelling of om hun bestelling op te halen. Vanuit een ecologisch perspectief dragen afhaalpunten de voorkeur, maar enkel indien consumenten wandelen, fietser of reeds onderweg zijn voor andere activiteiten. Daarom zijn lokale, crowd-gestuurde afhaalpunten interessant. Thuisleveringen hebben de tweede laagste milieu-impact, maar dit is grotendeels afhankelijk van de pre-aankoop verplaatsingen van consumenten (voor productonderzoek of tests). Online shoppers doen zo’n verplaatsingen significant meer dan traditionele shoppers. De milieu-impact hangt ook af van de partij die de thuisleveringen uitvoert. Leveringen door de crowd zijn in dat geval te vermijden, aangezien ze bijkomende verplaatsingen maken in plaats van hun
bestaande trips te optimaliseren. Daardoor verveelvoudigt hun milieu-impact per levering ten opzichte van de milieu-impact per levering van traditionele logistieke dienstverleners.
INTRODUCTION

Transport, retail and sustainability

In our aim to mitigate global climate change and to enhance local liveability and quality of life, transport plays a major part. Transport is a leading contributor to greenhouse gas emissions and air polluting emissions (WHO, 2011). Greenhouse gases constitute a group of gases contributing to global warming and climate change. In 2014, the transport sector was responsible for 23,2% of greenhouse gas emissions in the European Union. This is lower than the energy sector (28,2%) but higher than industry (19,6%), the residential sector (8,6%), the commercial and institutional sector (3,3%) and agriculture, forestry and fisheries (11,6%) (EC, 2016). In contrary to the other sectors listed, the transport sector did not yet succeed in reducing its total greenhouse gas emission compared to the reference year of 1990 (EC, 2016). This evolution is demonstrated in Figure 1. One of the main greenhouse gases is carbon dioxide (CO$_2$), which stems from the burning of fossil fuels (Eurostat, 2016). Transport is responsible for 28,1% of CO$_2$ emissions in the European Union, again higher than the other sectors except for the energy industry (34,2%) (EC, 2016). From total CO$_2$ emission emitted by the European transport sector, 72,8% is allocated to road transport. Navigation (13%) and civil aviation (13,1%) are responsible for most of the remaining emissions of
In 2014, total goods transport activities represented 3.524 billion ton-kilometres, while total motorised passenger transport activities amounted to 6.591 billion passenger-kilometres. For passengers, this comes down to an average of around 12.985 kilometres per person (EC, 2016). Next to global emissions, the transport sector is responsible for a large proportion of local emissions as well. The impact of air pollution is highly location-specific and depends on many factors, including local traffic conditions. The most important pollutants are particulate matter (PM), nitrogen oxides (NO\textsubscript{x}) and sulphur dioxides (SO\textsubscript{2}) (Gibson et al., 2014). Other transport-related impacts on the local environment stem from congestion, accidents, noise and infrastructure wear and tear (Gibson et al., 2014).

Despite the negative externalities that it generates, transport activities are fundamental to economic development (Macharis et al., 2014), not in the least for the retail sector (Fernie and Sparks, 2009). Retail is one of the most visible activities in any economy and entails the sale of goods and services from businesses to consumers (Reynolds and Cuthbertson, 2014). The sector encompasses a wide variety of forms (e.g. stores, online retail), formats (e.g. small stores, hypermarkets), products (e.g. food, non-food), legal structures (e.g. independent stores, franchises)

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Environmental sustainability of the last mile in omnichannel retail and locations (e.g. urban/rural, city centre/suburbs) (Reynolds and Cuthbertson, 2014). In Europe, retailing accounts for 3.6 million businesses and, together with wholesaling, represents over 22% of all business enterprises. This is twice as much as compared to enterprises related to manufacturing, three times as much as enterprises related to hotels and restaurants and one and a half times as much as enterprises related to construction. Combined, the sectors of retail and wholesale represent the second largest employer in the European Union (Reynolds and Cuthbertson, 2014). Retailers’ transport operations involve different forms of transport, different sizes of containers and vehicles and the scheduling and availability of drivers and vehicles (Fernie and Sparks, 2009). Hence, in our global and local environmental sustainability goals, retail is an important sector to include (McKinnon and Edwards, 2009). Within the retail supply chain, this PhD thesis focusses specifically on “the last mile”. This concept refers to transport and logistics processes in the final phase of the retail supply chain. This phase starts at the final distribution centre from which finished goods move to their delivery destination (Goodman, 2005). As such, it does not refer to an exact mile (or kilometre), but substantially depends on the supply chain's location and geographical configuration (Cardenas et al., 2017). Destinations can be diverse, e.g. offices, public institutions, service providers, construction sites and production plants. In the case of retail supply chains, the final delivery destination coincides with the place of consumption, i.e. end-consumers’ homes.

Sustainability of retail’s last mile

Due to the surge of internet-based retailing, the last mile gained importance (Edwards, McKinnon and Cullinane, 2010; Hübner, Kuhn and Wollenburg, 2016; Hagberg and Holmberg, 2017). While in conventional in-store retail, consumers bridge the last mile by visiting stores and “self-delivering” their purchases home, online retail put retailers in charge (Brown and Guiffrida, 2014), essentially extending the retail supply chain (Kull, Boyer and Calantone, 2007; Ducret, 2014). The last mile is considered the most critical transport activity to determine which model is more sustainable: online retail or in-store (i.e. “offline”) retail (Pålsson, Pettersson and Winslott Hiselius, 2017). When it comes to the remaining transport activities, differences between both models are more limited (Wiese, Toporowski and Zielke, 2012; Mangiaracina et al., 2015). Yet, other retail logistics areas contribute as well to generating effects associated with environmental sustainability, including warehousing, packaging and supply chain structure (Mangiaracina et al., 2015).
As Romm (2002) formulates it: “globalisation fostered by internet makes it easier to purchase objects from very far away”, causing an increase in travel (Cullinane, 2009). Such effects are not included in last mile research.

The last mile of the supply chain is often referred to as a “problem” or “challenge”, which materialises in two ways: high cost and high environmental impact (Boyer, Prud’homme and Chung, 2009; Fernie, Sparks and McKinnon, 2010; Brown and Guiffrida, 2014; Deutsch and Golany, 2018). Although it represents only a fraction of total transport-kilometres that products cover, the last mile is disproportionately responsible for transport-induced environmental damages (Rizet et al., 2010; Brown and Guiffrida, 2014; Kin, Ambra, et al., 2018). In line with transport in general, impacts comprise emission of global and local pollutants, congestion, accidents and noise. A case-study by US retailer Walmart demonstrates that emissions associated with the last mile multiply those emitted by remaining transport operations (e.g. long haul, transit within the retailers’ network) (Mclaughlin, 2017). Similarly, a study on food supply chains shows that about 36.4% of total transport emissions is emitted on the last mile (Weber and Matthews, 2008). Most goods end up in urban or urbanised areas, where consumers work and live (Ranieri et al., 2018). Here, goods vehicles represent about 13% of all vehicles, while accounting for approximately 25% of CO₂ emissions, 30% of local pollutants including PM and 18% of congestion (Verlinde, 2015). In the same vein, costs associated with the last mile are disproportionately high as well. Exact shares on these costs are not available, partly because it concerns sensitive information in industries that are highly cost-driven and competitive (i.e. retail and logistics), but also because it depends on many parameters, such as customer type and customisation degree (Goodman, 2005). One statistic that is often referred to, is cited by Goodman (2005) and states that 28% of all goods transport costs occur in the last mile. Based on data from parcel service providers, Gevaers (2013) found that costs of the last mile can amount from 13% to even 75% of total logistics costs. For retailers, last mile delivery of a product is between five and twenty-three times more expensive than product purchases in-store (Allen et al., 2017).

Logistics and behavioural variables lie at the root of the last mile’s disproportionate cost and environmental impact (Pålsson, Pettersson and Winslott Hiselius, 2017). Logistically, the last mile cannot profit from large distances, few stops and volume consolidation as long-distance goods transport can. On the contrary, its short distance trips, multi-stop routing and small drop sizes cause complexity and fragmentation (Verlinde, 2015; Cardenas et al., 2017; Kin, Spoor, et al., 2018). Urban areas suffer from congestion (Chen, Wu and Hsu, 2019) and are not always equipped with relevant logistics infrastructure, limiting access to specific areas (Allen et al., 2017; Cardenas et al., 2017). Moreover, in an effort to deal with the negative
impacts of transport, urban authorities implement regulations and measures such as time windows, pedestrian zones and congestion charges, adding complexity to last mile operations (Russo and Comi, 2010; Lindholm, 2012; Ducret, 2014). In urban areas, there is a lot of pressure on real estate as well, pushing distribution centres further away from delivery locations. This development is referred to as “logistics sprawl” (Dablanc, Ogilvie and Goodchild, 2014). Distances from the distribution centre to the first delivery address, and from the last delivery address back to the distribution centre (so-called “stem distance”) increase. Consequently, it increases transport-kilometres overall (Allen et al., 2017). Real estate prices also cause retailers to reduce their storage space, demanding more frequent store replenishment trips of smaller quantities (Fernie, Sparks and McKinnon, 2010). Such developments cause low load factors, which is considered a key last mile issue (MDS Transmodal, 2012; Kin, Ambra, et al., 2018).

Consumers’ purchase and travel behaviour has changed due to e-commerce, which has important implications for the last mile (Xing and Grant, 2006; Collins, 2015; Wang et al., 2018). Consumers are responsible for a great deal of energy consumed by the goods transport sector, thereby impacting on environmental sustainability (Wehner, 2018). This is in part due to the “seismic shifts” in consumers’ requirements and expectations (Bringg, no date), regarding location (Visser, Nemoto and Browne, 2014; Kedia, Kusumastuti and Nicholson, 2017), speed (Dablanc et al., 2017; Lin, Zhou and Du, 2017), time (Boyer, Prud’homme and Chung, 2009; Van Duin et al., 2016) and reliability (Xing and Grant, 2006; Ducret, 2014) of delivery, as well as failures due to consumers’ absence during delivery (McLeod, Cherrett and Song, 2006; Edwards et al., 2010; Fernie, Sparks and McKinnon, 2010; Pan et al., 2017).

Yet consumer behaviour affecting the last mile does not only relate to deliveries, but also to their purchase trips. How consumers organise their shopping trips is determined by various factors (i.e. socio-demographics, personal characteristics, situational variables and external variables) and generates environmental effects in turn (Wiese, Zielke and Toporowski, 2015). Investigating supply chain energy consumption, Browne et al. (2005) found that the amount of energy used during consumers’ last mile travel to stores can be as great or greater than the total energy used by retailers’ transport between the offshore point of production and stores.

In the last mile, internal and external costs are intertwined. Internal costs refer to the direct monetised costs for undertaking the last mile, while external costs capture its negative side-effects. In contrast to the benefits, these side-effects are generally not borne by transport users but by society (Gibson et al., 2014). They take place when the activities of one group affect the welfare of another group, without any payment or compensation for the harm caused (Button, 2010). In the last mile, enhancing environmental sustainability and decreasing logistics
costs go hand-in-hand, meaning that all stakeholders can benefit from efficiency improvements (Marshall, 2018). This connection has been demonstrated, e.g. by Cheris, Taylor, Hayes and Davis-Peccoud (2017), Lagey, Cassimon and Verstichel (2016) and Melacini and Tappia (2018). A survey from Eft (2018) among 194 executives from logistics and 129 supply chain executives from retail demonstrates the considerable potential of efficiency gains in the last mile. Respondents claim it is their biggest last mile challenge.

The last mile in online, multichannel and omnichannel retail

The context in which retail’s last mile operates, has changed radically. Globally, the number of consumers that uses the internet to make purchases is growing, together with the frequency in which these purchases are made. In 2017, online sales accounted for 10,2% of all retail sales worldwide, a figure that is expected to reach 17,5% in 2021 (Statista, 2018a). These figures include physical products as well as non-physical products and services (e.g. event tickets), which is important to consider from a transport perspective. Although Europe is not the fastest growing market in the world, levels of online shopping across the European region differ greatly (EuroCommerce, 2018). Some countries are considered mature e-commerce markets (e.g. the Netherlands, Sweden, the UK), while others are lagging behind (e.g. Macedonia, Romania, Montenegro). Belgium is situated between the two. In 2017, Belgian e-commerce sales grew with 15,6%, capturing 7,3% of total retail trade (Ecommerce Europe, 2018; Statista, 2018b). These numbers are similar to the European average (with a growth rate of 12,4% and a retail trade share of 8,8%) and deviate from Europe’s leading market, the UK (with a growth rate of 8,3% and a retail trade share of 17,8%). Comeos, the Belgian retail federation, organises an annual survey to get insights in Belgium’s e-commerce market. Its 2018 report shows that 76% of the online population and 67% of the total population made an e-purchase in 2018. The report concludes that socio-demographics do not impact on consumers’ online purchase behaviour. In fact, they state that “everybody buys online” (Comeos, 2018). Studies in Belgium and the US demonstrate that gender, age and income do affect the probability to shop.

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online (Wang and Zhou, 2015; Beckers, Cárdenas and Verhetsel, 2018). While this question is interesting, product-categories differ and the context changes rapidly, leading these studies to come with different results. Together with the surge of online retail, the importance of the last mile increased dramatically (Esper et al., 2003; Lim, Jin and Srai, 2018). This co-evolution and co-development is far from coincidental (Wang and Xiao, 2015), but rooted in online retailers’ lack of physical customer contact. As opposed to competitor retailers with a traditional model (i.e. brick-and-mortar retailing that requires a physical presence), e-retailers have no stores that allow them to connect with their customers. Their only customer touchpoint materialises in the last mile, when handing over purchases (Xing et al., 2010). As Goodman (2005) puts it, few things represent the “face of a company” more than the last mile. So despite logistics service providers operating below the so-called “line of visibility”, their services reflect on retailers’ reputation and brand (Xing et al., 2011). What’s more, the last mile is considered the most significant driver for online sales (Ghezzi, Mangiaracina and Perego, 2012).

To compete with their physical counterparts and persuade consumers into buying online, e-retailers enhanced their last mile offer. Their goal was to match (and even exceed) service and experience that consumers are used to receive in-store. “Free delivery” became a key lever for acquisition and retention (Lantz and Hjort, 2013; Lagey, Cassimon and Verstichel, 2016; Nguyen et al., 2019). Consumers’ expectations about the last mile changed accordingly, making it common to expect a product to be delivered at the doorstep one day after purchase, free of charge (Van Loon, 2013; Ishfaq et al., 2016; Cherrett et al., 2017). Product return options offered by e-retailers proved of equal importance as well in convincing consumers to adopt e-retail and e-retailers. Such product returns are part of the “first mile”. In accordance, returning damaged, faulty or even unwanted products back to e-retailers’ distribution centre is made to be free of hassle, as well as free of charge (Xing et al., 2010; Lantz and Hjort, 2013). Evidently, such service conditions have financial implications. The popular press reported on some notable cases, in which even large e-retailers struggle to meet break-even as a result of generous delivery and return policies. Examples include fashion e-retailer Zalando that takes back more than half of what it sells (Vanbrussel, 2018) and online marketplace Amazon that is profitable thanks to many of its services, but not the retailing part for which it is known best (Sephina and Broekhuizen, 2019).

Nowadays, this strict divide between online-only retail and traditional store-based retail has blurred (Hagberg, Sundstrom and Egels-Zandén, 2016). In an attempt to capture benefits from both retail worlds, it has largely been replaced by a model in which retailers combine several channel types. A “channel” is a contact
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point or medium through which retailers and consumers interact (Beck and Rygl, 2015). Physical stores are the main offline channels, while online channels include web-shops, mobile shops and social media. At first, these channels coexisted next to each other in a separated, siloed way. An approach that has been termed “multichannel retail” (Lazaris and Vrechopoulos, 2014). Multichannel retailers allow consumers to purchase online as well as offline, but do not facilitate to mix channels. This has implications on several aspects related to consumers’ purchase journeys (i.e. consumers’ decisions and experiences during a transaction), but it also affects how the last mile is organised (Hagberg, Sundstrom and Egels-Zandén, 2016). In multichannel retail, consumers who purchase in the web-shop can receive their purchase via home delivery or collection point pick-up, both of which options are facilitated by the retailer’s logistics partner. They cannot, however, pick-up their purchase in the retailer’s store, nor can they ship an in-store purchased product to their home or local collection point, if desired. Similarly, an in-store purchase can be replaced or returned in-store, but this does not apply for products that are purchased online. Multichannel retailers’ online and offline channels function as separate entities and consumers interact with either one or the other (Ailawadi and Farris, 2017).

Although this multichannel retail model is still very common, it also spurred the development of a more advanced model, called “omnichannel retail” (Lazaris and Vrechopoulos, 2014; Hübner, Wollenburg and Holzapfel, 2016a). This approach is perceived as “the next logical step after a multichannel approach” and requires separate channels to “converge into a single, seamless channel of orchestrated product flow”, states Kraemer (2015) in a DHL Trend Research report on the topic. The word “omni” stands for “without limits” and “all”, meaning in all ways, all places, and so on (Kraemer, 2015). Accordingly, this model has also been termed “everywhere commerce” and “no-line commerce” (Beck and Rygl, 2015). The key in omnichannel retail is the integration of online and offline channels, which entails that channels can be “mixed and matched” and used seamlessly, simultaneously and interchangeably. Omnichannel retail enables to shift from a sequence of actions in a single channel, to a continuum of actions across multiple channels (Kraemer, 2015). Similar to multichannel retail, the transformation to an omnichannel retail model requires retailers to adapt a multitude of aspects (e.g. related to marketing, IT and human resources), logistics not in the least (Hübner, Holzapfel and Kuhn, 2016; Hübner, Wollenburg and Holzapfel, 2016a; Yu et al., 2016; Marchet et al., 2018; Wollenburg et al., 2018).

In redesigning their supply chain systems, omnichannel retailers allocate a major role to their stores (Gao and Su, 2016; Hagberg, Jonsson and Egels-Zandén, 2017). Next to traditional sales functions, stores additionally serve as collection
point for purchases, drop-off point for returns and local logistics hubs for faster, more cost-efficient and/or more sustainable product deliveries (Hübner, Kuhn and Wollenburg, 2016). By activating multiple inventory locations as shipment point (e.g. distribution centres, retail stores) and integrating multiple consumer locations as destination point (e.g. homes, collection points), consumers can compose a last (and first) mile, irrespective of other activities in the purchase journey (Lim, Jin and Srai, 2018). In this way, omnichannel retail creates opportunities in terms of logistics efficiency (e.g. inventory optimisation), but it also complicates the last mile to an unprecedented extent and creates new challenges. Accordingly, Banker (2016) states that “omnichannel fulfilment is all about the last mile”. All kinds of retailers transformed (or are transforming) towards this omnichannel retail model, as it provides a response to pressing challenges in the retail sector (Hagberg, Sundstrom and Egels-Zandén, 2016). For traditional retailers, it allows to have an online presence next to their e-competitors and remain relevant for their increasingly online and connected customer base. For online-only retailers, launching stores or entering into partnerships with store-owners creates physical moments-of-truths and opportunities to connect with their customers during crucial decision-making processes. Omnichannel retail brings about more satisfied and profitable customers (Nash, Armstrong and Robertson, 2013; Lewis, Whysall and Foster, 2014; Cao and Li, 2015) and enables to capture rich customer data (Kraemer, 2015). Yet, the most important driver for omnichannel retail is the fact that consumer behaviour has already changed. Thanks to the use of mobile devices that connect to the internet, consumers started to combine online and offline activities, leading to increasingly fragmented purchase behaviour (Couclelis, 2004; Hagberg, Sundstrom and Egels-Zandén, 2016). In fact, consumers became “omnichannel” even before retailers started to transform their business models (Brynjolfsson, Hu and Rahman, 2013; Bell, Gallino and Moreno, 2014a).

Consumers’ omnichannel behaviour

Consumers’ omnichannel behaviour can be conceptualised by means of a path-to-purchase that consists of five phases. These phases reflect the different consumer activities linked to the purchase of a product. Next to purchasing products and receiving these products, three additional activities are considered of relevance:

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researching product information, testing and trying out products and returning products (Cook, 2014; Schoutteet et al., 2017). Various channels can be used for each activity, which is illustrated in Figure 2. Not all activities are inherent to all purchase journeys: researching, testing and returning are optional activities and visualised in dotted lines, as opposed to product purchase and reception that are visualised in solid lines. Instead of a linear path-to-purchase, it has become more of a cycle: consumers move through, back and forth between phases, influenced by a myriad of offline and online options at every phase (KPMG, 2017).

Figure 2. Omnichannel path-to-purchase, adapted from Schoutteet et al. (2017). Solid lines refer to activities inherent to all purchase journeys and dotted lines refer to optional activities.

The first path-to-purchase phase comprises investigating product information. This can be done in-store, but today’s consumers make most use of the wealth of information that is available online (Fulgoni, 2014), 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 (Fulgoni, 2014; Hoehle et al., 2018).

The second path-to-purchase phase covers testing activities, which 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 (Bell, Gallino and Moreno, 2014b). While this is true in most cases, new solutions have been created to carry out this activity at home, e.g. through “test at home” or “home sampling” programs (Bell, Gallino and Moreno, 2013). 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” (Gao and Su, 2016). Building further on the example of eyewear, consumers can upload their picture to test out various pairs, employ digital avatars for fitting (Rigby, 2011; Gao and Su, 2016) or make use of options created by augmented reality (Brynjolfsson, 2014).
Environmental sustainability of the last mile in omnichannel retail


In the omnichannel environment, consumers’ research shopping is observed with great attention. Research shopping means that consumers research and/or test in one channel and purchase in another (Verhoef, Kannan and Inman, 2015). This behaviour materialises in two phenomena: “showrooming” and “webrooming”. When showrooming, consumers carry out testing activities in-store while using their smartphone to look for lower prices online. The showrooming practice is critiqued widely, accusing consumers and e-retailers of free-riding (Gao and Su, 2016). Contrary, webrooming implies online research activities, while still making the actual purchase in-store (Verhoef, Kannan and Inman, 2015). Compared to showrooming, webrooming is the most common practice (Lazaris et al., 2014; UPS, 2016; bpost, 2017).

The third phase of the path-to-purchase concerns purchasing. This can be done in-store or online. In omnichannel retail, the concept of “store” includes traditional shops, next to innovative initiatives, e.g. pop-up stores (Picot-Coupey, Huré and Piveteau, 2016) and “showrooms” (or also termed “zero-inventory stores” or “guide shops”) (Bell, Gallino and Moreno, 2018b, 2018a). In case of shopping online, computers and tablets are common, but also smartphones have become ubiquitous (Brynjolfsson, Hu and Rahman, 2013). While such activities were previously more restricted to the store-setting or to the home in front of a computer screen, the proliferation of mobile devices makes purchasing possible at more settings, e.g. at the bus or tram when commuting, anytime and anywhere (Hagberg, Sundstrom and Egels-Zandén, 2016). Responding to this on-the-go purchase behaviour, retailers implemented “virtual stores” (Rigby, 2011), in which images of store shelves are attached in public spaces. 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 (Piotrowicz and Cuthbertson, 2014). 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 (Melacini et al., 2018). Next to screens, retailers are introducing other advanced technologies, e.g. self-service kiosks equipped with radio frequency identification (or RFID) systems, digital signage, informative touch points and contactless technologies for mobile payments (Savastano, Barnabei and Ricotta, 2016).

The fourth phase of the path-to-purchase comprises the ways in which purchases reach consumers, i.e. how they are transported along the last mile. 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 implies a
transformation of existing retail settings (Hagberg, Sundstrom and Egels-Zandén, 2016) and has been termed “click-and-collect” (Hübner, Holzapfel and Kuhn, 2016) or “BOPS”, which stands for “buy-online-and-pick-up-in-store” (Gao and Su, 2016). 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 (Melacini et al., 2018). However, when products are bought online, the majority of consumers prefers delivery to home or work. These deliveries can be sourced from three types of location: retailers’ distribution centres, retailers’ suppliers and retailers’ stores (Hübner, Holzapfel and Kuhn, 2016; Bayram and Cesaret, 2017). The emergence of omnichannel retail has brought a number of new retail locations as well, in addition to stores or homes (Hagberg, Sundstrom and Egels-Zandén, 2016). These locations include collection points, that are managed by the same logistics players that carry out these deliveries and 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 (or QR) codes, or similar solutions (Melacini et al., 2018). Because of this variety of reception options, adequate and efficient distribution systems are key in omnichannel retail (Hübner, Holzapfel and Kuhn, 2016; Hübner, Wollenburg and Holzapfel, 2016a).

The fifth and final phase of the path-to-purchase concerns the first mile of product returns. Depending on the product type, it is estimated that 30% to 40% of orders are returned. This is a major burden for retailers (Bell, Gallino and Moreno, 2018b). Accordingly, returns management has become a top priority (Daugherty, Bolumole and Grawe, 2018). Returns can be collected at consumers’ homes or workplaces. In most cases, however, consumers take damaged, faulty or even 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 (Bernon, Cullen and Gorst, 2016).

Omnichannel consumers traverse through consecutive path-to-purchase activities, creating a purchase journey that fits their general and context-specific preferences and needs. This is particularly the case for well-considered purchases, such as electronics or “fit critical” fashion items. Breugelmans (2018) refers to problem solving scenarios, that can be extended (e.g. purchase of a car) or limited (e.g. purchase of running shoes), as opposed to habitual purchases that are less demanding in terms of decision-making (e.g. purchase of groceries). These highly personal purchase journeys also drive the complexity of the last mile. As Eft
Environmental sustainability of the last mile in omnichannel retail (2018) puts it, “consumers’ minimum expectation is now: what I want, where I want and when I want it”. This calls for last mile options that are diverse, tailored and dynamic. Accordingly, retailers and logistics service providers alike adapt their business models and new players enter the market, all supported by technological advancements that create opportunities (Ducret, 2014; Castillo et al., 2017). In turn, these changes to the retail environment in terms of consumer behaviour and last mile possibilities affect the environmental impact it brings forth (Xing and Grant, 2006; Collins, 2015; Wang et al., 2018). Given the impact of transport operations on climate change and quality of life, there is a need to understand the last mile and the last mile’s environmental sustainability in the novel omnichannel retail space.

Research objective and questions

The objective of this PhD research is to understand the impact of omnichannel retail on the last mile, and on the last mile’s environmental sustainability. In addressing this objective, the aim is to go beyond so-called “bipolar narratives” that dominated early e-commerce literature (e.g. physical versus virtual, clicks versus bricks) (Crewe, 2013). The hard distinction between online and offline affects the estimation of the overall transport effects of retail and leads to ignoring certain effects (Rotem-Mindali and Weltevreden, 2013; Hagberg, Sundstrom and Egels-Zandén, 2016), such as how online shopping relates to conventional shopping, how online and offline purchases are delivered and the way consumers’ remaining purchase trips are altered (Winslott Hiselius, Smidfelt Rosqvist and Clark, 2012). Hence, omnichannel retail implies to take a holistic view, that considers consumers’ travel behaviour, including rebound and complementary effects from researching, testing and returning trips, as well as retail logistics (Winslott Hiselius, Smidfelt Rosqvist and Clark, 2012; Visser, Nemoto and Browne, 2014). Following a review on the topic, Rotem-Mindali and Weltevreden (2013) conclude that most studies focus either on personal travel or goods movement. Studies investigating consumers’ transport behaviour on the one hand and the combination of passenger and goods transport on the other hand lack (Hagberg and Holmberg, 2017).

In addressing this gap, it is necessary to determine first, how omnichannel retail changes the last mile options that are offered to consumers and second, which of these options consumers prefer. This is supported among others by Pålsson et al. (2017), who highlight the importance of analysing various logistics structures in business-to-consumer retail, given that ordering and delivery methods are
increasingly mixed, and Wehner (2018), who calls for research on different options in the last mile and supply chain impacts that are triggered by consumer behaviour. Building on this knowledge, the environmental sustainability of the last mile in omnichannel retail can be assessed. This thesis adopts a threefold approach: identifying insourcing, outsourcing and crowdsourcing strategies as well as the last mile options in omnichannel retail by means of literature reviews and expert-interviews; assessing consumer preferences for these last mile options by means of surveys; and determining the environmental impact of these last mile options by means of case-study based external transport cost calculations. The research objective is translated into four research questions, which are motivated one by one below.

Online retail pushed retailers to logistics outsourcing (Delfmann et al., 2002). It is unclear if this trend continues in omnichannel retail. On the one hand, Rao et al. (2009) found that multichannel retailers are more likely to insource logistics functions compared to pure online retailers and Ducret (2014) identified new players from retail that entered the logistics market, e.g. large marketplaces providing freight forwarding and last mile services. These studies seem to build the case in favour of “self-built logistics” or logistics insourcing. On the other hand, reasons to outsource the last mile to logistics service providers are evident, as they have knowledge, expertise, experience and volume to outperform retailers in terms of efficiency and costs (Xing et al., 2011). What’s more, with the emergence of the sharing economy, an umbrella term to describe the sharing of consumption through online platforms (Standing, Standing and Biermann, 2019), also a “crowd” of non-professional individuals can be involved in the last mile (Botsman, 2014b). Different from traditional logistics service providers that typically rely on hub-and-spoke networks, such sharing economy initiatives are non-asset based. They connect a demand for logistics services (e.g. transport, storage) to a supply of crowd that has excess capacity in terms of goods, time and/or space to carry out these services. Crowd logistics allows to increase visibility and transparency in the supply chain, unlock the excess capacity that is otherwise hidden and reduce vehicle fleet size. The crowd creates direct “store-to-door” and “door-to-door” connections between commissioners and receivers of goods as well and is therefore particularly well-suited for local express deliveries (Lin, Zhou and Du, 2017; Sampaio et al., 2017). In particular, for small retailers it provides access to on-demand capacity at a more manageable cost, while it can support large retailers to cope with surges in product demand (Standing, Standing and Biermann, 2019). Crowdsourcing logistics is perceived as an innovative concept for omnichannel retailers in their quest to provide qualitative and low-cost last mile services (Dayarian and Savelsbergh, 2017). The amount of knowledge that exists about the effects of new
retail models on transport and logistics is limited (Akeb, Moncef and Durand, 2018). Yet, as omnichannel retailers use their last mile offer to distinct themselves from the competition (Murfield et al., 2017), it is important to understand their strategic choice to insource (using their own vehicle fleet), outsource (to logistics service providers) and/or crowdsourcing (to non-professional individuals) the last mile (Castillo et al., 2017; Dayarian and Savelbergh, 2017; Lim, Jin and Srai, 2018). These observations give rise to the following research question:

**RQ1 Are omnichannel retailers insourcing, outsourcing or crowdsourcing the last mile?**

Figure 3 summarises the increasingly complicated and fragmented last mile configurations in omnichannel retail in nine simplified flows. These flows combine transport actions by four types of stakeholder: omnichannel retailers (in dark pink), logistics service providers (in dark blue), crowd (in light blue) and consumers (in light pink). This research takes an omnichannel retail perspective, meaning that all flows start at omnichannel retailers’ distribution centres and end at consumers’ homes. It can be a direct stretch or consist of multiple parts or “legs”, comprising different modes of picking and handling (i.e. distribution centres, stores) and different modes of reception (i.e. stores, collection points, homes). Omnichannel retailers’ stores serve as picking locations, as well as collection points for consumers (i.e. click-and-collect). More closely located to consumers are collection points managed by logistics service providers as an alternative to home delivery and home re-delivery (following delivery failure). These collection points are either attended (i.e. shop-in-shop) or unattended (i.e. automated lockers). The crowd manages collection points as well. Common models are individuals (e.g. pensioners, homeworkers) that open up their homes for their neighbours’ parcels (e.g. ViaTim and Homerr in the Netherlands). While facilities by logistics service providers and omnichannel retailers are supplied in a traditional way, the crowd focuses on small-scale operations, i.e. the very last part of the last mile (Carbone, Rouquet and Roussat, 2017), e.g. from distribution centres (e.g. Amazon and Uber in Germany), stores (e.g. Walmart in the US) and collection points directly to homes. It is possible to combine insourcing, outsourcing and crowdsourcing strategies (Castillo et al., 2017; Dayarian and Savelbergh, 2017) and common to operate multiple last mile configurations (Lim, Jin and Srai, 2018).

As a consequence, the last mile offer to consumers alters. Potentially, retailers have an extensive store network to deploy as picking location and collection point, as well as enabler of speedy ship-from-store orders (Hübner, Holzapfel and Kuhn, 2016; Hagberg, Jonsson and Egels-Zandén, 2017), logistics service providers build on years of experience and expertise in the courier, express and parcel delivery
sector and leverage sophisticated networks (Cho, Ozment and Sink, 2008; Xing et al., 2011; Ducret, 2014), while crowd profits from a novel type of economy that facilitates efficiency and optimisation (Y. Wang et al., 2016; Castillo et al., 2017). The distinction is made between providers of more traditional last mile options (i.e. omnichannel retailers, logistics service providers) and crowdsourced options as an alternative, to answer the following research question:

**RQ2 Which last mile options are offered to consumers?**

The last mile is found to drive consumers’ purchase decisions to a growing extent (Ghezzi, Mangiaracina and Perego, 2012). Among the variety of last mile options, it is unclear which ones attract consumers’ preferences: e.g. in terms of providers (i.e. omnichannel retailers, logistics service providers, crowd) but also time (e.g. speed, time windows), space (e.g. stores, collection points, homes) and form (e.g. information, flexibility) (Xing et al., 2011). Consumer behaviour is a critical component that is currently missing in the context of the last mile (Van Loon et al., 2015; Pålsson, Pettersson and Winslott Hiselius, 2017). Research dedicated

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Environmental sustainability of the last mile in omnichannel retail towards this topic is timely and pressing (Collins, 2015; Wang et al., 2018), because of consumers’ growing power in dictating the organisation of the last mile (so-called “logsumers”) (Savelsbergh and Van Woensel, 2016), but also because it provides essential information to steer desirable consumer behaviour (Nguyen, De Leeuw and Dullaert, 2016). The following research question is addressed:

**RQ3 Which last mile options do consumers prefer?**

The combination of knowledge about last mile options on the one hand and consumer preferences for these options on the other hand, allows to evaluate the sustainability of omnichannel retail’s last mile. Omnichannel retailers can promote sustainability throughout the retail supply chain and contribute to sustainable consumption (Kotzab et al., 2011; Adivar, Hüseyinoğlu and Christopher, 2019). Only a few works have started to consider the environmental dimension of omnichannel retail (Melacini and Tappia, 2018), but comprehensive assessments lack. This knowledge is important, as it can steer (self-)regulation, empower behavioural change and constitute a basis for evaluating the potential of (future) technologies. It generates the following research question:

**RQ4 How do the last mile options in omnichannel retail impact on environmental sustainability?**

**Thesis structure**

This PhD research has been conducted under supervision of prof. dr. Cathy Macharis and dr. Sara Verlinde. The core of the thesis consists of eight articles (chapters 1 to 8), which were realised in the course of three research projects. Figure 4 visualises the thesis structure and shows how the six parts and eight chapters relate to the four research questions. All chapters are identical to the original articles that are published (chapters 1, 2, 3, 5, 7 and 8) or submitted for publication (chapter 6) in double-blind peer-reviewed international academic journals, except for chapter 4 that was published in a peer-reviewed conference proceedings book. The next section lists references and co-author contributions for all articles. Additionally, the research objective, methodological approach and contribution of each article is discussed.

**Chapter 1** Several studies have demonstrated that omnichannel retailers
increasingly prioritise their logistics operations (Hübner, Holzappel and Kuhn, 2016; Hübner, Wollenburg and Holzappel, 2016a; Marchet et al., 2018; Wollenburg et al., 2018). Omnichannel retailers offer different channels, which creates separate demand streams that vary in terms of order size, delivery requirements and customer expectations. This leads to logistics complexities (Ishfaq et al., 2016).

According to Bernon, Cullen and Gorst (2016), omnichannel retailers’ capacity to develop their own solutions or engage with specialist logistics service providers is a point of differentiation. Logistics service providers could play an important role in developing unique competencies and new omnichannel solutions (Kembro, Normann and Eriksson, 2018). How such competencies and solutions should be realised, is unclear.

Based on a review of the literature on omnichannel retail logistics and semi-structured expert-interviews with sixteen omnichannel retailers from the food sector (six) and the non-food sector (ten), chapter 1 investigates how omnichannel retailers organise their logistics operations, if and why they are insourcing or outsourcing part(s) of their logistics operations and how logistics service providers should adapt to omnichannel retail.

Penelope Schoutteet and I planned and conducted the expert-interviews together. The literature review was done by me, as well as design, analysis and writing of the study, in close collaboration with Sara Verlinde, Cathy Macharis and Lieselot Vanhaverbeke. An earlier version of this study has been presented at the METRANS Urban Freight Conference 2017 in Long Beach (USA).

Chapter 2 Omniclannel retail and the use of e-channels in particular has led to an increase in parcels shipped to consumers’ homes (Galipoglu et al., 2018). Several researchers expect these rising parcel volumes to accelerate implementation of efficiency and sustainability enhancing measures, e.g. electric vehicles and pick-up models (Visser, Nemoto and Browne, 2014; Goodchild, 2017). As research on logistics service providers in the parcel market is limited (Ducret, 2014), little evidence can be found to support this premise. Hence, opportunities remain to examine the business-related challenges faced by logistics service providers in cities (Rose et al., 2016).

Focused on six logistics service providers that capture the vast majority of Brussels’ parcel volume, chapter 2 presents a document-analysis of annual reports and news articles and semi-structured expert-interviews with thirteen senior managers. The interviews explore parcel distribution in Brussels’ omnichannel environment, implementation of current and planned city logistics measures and policy-making for parcel distribution.


The document-analysis and expert-interviews were done by me, as well as planning, design, analysis and writing of the study, in close collaboration with Sara Verlinde and Cathy Macharis.

Chapter 3 Crowdsourcing logistics exploits a new spirit of collaboration and commercialises social networks in a way that can be beneficial from an economic, social and environmental point of view (McKinnon, 2016). As leading companies (including omnichannel retailers and logistics service providers) are outsourcing their last mile to the crowd (Thaker, 2015), much of the thinking and discussion about crowd logistics has developed from the practitioner’s side (Carbone, Rouquet and Roussat, 2015). Together with the rise of crowd logistics initiatives, the variety of services and platforms has grown significantly over the past years.
of business models that are applied is growing. Its true potential in logistics and in enhancing sustainability in the last mile remains unclear.

This article systematically reviews the available literature on crowd logistics and verifies these theoretical insights with sixteen logistics managers, by means of semi-structured expert-interviews. These logistics managers represent logistics service providers (eight), retailers (two) and manufacturers (one) that have an interest in crowdsourced logistics. In this way, the characteristics that describe the various crowd logistics concepts are explored, as well as how these characteristics affect the economic, social and environmental sustainability of crowd logistics.


Jan Merckx and I planned and conducted the expert-interviews together. The literature review was done by me, as well as design, analysis and writing of the study, in close collaboration with Sara Verlinde and Cathy Macharis. An earlier version of this study has been presented at the Logistics Research Network annual conference 2016 in Hull (UK) and VREF conference on Urban Freight 2016 in Gothenburg (Sweden).

**Chapter 4**

Logistics has become a key differentiator in the space of retail (Xing and Grant, 2006). Although consumers’ expectations of the last mile are high, they are reluctant to pay for the improved services they receive (Joerss et al., 2016). Crowd logistics is a potential solution to respond to consumers’ delivery preferences and reduce costs (Goetting and Handover, 2016). On the one hand, initiatives that adopt a sustainability-enhancing approach emerge, on the other hand, more business-oriented initiatives seem to be more successful. Similar to other innovations in the last mile, implementation and long-term success depend on the perception of all stakeholders involved.

To this end, **chapter 4** extends the systematic literature review and semi-structured expert-interviews with findings from a multi-actor multi-criteria analysis (MAMCA) workshop. It identifies the various crowd logistics concepts that exist and the support each concept receives by (all or some of) the stakeholders involved.

Environmental sustainability of the last mile in omnichannel retail

Jan Merckx and I planned and conducted the expert-interviews, Sara Verlinde and I organised the workshop. The literature review was done by me, as well as design, analysis and writing of the study, in close collaboration with Sara Verlinde and Cathy Macharis. An earlier version of this study has been presented at the International Conference on City Logistics 2017 in Phuket (Thailand).

Chapter 5 The omnichannel retail model is gaining ground among consumers. Similar to pure online retailers, who are under pressure to provide qualitative deliveries in terms of speed, price, service and quality (Conlumino for Barclays, 2014), omnichannel retailers are investigating ways to create a last mile offer that is attractive to consumers as well as sustainable from an economic and environmental point of view (Hübner, Kuhn and Wollenburg, 2016). National and international reports indicate the importance of free and fast delivery (MetaPack, 2016; Comeos, 2018). Yet, it is unclear to which extent consumers are making trade-offs among different last mile options when purchasing online. Using choice-based conjoint experiments, chapter 5 builds on a survey with a representative sample of one-thousand Belgian consumers. Consumers’ preference structures for several last mile options are analysed.


The planning, design, analysis and writing of the study were done by me, in close collaboration with Sara Verlinde and Cathy Macharis.

Chapter 6 Crowd logistics receives more and more attention and generates a growing number of initiatives. Different concepts emerged, both in terms of service offer and type of crowd. Although sharing practices are anything but new, it differs significantly from the type of “stranger-sharing” on which crowd logistics builds (Sundararajan, 2016). As consumers are shaping the last mile (Joerss et al., 2016), it is important to know their preferences and perceptions towards the various crowd logistics concepts that exist. Taking the perspective of receivers allows to determine the overall acceptability of crowd logistics (Punel and Stathopoulos, 2017). To date, this information is unknown. Building on a representative sample of one-thousand Belgian consumers, chapter 6 addresses consumers’ perception towards different crowd logistics concepts by
means of a survey.


The planning, design, analysis and writing of the study were done by me, in close collaboration with Sara Verlinde and Cathy Macharis.

Chapter 7 Retailers and consumers are increasingly omnichannel. In terms of consumers’ purchase journeys, this potentially entails additional trips 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. Accordingly, environmental assessments of transport that compare impacts of online and offline shopping do not account for the complexities created by consumers’ omnichannel behaviour. Incorporating knowledge on consumers’ purchase and travel behaviour into such environmental impact assessments, chapter 7 builds on a case-study with a leading omnichannel footwear retailer. Data on logistics and consumer flows is collected by means of interviews, information exchange, a survey and an agent-based simulation model. By means of external transport cost calculations, CO₂ emissions related to several omnichannel purchase journeys are determined.


The planning, design, analysis and writing of the study were done by me, in close collaboration with Koen Mommens, Sara Verlinde and Cathy Macharis. Koen Mommens developed the agent-based simulation model TRABAM and conducted the part of the analysis that was executed in TRABAM.

Chapter 8 Crowd logistics is increasingly used for the last mile. Due to novelty of the concept and the fact that existing crowd logistics platforms are continuously changing (Carbone, Rouquet and Roussat, 2017), knowledge on the actual impact of crowd logistics is limited. As a consequence, it is unclear if the marriage between the sharing economy and online retailing is able to deliver on its claimed merits, i.e. in terms of sustainability and service quality (Qi et al., 2016). Based on a case-study with an existing crowd logistics platform, chapter 8 presents
external transport cost calculations and a MAMCA. These analyses are built on user-data generated by the platform during a year, as well as surveys with platform users and logistics experts.


The planning, design, analysis and writing of the study were done by me, in close collaboration with Sara Verlinde and Cathy Macharis.
ARE OMNICHANNEL RETAILERS INSOURCING, OUTSOURCING OR CROWDSOURCING THE LAST MILE?
Chapter 1

Logistics outsourcing in omnichannel retail: state of practice and service recommendations

Introduction

Ongoing digitalisation has transformed the field of retailing radically. From a dedicated focus on stores, today's retailers are engaging both their physical (“offline”) and online presence in attracting and retaining consumers. Ranging from small companies with a single store to multinationals, retailers are moving towards an omnichannel model. In omnichannel retail, both online and offline channels are combined and integrated (Lazaris and Vrechopoulos, 2013). A channel is a contact point or medium through which retailers and consumers interact (Beck and Rygl, 2015). Two most prominent channels are physical stores and web-shops. In this way, the model is distinct from multichannel retail. While the concept of multichannel aims at managing and optimising performance of each channel, the concept of omnichannel focuses on integrating activities across channels (Ailawadi and Farris, 2017). The concept is also termed “everywhere commerce” and “no-line commerce” (Beck and Rygl, 2015). As there is no distinction between channels, omnichannel retail allows consumers to research product information online, test products in-store, purchase it on the go using a smartphone, get it delivered at home and return it back to the store. Offering such flexible and convenient purchase possibilities creates more loyal and profitable customers (Lewis, Whysall and Foster, 2014).

Consequences of the omnichannel retail model on retailers are diverse and comprise activities related to marketing (Ailawadi and Farris, 2017; Payne, Peltier and Barger, 2017), communication (Gonzalez-Lafaysse and Lapassousse-Madrid, 2016; Hüseyinoglu, Galipoglu and Kotzab, 2017) and human resources (Rapp et al., 2015; Lapoule and Colla, 2016). Also retailers' logistics organisation is impacted and in need of an upgrade (Yu et al., 2016). While the store was the end-point of transaction before, online retailing has placed logistics on the front line (Hübner, Holzapfel and Kuhn, 2016). Not only is it challenging to organise product flows in a way that ensures replenished stores and fast home deliveries (Hübner, Wollenburg and Holzapfel, 2016a). The collection and delivery options that retailers offer to their customers are an increasingly important lever to distinguish themselves from the competition (Murfield et al., 2017).

Considerable research has been executed on the topic of logistics in digitalised retail models. In e-commerce, logistics is considered the most significant driver for sales (Ghezzi, Mangiaracina and Perego, 2012). Consequently, the majority of online retailers outsource their entire logistics operation to specialised logistics service providers.

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Heleen Buldeo Rai
providers, allowing them to create a broad and sophisticated service offer (Cho, Ozment and Sink, 2008). According to Wang and Xiao (2015), pure online players and logistics service providers have contributed to the evolution and promotion of both their sectors. Such developments can be framed within a general trend of logistics outsourcing (Cho, Ozment and Sink, 2008), which brought along major opportunities for logistics service providers (Xing et al., 2011). However, this trend might be turning around. For example, Rao, Goldsby and Iyengar (2009) found that multichannel retailers are more likely to insource logistics functions compared to pure online retailers and Ducret (2014) identified new players from retail (e.g. large marketplaces) that entered the logistics market, providing services such as freight forwarding and last mile transport.

So far, research on omnichannel retail logistics has been dedicated to case-study analysis (Cavender and Kincade, 2015; Picot-Coupey, Huré and Piveteau, 2016; Chen, Goh and Zou, 2018; Larke, Kilgour and O’Connor, 2018), literature review (Daugherty, Bolumole and Grawe, 2018; Galipoglu et al., 2018; Melacini et al., 2018) and operational investigation of specific parts of the supply chain, such as warehousing, last mile transport and product returns (Bernon, Cullen and Gorst, 2016; Hübnner, Kuhn and Wollenburg, 2016; Ishfaq et al., 2016; Kembro, Norrman and Eriksson, 2018). Several studies have researched omnichannel retail logistics comprehensively. Hübnner, Wollenburg et al. (2016) address how retailers develop from isolated multichannel to integrated omnichannel retail logistics, Hübnner, Holzapfel et al. (2016) conceptualise forward and backward distribution concepts, Wollenburg, Hübnner, Kuhn and Trautrim (2018) introduce a typology of logistics networks and Marchet, Melacini, Perotti, Rasini and Tappia (2018) extend the literature by investigating logistics variables relevant for management strategies. These research endeavours have demonstrated that omnichannel retailers increasingly prioritise their logistics operations. In these operations, the store plays a major role (Gao and Su, 2016). The complexities that omnichannel retail logistics entails are largely due to the different channels that such retailers offer, creating separate demand streams that vary in terms of order size, delivery requirements and customer expectations (Ishfaq et al., 2016). Making the transition to omnichannel retail with “front-end” customer experience and “back-end” order management requires innovative technologies and a superior organisation (Angeles, 2016). According to Bernon, Cullen and Gorst (2016), omnichannel retailers’ capacity to develop their own solutions or engage with specialist logistics service providers will become a point of differentiation. Logistics service providers could play an important role in developing unique competencies and new omnichannel solutions (Kembro, Norrman and Eriksson, 2018). How such competencies and solutions should be realised is unclear.
To address this gap in research, we first identify how omnichannel retailers organise their logistics operations and who carries out the logistics operations. Do the increased importance and complexity of logistics result into more outsourcing, or are they reversing the tendency towards insourcing? Based on retailers' operations, experiences, perspectives and needs, we then identify how logistics service providers should adapt to remain relevant in the omnichannel retail environment. This translates in the following research questions:

RQ1. How are omnichannel retailers organising their logistics operations?
RQ2. (Why) are omnichannel retailers insourcing or outsourcing part(s) of their logistics operations?
RQ3. How should logistics service providers adapt to omnichannel retail?

To this end, we executed desk and field research. This paper covers the results of the desk research in the second section, which entails a comprehensive analysis of scientific articles on omnichannel retail logistics and logistics outsourcing in retail. Based on these insights, we developed the field research that comprises semi-structured expert interviews with representatives of both food and non-food retailers that we categorise as “omnichannel”. Our methodological research approach is described in the third section. The fourth section elaborates on research findings, while answers to the research questions are discussed in the fifth section. In the final section, conclusions are drawn.

Literature

Retailers implement logistics strategies of which they believe they ensure high service levels to customers, while managing efficiencies and staying in control of operational costs. Retailers' logistics strategy is an underexposed topic (Blanquart et al., 2012), particularly for omnichannel retail (Angeles, 2016). To capture the available knowledge, we scanned the literature by consulting several scientific databases (Google Scholar, Scopus and Web of Science) and used the following keywords: “omnichannel retail” and “omnichannel retail”, together with “logistics”, “transport”, “delivery”, “distribution”, “last mile” and “supply chain”. All information was collected in a spreadsheet file and systematically analysed. To structure the logistics strategies, we categorised the literature according to three representative areas of logistics: “fulfilment”, “internal transport” and “last mile transport” (Fernie, Sparks and McKinnon, 2010). Fulfilment entails the process of preparing orders.
Environmental sustainability of the last mile in omnichannel retail

Chapter 1

for delivery to stores and end-consumers, internal transport covers the flow between distribution centres and stores and last mile transport comprises the way orders reach end-consumers. As emphasised by Wollenburg et al. (2018), these aspects are interrelated in omnichannel retail and need to be analysed together.

We discuss the identified logistics strategies for omnichannel retail in the first part of this section.

Knowledge on outsourcing in omnichannel retail is limited. Therefore, we consulted the same scientific databases as listed above to identify outsourcing strategies of online and multichannel retailers as well. We used the following keywords: “omnichannel retail”, “omnichannel retail”, “multichannel retail”, “multichannel retail” and “e-commerce”, together with “outsourcing”, “insourcing”, “logistics”, “fulfilment”, “transport” and “last mile” in accordance with the categorisation presented in the first part of this section. We excluded literature on outsourcing strategies in traditional offline retail, as it does not provide relevant insights on last mile transport. We discuss the findings of this review in the second part of this section.

Omnichannel retail logistics strategies

Figure 5 illustrates the identified logistics strategies for omnichannel retail. Omnichannel retailers can use multiple strategies to realise each phase in the supply chain of which some strategies can be combined. Each strategy is discussed in the next paragraphs.

Figure 5. Logistics strategies for omnichannel retail. Bold boxes refer to strategy categories and non-bold boxes refer to strategies. DC = distribution centre.
Fulfilment strategies

Two types of fulfilment locations are used: distribution centres and physical stores. The distribution centre-based model is most traditional: products are supplied to the distribution centre from which they are delivered to stores and homes. One distribution centre can be used for both activities, following an integrated model. Distribution centre integration is the most advanced and cost-efficient option and allows higher product availability (Hübner, Holzapfel and Kuhn, 2015). However, the logistics processes for home delivery and store replenishment are different, e.g. in terms of shipment sizes and service requirements (Yu et al., 2016). Therefore, omnichannel retailers can choose to adopt a separated model, with dedicated distribution centre(s) for fulfilling online orders (also called “dark store”) and dedicated distribution centre(s) for fulfilling store orders. When starting from a store-based retail model, distribution centre separation accelerates market entry and simplifies operational processes (Hübner, Holzapfel and Kuhn, 2015).

Distribution centres are organised in a centralised or decentralised way. A centralised distribution centre is responsible for a (large part of a) commercial area, while decentralised distribution centres serve only a specific part (Hübner, Holzapfel and Kuhn, 2016). Centralisation is the dominant model in retail (Fernie, 1997), as it reduces warehousing and inventory costs and increases reactivity to changes in demand (Blanquart, Seidel and Lenz, 2014). A centralised structure has been found the best fit to realise retailers’ omnichannel ambitions (Yu et al., 2016). In omnichannel retail, distribution centre fulfilment can be complemented with fulfilment in-store (Agatz, Fleischmann and van Nunen, 2008). It enables retailers to achieve rapid geographical expansion, in this way securing market share and customer loyalty more quickly than competitors committed to distribution centre fulfilment (Fernie, Sparks and McKinnon, 2010). Store fulfilment allows retailers to postpone investments in logistics facilities until demand suffices (Fernie, Sparks and McKinnon, 2010). As stores are generally located closer to areas where consumers work and live, fulfilment in-store lowers transport costs and delivery times (Hübner, Kuhn and Wollenburg, 2016). This is important, as delivery conditions are increasingly driving consumers’ purchase decisions (MetaPack, 2016). Moreover, retailers often bear the costs of “free shipping” themselves, which makes shorter distances also interesting from a cost perspective (Ishfaq et al., 2016). However, opening up the store’s stock for fulfilment is only possible with the right type of product (Gao and Su, 2016) and when real-time inventory and planning software is in place (Hübner, Holzapfel and Kuhn, 2016). Moreover, in-store picking is inefficient (Hübner, Kuhn and Wollenburg, 2016), demands careful observation of stock (Angeles, 2016), diminishes commercial space (Hübner, Kuhn...
and Wollenburg, 2016) and creates competition for space between customers and pickers (Murphy, 2003).

City distribution centres or urban hubs are gaining traction. Such hubs serve as injection points to cities, serving urban markets in a fast and cost-efficient way (Yu et al., 2016). Distribution centre urbanisation provides an answer to today’s demand for small quantities and short lead times and responds to urban policies restricting the access for large vehicles (Ruesch et al., 2016; Kembro, Norrman and Eriksson, 2018). Urban hubs are particularly interesting for delivering online orders (Currah, 2002), but pose challenges in terms of land use, which is often difficult and expensive (Kembro, Norrman and Eriksson, 2018).

Internal transport strategies

Internal transport deals with deliveries between distribution centres and between distribution centres and stores (Wollenburg et al., 2018). These transport flows are largely excluded in research on omnichannel retail logistics, despite being a key element (Marchet et al., 2018). Internal transport operations are driven by retail format, products type and store locations (Blanquart, Seidel and Lenz, 2014). These flows are organised in repetitive delivery patterns, from once a week to a couple of times per day (Wollenburg et al., 2018), in accordance with the implemented fulfilment and last mile strategies.

Last mile transport strategies

Last mile delivery has emerged as the most critical transport activity. Omnichannel retailers provide a variety of delivery modes (Hübner, Wollenburg and Holzapfel, 2016a). The main strategies are home delivery and customer pick-up. Customers can pick up their orders in three locations: omnichannel retailers’ stores, logistics service providers’ parcel points and logistics service providers’ locker points. Offering various delivery and pick-up options across channels is a recent phenomenon (Wollenburg et al., 2018). Nevertheless, consumers prefer delivery at home, or another address of choice, when they order online (DPD Group, 2017; Comeos, 2018). Specifically time saved by eliminating trips to and from stores is perceived as a key advantage (Hübner, Kuhn and Wollenburg, 2016). Literature refers to two models: home delivery with attended reception and with unattended reception (Melacini et al., 2018). Attended delivery requires consumers to be at home to receive their order, while unattended delivery does not need consumers to be present (Marchet et al., 2018). Although largely dependent on geographical context, attended home delivery is the most dominant model. More relevant differences in home delivery services relate to price, speed and moment of delivery.
As retailers generally bear last mile transport costs themselves, home delivery is associated with many organisational and financial challenges. Therefore, omnichannel retailers encourage consumers to pick up their orders in-store (Bernon, Cullen and Gorst, 2016; Gao and Su, 2016). This store pick-up strategy employs the store for click-and-collect and click-and-reserve services. Within click-and-collect, consumers purchase items online and pick them up at the store. It differs from click-and-reserve as consumers are allowed to pay in-store, after they have been able to check, test and try the product (Kuźmicz, 2015). Omnichannel retailers leverage their store network to compete with pure online players that have no “physical footprint” in local markets (Ishfaq et al., 2016). For omnichannel retailers, store pick-up offers two advantages. First, it releases them from inefficient home deliveries and instead allows them to ship packages with routine replenishment routes to their stores (Ishfaq et al., 2016). Although in some cases, packages are delivered in separate flows (Hübner, Holzapfel and Kuhn, 2016). Second, it creates opportunities to engage with customers inside the store (Ishfaq et al., 2016), generating store traffic and additional purchases (Gao and Su, 2016).

Omnichannel retailers also make use of parcel and locker points that are managed by logistics service providers (Larke, Kilgour and O’Connor, 2018). These points are located in easy-to-access locations within high-density shipment areas (Mangiaracina et al., 2015). Parcel points are attended by service personnel and based in existing outlets (e.g. small local shops), while locker points are automatic boxes that are accessible 24/7 (Weltevreden, 2008). Omnichannel retailers need to offer their customers the option to return the products they bought (Hübner, Wollenburg and Holzapfel, 2016a). The return process (or “first mile”) is therefore a key issue (Melacini et al., 2018). Similar to the options offered for the last mile, product return options cover drop-off at stores, parcel points and locker points, or collection at home (Bernon, Cullen and Gorst, 2016).

**Outsourcing in online, multichannel and omnichannel retail**

Next to selecting the most appropriate logistics strategies, deciding on who performs the logistics operations remains a key question (Razzaque and Sheng, 1998; de Koster, 2003). Generally, retailers decide between contracted fulfilment, in which they rely on third parties (“outsourcing”), and “self-built logistics”, in which retailers establish their own logistics system (“insourcing”) (Sun, 2015). In some cases, retailers choose for a hybrid model, in which they combine their own...
logistics organisation together with the use of logistics service providers (C. Wang et al., 2016; Hübner, Holzapfel and Kuhn, 2016). For example, logistics service providers can be introduced for home deliveries in areas remote to retailers’ main location (Seidel, Mareï and Blanquart, 2016) or in markets that are not considered of key importance (Wang and Xiao, 2015). Hybridisation approaches envision to capture advantages of both models.

Factors driving outsourcing decisions are discussed in literature and categorised by Selviaridis and Spring (2007) as strategic, financial and operational in nature. From a strategic point of view, a key motivation to outsource logistics is logistics service providers’ ability to provide expertise and experience (Razzaque and Sheng, 1998). This also relates to logistics capacities. Yu et al. (2016) demonstrate that retailers with low logistics capacity profit from outsourcing with positive performance and sales growth. Contrary, retailers with high logistics capacity encounter negative consequences (Yu et al., 2016). Retailers that consider logistics as part of their key competencies gain from insourcing. Otherwise, outsourcing allows them to concentrate on their core business (Hsiao et al., 2010), but this is accompanied with a loss of control (Razzaque and Sheng, 1998).

From a financial point of view, outsourcing can reduce retailers’ costs for asset investments, labour and equipment maintenance (Selviaridis and Spring, 2007), while also enabling to allocate more resources to their core business (Fairchild, 2014). Volume is important in this respect. When the business develops to a stage where retailers can no longer manage the scale, outsourcing is advised. As the business continues to expand, retailers can take operations back in-house to achieve economies of scale (de Koster, 2003; Xing et al., 2011). However, large product volumes allow retailers to negotiate better terms in the outsourcing contract (Hsiao et al., 2010).

From an operational point of view, retailers assess logistics service providers’ impact on the logistics operations. They judge inventory levels, order cycle times and lead times, information technology, asset use and quality of service (Selviaridis and Spring, 2007; Cho, Ozment and Sink, 2008). In this respect, it is important to point out the “human factor” in outsourcing, as its success depends on the relationship between logistics service provider and retailer (Razzaque and Sheng, 1998). As large differences exist among logistics service providers, choosing the most appropriate partner is crucial (Xing et al., 2011). Nevertheless, when the logistics offer does not meet retailers’ demand and expectations, they might be forced to insource the logistics processes after all (Seidel, Mareï and Blanquart, 2016).

Although literature is indicative about logistics strategies for omnichannel retail, it remains largely inconclusive on who performs the logistics operations and
which role logistics service providers play. Rao, Goldsby and Iyengar (2009) found that multichannel retailers are more likely to insource logistics functions compared to pure online retailers. Some researchers have touched upon the topic within omnichannel retail. Regarding fulfilment, online sales volume is identified as an important driver. Until online sales reach a certain threshold, omnichannel retailers are inclined to outsource fulfilment operations to third parties, state Ishfaq et al. (2016). However, Kembro, Normman and Eriksson (2018) contradict this by claiming that omnichannel retailers initially prefer fulfilment insourcing and move on to outsourcing when volumes increase. For last mile transport, Chen, Goh and Zou (2018) identified eight criteria that are crucial in logistics service provider selection: flexibility and reliability, service quality, reputation, financial record, information system strength, expected cost, business growth potential and environmental impact. Nevertheless, Wollenburg et al. (2018) state that food retailers avoid working with logistics service providers and prefer to keep home delivery within the company. This is due to the delicate procedure of handling and handing over grocery items to consumers. The purpose of this research is to verify and extend the knowledge on outsourcing in omnichannel retail and identify how logistics service providers should adapt to remain relevant for omnichannel retailers.

Methodology

The research questions require in-depth understanding of key assumptions (McCracken, 1988) and call for empirical exploration (Babbie, 1990; Forza, 2002). To this end, we organised semi-structured expert interviews with respondents from ten non-food retailers and six food retailers. The expert-interview is a suitable data collection method, because the knowledge of the experts stems from their position within the companies (Creswell, 2003). Literature indicates that six to twelve interviews are sufficient to describe and explore structures for a homogenous group of participants (Guest, Bunce and Johnson, 2006).

We collaborated with the Belgian retail federation to engage respondents. This federation represents trade and services in Belgium and their members are active in eighteen different sectors. We received contact information of retailers that we characterise as omnichannel, active within our selected sectors (fashion, electronics and food), that have at least one store in the Brussels-Capital Region (Belgium). In this respect, an omnichannel retailer has multiple channels that are integrated to at least some extent and provide consistent information on products and services.
(Beck and Rygl, 2015). With the exception of one retailer that implemented an omnichannel model immediately (“non-food 1”), all retailers in our sample started from a brick-and-mortar model and are leading the omnichannel development in Belgium. This has been acknowledged by national achievement awards: six of the non-food retailers and five of the food retailers received a nomination or award for their performance in combining online and offline retail channels. The sectors we selected on the basis of online penetration. While fashion and electronics products represent the online categories that are bought the most, food and groceries comprise the online category that is bought most recurrently (DPD Group, 2017; Comeos, 2018).

In total, we contacted multiple respondents from over 30 retailers that matched our criteria. Indeed, best practices in omnichannel retail are still in development (Snoeck and Neerman, 2017). The respondents that we interviewed are decision-makers on their company’s omnichannel retail strategy, mainly occupied with commercial and logistics matters. Table 1 provides information on retailers and respondents.

Table 1. List of retailers and respondents.

<table>
<thead>
<tr>
<th>Retailer description</th>
<th>Product type</th>
<th>Retail type</th>
<th>Stores</th>
<th>Respondent title</th>
<th>Interview date</th>
<th>Interview code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty fashion</td>
<td>Non-food</td>
<td>National chain</td>
<td>1</td>
<td>Chief executive officer</td>
<td>25/07</td>
<td>Non-food 1</td>
</tr>
<tr>
<td>Fashion</td>
<td>National chain</td>
<td>International chain</td>
<td>4</td>
<td>District manager</td>
<td>27/07</td>
<td>Non-food 2</td>
</tr>
<tr>
<td>Specialty fashion</td>
<td>National chain</td>
<td>National chain</td>
<td>1</td>
<td>Logistics manager</td>
<td>23/08</td>
<td>Non-food 3</td>
</tr>
<tr>
<td>Fashion, food and home</td>
<td>National chain</td>
<td>International chain</td>
<td>1</td>
<td>Commercial manager</td>
<td>25/08*</td>
<td>Non-food 4</td>
</tr>
<tr>
<td>Footwear</td>
<td>National chain</td>
<td>National chain</td>
<td>1</td>
<td>Sales manager</td>
<td>19/09</td>
<td>Non-food 5</td>
</tr>
<tr>
<td>Fashion</td>
<td>National chain</td>
<td>National chain</td>
<td>5</td>
<td>Marketing manager</td>
<td>28/09</td>
<td>Non-food 6</td>
</tr>
<tr>
<td>Fashion</td>
<td>National chain</td>
<td>National chain</td>
<td>1</td>
<td>Chief financial officer</td>
<td>06/10</td>
<td>Non-food 7</td>
</tr>
<tr>
<td>Fashion</td>
<td>National chain</td>
<td>International chain</td>
<td>10</td>
<td>Logistics controller</td>
<td>11/10</td>
<td>Non-food 8</td>
</tr>
<tr>
<td>Sports equipment (i.a.</td>
<td>International chain</td>
<td>International chain</td>
<td>3</td>
<td>Commercial manager</td>
<td>12/10</td>
<td>Non-food 9</td>
</tr>
<tr>
<td>fashion, electronics)</td>
<td>Electronics</td>
<td>International chain</td>
<td>4</td>
<td>Logistics manager</td>
<td>02/11</td>
<td>Non-food 10</td>
</tr>
<tr>
<td>Food</td>
<td>Prepared food market</td>
<td>National chain</td>
<td>3</td>
<td>Chief executive officer</td>
<td>30/06</td>
<td>Food 1</td>
</tr>
<tr>
<td>Supermarket</td>
<td>International chain</td>
<td>International chain</td>
<td>± 20</td>
<td>Commercial manager</td>
<td>06/07</td>
<td>Food 2</td>
</tr>
<tr>
<td>Supermarket</td>
<td>National chain</td>
<td>National chain</td>
<td>10</td>
<td>Logistics manager</td>
<td>12/09</td>
<td>Food 3</td>
</tr>
<tr>
<td>Supermarket</td>
<td>International chain</td>
<td>International chain</td>
<td>1</td>
<td>Commercial manager</td>
<td>13/09</td>
<td>Food 4</td>
</tr>
<tr>
<td>Supermarket</td>
<td>International chain</td>
<td>International chain</td>
<td>± 80</td>
<td>Logistics manager</td>
<td>23/10</td>
<td>Food 5</td>
</tr>
<tr>
<td>Supermarket</td>
<td>International chain</td>
<td>International chain</td>
<td>8</td>
<td>Commercial manager</td>
<td>30/10*</td>
<td>Food 6</td>
</tr>
</tbody>
</table>

* Telephone interviews
The data collection period spanned from June to November 2017, until we reached theoretical saturation. To avoid any bias caused by differences in interviewer behaviour, the same interviewer conducted all interviews. Most interviews were organised in a face-to-face setting, with the exception of two telephone interviews. The interview duration varied between thirty minutes and one hour. We used a topic-list to structure the interviews, which we developed based on the literature review. We asked our respondents which logistics strategies their organisations (plan to) implement (by using Figure 5), who carries out the logistics operations, possible changes in logistics strategies and insourcing/outsourcing in the future. For all strategies, we asked for their organisations’ motivations behind it. The list includes closed as well as open-ended questions so the interviews would be flexible enough to be exploratory and at the same time rigorous enough to collect in-depth information from all respondents (Xing et al., 2011). The interviewer analysed the interviews to ensure that the interview context was captured adequately. Notes were taken during the interviews and all interviews were recorded and transcribed. We used the computer-assisted qualitative data analysis software NVivo (www.qsrinternational.com/nvivo/nvivo-products) to structure, categorise and code the transcripts and find connections (Miles and Huberman, 1994). Codes were derived from the literature review. First, we categorised all information on logistics operations using the identified strategies as codes. Second, we analysed the information on insourcing/outsourcing decisions and motivations for all strategies, building on the categorisation by Selviaridis and Spring (2007).

Findings

In omnichannel retail, neither consumers nor retailers distinguish between offline and online channels anymore (Brynjolfsson, Hu and Rahman, 2013; Wollenburg et al., 2018). This is true for both food and non-food retail. We observed differences in logistics organisation among the retailers, but the clearest distinction was found between these two sectors, which is in line with Marchet et al. (2018). Distinct differences between these sectors have already been found in terms of logistics (Fernie, Sparks and McKinnon, 2010; Hübner, Holzapfel and Kuhn, 2016), consumer behaviour (Cairns, 1996) and online sales. In our sample of retailers, food retailers’ online share amounts consistently to a few percentages, while non-food retailers sell on average 14% of their volume online (with considerable differences ranging from 3% to 50%). Nonetheless, in accordance with international predictions (Nielsen, 2015a), the expert interviews with food retailers highlight
the growing importance of the online channel, both in terms of sales percentage and allocated efforts. Accordingly, the findings section addresses results for food retail in the first part and results for non-food retail in the section part. We discuss applied logistics strategies and mechanisms for outsourcing.

**Logistics outsourcing in omnichannel food retail**

The expert interviews demonstrate that omnichannel food retail commonly combines fulfilment in-store with fulfilment in a dedicated distribution centre (or dark store, following the strategy of distribution centre separation). When online volumes reach critical levels, fulfilment in-store is ceased. The reasons for this include low productivity of the process and the space it requires. Nevertheless, hybrid forms are developing, e.g. in which stores are only used to fulfil orders in remote and thinly populated areas or in areas where demand for online retail is more limited. In these cases, the shorter distance from stores to consumers prevails compared to issues with productivity and space.

Integrating distribution centres for fulfilment is not part of food retailers’ future ambitions, because of operational differences between orders for store replenishment and orders for consumers. Their goal is to expand and extend their dedicated distribution centre, to be able to offer an equally large offer online as they do offline. As food retailers dispose of several distribution centres, mostly dispersed on critical locations across the country, their adopted strategy is decentralisation. Although no retailer makes use of urban distribution centres in their operations yet, interest in this strategy grows. This is motivated by congestion levels in cities and in anticipation of restrictive urban regulations (e.g. kilometre or congestion charging). Distribution centre urbanisation models that are considered include a distribution centre at the edge of the city from which consolidated flows are organised to distribute online orders and an advanced cross-dock facility that allows to transfer loads from large trucks to smaller (and possibly more ecological) vans or cargo-bikes to start distribution before congestion.

The expert interviews indicate that fulfilment in omnichannel food retail is organised in-house and the reasons for this are mainly strategic in nature. More than non-food retailers, food retailers consider logistics as part of their core business, allowing them to gain dedicated expertise that external parties lack. Insourcing allows to control quality and performance of the logistics process, which is particularly critical for a perishable and sensitive product like food. Automation is an additional argument that food retailers quote. Although external parties offer automated fulfilment as well, insourcing allows to customise these processes. In response to consumers increasingly buying smaller quantities, retailer “food 2” invested in an automated distribution centre that optimises store replenishment.
processes for smaller volumes, while retailer “food 3” is investigating the volume needed to automate its dark store. Financially, insourcing proves beneficial too. Although wages are higher for retail staff (compared to staff of logistics service providers), this is compensated by gains achieved through efficiency and economies of scale.

Contradicting the general line of reasoning, retailer “food 5” is more inclined to outsource its fulfilment operations, according to the strategy of the international group to which the retailer belongs. Group strategies are determined by historical preferences and developments and are also claimed as motivation for the retailers that insource logistics. Nevertheless, retailer “food 5” does operate its dark store in-house. No additional reasons of strategic nature are behind this strategy, instead an operational matter was raised. At the time of starting its online activities some years ago (“as a small-scale project”), there was no qualified logistics service provider available to carry out the online fulfilment activities, thus pushing the retailer to develop the activities itself. Indeed, when starting off with online activities, outsourcing has specific advantages, as it provides flexibility in terms of investments, infrastructure and staff. When a qualified model for fulfilment is developed and online sales increase, most retailers agree that fulfilment should be organised in-house.

Developing an omnichannel model does not affect internal transport flows. Food retailers do not consolidate store replenishment products with online orders, as distribution centres are separated. Although they are closely involved in the planning process, transport flows between distribution centres and between distribution centres and stores are outsourced to logistics service providers and subcontractors. From an operational and financial perspective, such players are positioned best to carry out these activities. The business model of “food 1” differs from the other retailers in the sample as they deal with smaller volumes and fresh products only. Lower volumes mean that logistics service providers share vehicle capacity with other suppliers, adding time and constraints to transport. To respond to its just-in-time production and sustain product freshness, this retailer operates its internal transport flows in-house.

Food retailers offer customer pick-up in-store and most combine it with home delivery. Of total online volume, the majority is picked up, but the share of deliveries is growing. Retailers inclined to insourcing logistics, also organise home deliveries in-house. For this strategy too, strategic arguments include logistics being part of their core business, related expertise they have built up and the ability to keep close control on the operations. More important are operational reasons. The transfer of online orders takes place on consumers’ doorstep. This moment is critical in the online shopping journey and demands couriers to deliver impeccable service,
express the retailers’ brand and evoke feelings of trust. In particular with food retail, discussions about the selected items regularly occur and retailers need their couriers to respond commercially. Despite a strong strategic and operational motivation, respondents report gaps in the current logistics offer. The main gap is situated in geographical coverage. Currently, home delivery is only outsourced when retailers do not aspire to offer national coverage. For example, food retailers can choose to offer home deliveries only in densely populated areas or cities. Retailers outsourcing last mile transport to logistics service providers complain primarily about not respecting agreed timeslots (typically of one hour). Choosing a logistics service provider to carry out online deliveries depends on criteria related to costs, experience and expertise in food distribution and adapted information technology systems.

Food retailers offer store pick-up of orders. Generally, two models apply: pick-up at a counter in-store and pick-up at a counter outside of the store. A third model is emerging: pick-up in lockers outside of the store. These lockers are an unattended alternative to counters and accordingly do not need permanently available staff, which is perceived as an important challenge to profitability of e-activities and in-store productivity. Moreover, challenges in staff management for in-store pick-up of online orders are particularly true in case of franchise stores, in which management not only has to convince in-store staff to embrace the online activities, but as well the franchise store’s managers. Outsourcing pick-up of e-groceries to logistics service providers’ network of parcels points and lockers is not possible for food retailers because of product sensitivity and complexity (e.g. three temperature zones, perishability).

**Logistics outsourcing in omnichannel non-food retail**

The most common fulfilment strategy for omnichannel retail in the non-food sector combines a centralised distribution centre with a dark store. The centralised distribution centre holds stock for store replenishment and from here, stock for online orders is shipped to the dark store. This separated strategy is common, due to the significant operational differences between store and consumer orders (e.g. required detail, productivity levels). These differences drive a hybrid outsourcing strategy: while retailers organise their store distribution centre in-house, dark stores are outsourced to third parties. Arguments to explain these strategies are strategic and operational in nature. Strategically, retailers point out that they are strong in fulfilling large volumes for stores but lack in-house expertise and experience when it comes to item picking. As retailer “non-food 10” states: “It requires very specialised knowledge. That is a different job, a different craft, but not our craft”. Operationally, regulation on night labour that generally favours logistics service
providers (in terms of flexibility and cost) is found decisive. Offering short delivery lead times to consumers requires flexible fulfilment operations during the night, in which logistics service providers excel. Moreover, their information technology is adjusted to these processes, providing an additional motivation for outsourcing dark stores.

The few non-food retailers that apply an integrated strategy for their store and online fulfilment manage it in-house. Strong strategic motivations are behind this integrated, insourced fulfilment strategy: logistics is considered part of their core business, which is also the dominant group strategy and allows keeping control on the fulfilment process. Financially, integrated, insourced fulfilment is preferred because retailers avoid keeping costly double stock and having lower return levels. These lower return levels are attributed to a better, more customised fulfilment service, compared to the service logistics service providers provide. “There is a strict quality control before products leave the warehouse: is there both a left and right shoe, are they looking impeccable, unworn, no flaws. We even check zippers by opening and closing them” says retailer “non-food 5”.

Non-food retailers open up their store’s stock for fulfilment, or at least intend to do so in the future. The store’s stock can be used when consumers choose to pick-up their ordered items in-store with a click-and-collect or click-and-reserve model. If the items are already present in the store, they can be prepared and packaged there, instead of at the distribution centre. This allows optimising the process. In-store fulfilment is also interesting for home delivery services. In non-food retail, there is only one location to ship orders from (either the dark store or the integrated distribution centre). Store fulfilment allows to add shipment locations and deliver faster. Although same-day delivery is not common yet in non-food retail, retailers expect this to change in the short term, to same-day delivery or even delivery within one or two hours after purchase. Fulfilling orders in-store and shipping from there is a strategy that anticipates on this development. Another advantage of store fulfilment is stock optimisation. Retailers’ stock loss and product availability to consumers improves as any store’s last available item can be bought online.

Deciding to employ stores for fulfilment is a decision retailers do not make in isolation. In fact, logistics service providers distributing the parcels need to be able to accommodate this service. As it requires logistics service providers to pick up parcels at every store, potentially multiple times per day, most logistics service providers do not provide this service or offer it at a cost that retailers are not willing to bear. As an alternative, retailers think of couriers on cargo-bikes or “crowd logistics” solutions using non-professional couriers connected on a platform to ship in-store fulfilled parcels. However, to protect the negotiating power they have towards logistics service providers, retailers prefer logistics players that offer

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multiple services. In this way, they improve and customise their service offer while sustaining their home delivery cost. Despite these developments, retailers are not inclined to distribute ship-from-store orders themselves.

Also in the non-food sector, internal transport flows are not affected by omnichannel retail. Outsourcing these flows to logistics service providers remains the main mode of operation because of operational and financial reasons. Mainly logistics service providers’ nationwide coverage area and similar customer types (other retailers) allow them to replenish efficiently and at a cost that retailers cannot challenge with their own organisation. Moreover, retailers do not consider internal transport to be part of their strategic core business. Generally, orders for store replenishment and customer pick-up are not consolidated in internal transport flows, unless retailers dispose of an integrated distribution centre.

Omnichannel retailers in the non-food sector offer home deliveries and pick-up in store, which in most cases is complemented with pick-up in parcel points and lockers. Although parcel points and lockers are consumers’ least preferred delivery location, consumers appreciate the possibility to pick-up orders in-store. In our sample of non-food retailers, on average 40% of parcels are picked up in their stores. This is stimulated by advantages that retailers offer: short lead times for pick-up (e.g. within half an hour, within two hours), knowledgeable staff and the option to test and try items, exchange items and get reimbursed in cash (in case of returns). For retailers, in-store pick-up is beneficial too. As retailer “non-food 6” formulates it: “Digital remains rather impersonal. Real personal contact and real experience we are better at providing in-store”. In-store pick-up of orders strengthens customer relations, but it also creates up and cross sell possibilities. In general, retailers find consumers responding positively to this.

Omnichannel non-food retailers choose to outsource home deliveries. Generally, they are not equipped to carry out parcel distribution themselves (e.g. in terms of fleet and staff), but more importantly, retailers do not perceive a need for insourcing. Financial arguments are important in the logistics service provider selection process. Accordingly, cost negotiations between retailers and logistics service providers are frequent. Other determining criteria for selecting an appropriate logistics service provider are operational in nature and depend on retailers’ own assets, brand proposition and service gaps: size of the coverage area (national or international), accurate track-and-trace information, appeal and suitability of the logistics service provider’s brand and their couriers and the variety of services they offer. Next to facilitating store fulfilment as discussed above, such services include availability of pick-up points, flexibility towards various parcel sizes, flexibility in rerouting options, possibility of home delivery within specific timeslots, variety in delivery lead times and variety in delivery moments (also evening) and days (also
Saturday and Sunday). Although the market of parcel distribution is demanding and competitive and retailers’ expectations are high, most retailers in our sample have not changed logistics service providers for their home deliveries so far and did not share intentions to do so in the future.

Discussion

This section formulates answers to the research questions:

RQ1. How are omnichannel retailers organising their logistics operations?

We discuss the various ways in which omnichannel retailers can organise their logistics operations according to the three representative areas of logistics: “fulfilment”, “internal transport” and “last mile transport”. First, omnichannel retailers can choose to operate fulfilment in a distribution centre or in-store, but usually combine both. In food retail, in-store fulfilment is a strategy in anticipation on online growth, while in non-food retail it is a way to optimise transport processes (in case of store pick-up) and deliver faster (in case of home delivery). Distribution centres accommodate fulfilment to serve an area with either one facility (centralisation) or several facilities (decentralisation), combining order fulfilment for stores and consumers (integration) or focussing on only one fulfilment type (separation). Distribution centre separation is the main mode of operation in omnichannel retail, organised in a centralised model for non-food retail and in a decentralised model for food retail. For food retail, urban distribution centres are gaining traction. Second, internal transport between distribution centres and between distribution centres and stores allows for limited variation in strategies to apply. In fact, the main question relates to who organises the transport flows, which is either the retailer itself or a third party. Third, last mile transport can be divided in two strategies: home delivery or consumer pick-up. In practice, omnichannel retailers combine both. Non-food retailers are inclined to offer all options available, including pick-up in-store, in parcel points and lockers, which is less interesting for food retailers, who focus on home delivery and store pick-up only.

RQ2. (Why) are omnichannel retailers insourcing or outsourcing part(s) of their logistics operations?

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The research showed that in terms of outsourcing, distinct differences exist between food and non-food retailers. As visualised in Figure 6 (top), omnichannel food retailers are inclined to organise logistics activities in-house. This counts in particular for fulfilment, in which separated and decentralised distribution centre strategies are preferred, and last mile transport, both for home deliveries and customer pick-up strategies. In contrast, omnichannel food retailers largely outsource their internal transport flows to logistics service providers.

Also visualised in Figure 6 (bottom), omnichannel non-food retailers employ their stores for fulfilment. For distribution centre fulfilment, these retailers apply a hybrid strategy: while the distribution centre for store fulfilment is insourced, they outsource the dark store that fulfils consumer orders. Integrated distribution centres are organised in-house. Transport is mainly outsourced and covers both internal flows to stores and last mile flows to consumers’ homes. Next to home delivery, omnichannel retailers in the non-food sector also enable their customers to pick up their orders: either in retailers’ stores or in their logistics service provider’s parcel points or lockers.

Figure 6. Logistics and outsourcing strategies for omnichannel food retail (top) and non-food retail (bottom). Blue boxes refer to outsourcing, pink boxes refer to insourcing, yellow boxes refer to a hybrid strategy, grey boxes refer to unconsidered logistics strategies and white boxes refer to considered logistics strategies with unknown outsourcing strategies. DC = distribution centre.
Literature suggests three types of arguments that drive outsourcing decisions: strategic, financial and operational arguments. Outsourcing decisions of omnichannel food retailers are strongly driven by strategic considerations. They reflect on logistics as a key competency, that is part of their core business. Operationally, this strategy has allowed them to develop experience and expertise that third parties cannot match. Particularly for a sensitive product as food, logistics capability and performance are decisive. Outsourcing decisions of omnichannel non-food retailers are driven mainly by considerations that are operational and financial in nature. They are inclined to outsource logistics operations because logistics service providers’ services and service levels are considered adequate and convenient. Fulfilment insourcing stems from strong logistics capacities. For non-food retail, the pool of logistics service providers to choose from is larger. Consequently, non-food retailers’ choice for a particular third party is mainly driven by costs. Nevertheless, more than omnichannel food retail, logistics in omnichannel non-food retail evolves around stores. Because of operational advantages, retailers’ store network attracts a growing part of logistics activities (e.g. for fulfilment and last mile) that are managed in-house:

RQ3. How should logistics service providers adapt to omnichannel retail?

This research demonstrates that the activities and consumer expectations that are associated with omnichannel retail are pushing retailers to prioritise logistics. This development implicates a need for both retailers and logistics service providers to reinvent themselves. For logistics service providers to sustain their relevance and strengthen their position for the future, we present a competency recommendation framework in Table 2. Recommendations are formulated for each of our investigated sectors (i.e. food and non-food omnichannel retail) and for each investigated supply chain phase (i.e. fulfilment, internal transport and last mile transport). We claim that service differentiation can prove to be a viable growth direction for logistics service providers in the omnichannel environment. The expert interviews demonstrate a need for fulfilment urbanisation, to better accommodate food deliveries for the last mile. Omnichannel retailers are not eager to operate urban hubs in-house (contrary to other types of logistics facilities), which makes it a viable growth direction for logistics service providers. Moreover, because of their experience and their ability to combine volume of several parties, logistics service providers are better placed to overcome the challenges posed by logistics facilities in or at the edge of the city, i.e. finding adequate space and creating a viable business model to cover urban real estate prices (Kembro, Norrman and
Environmental sustainability of the last mile in omnichannel retail

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Eriksson, 2018). Non-food retailers that apply an omnichannel model prefer an integrated distribution centre, but commonly arrive at a hybrid strategy in which the distribution centre for store replenishment is insourced and the distribution centre for online orders is outsourced. Integrating both activities into one distribution centre creates advantages (e.g. avoiding costly double stock), in particular for non-perishable non-food products that can be stored for a longer time. However, the expert interviews demonstrate that only retailers with distinct logistics capacities are able to realise integrated fulfilment. Logistics service providers could develop such facilities to enable distribution centre integration for omnichannel retailers with insufficient logistics competency.

Internal transport flows are affected least by omnichannel retail developments. Both food and non-food retailers are outsourcing these flows to qualified logistics service providers. Nonetheless, service levels can be increased by focusing on consolidation of various product categories. Because of distinct differences, e.g. in terms of product size, product type or delivery requirements, different products categories are commonly transported in separate, dedicated chains. Consolidation not only enhances in-store efficiency and productivity, it allows consolidated pick-up by consumers as well. For food retailers, such consolidation efforts can target regular groceries and the increasingly common “recipe solution” food boxes (Hertz and Halkier, 2017), so they can be ordered and picked up in a coordinated way. Also non-food retailers could benefit from consolidation in internal transport flows, e.g. consolidating store replenishment volume with click-and-collect orders and product returns.

Consolidation of product categories is interesting for last mile transport as well. The expert interviews highlighted that retailers catering for diverse product categories are often forced to use different logistics service providers, although they prefer outsourcing to one logistics service provider and capture volume advantages instead. Hence, another point of differentiation could be in consolidating product categories.
categories with large variation for deliveries at home. This need is most pressing for food retail, where retailers offer pantry products, fresh produce and food boxes, which could be consolidated in one trip, instead of being delivered via different flows and at different times. In non-food retail, there is a need for logistics service providers combining delivery of smaller items with large and heavy goods in one trip.

Omnichannel non-food retailers need logistics service providers that handle a variety of services in the last mile. Such variation can materialise in different ways: i.e. alternative vehicles and alternative models. As emerged from the expert interviews, retailers are evolving towards a strategy that combines distribution centres and stores for fulfilment. Accordingly, a viable service combination for logistics service providers is operating delivery rounds from the distribution centre, with regular vans, and from the stores, with adjusted vehicles such as cargo-bikes or electric vehicles. An interest for alternative home delivery models rose from the expert interviews as well. Such alternative models comprise working with a “crowd” of non-professionals. In these ways, logistics service providers support retailers in their omnichannel need to ship from their stores and current tendencies such as instant delivery and environmental concerns.

Another model, alternative to regular last mile services, can be offered with value-added, service-oriented deliveries at home, also termed “white glove deliveries” (Daugherty, Bolumole and Grawe, 2018). Such services complete the mere transaction of parcels from logistics service provider to consumer, and the other way around. Examples include delivery and installation of household appliances. Other services are of interest to retailers and can lead to a considerable competitive advantage. Such services include a network of pick-up points and lockers, rerouting options of parcels that are already in transit, specific one hour or two-hour timeslots and deliveries on evenings and weekends.

Omnichannel food retailers operate home deliveries in-house. They do so because of strategic and operational reasons, but also report a lacking service offer. This is particularly the case when national coverage is pursued. Taking into account the considerable growth that is expected for online food retail (Nielsen, 2015a), retailers will have to present a home delivery offer that matches the geographical spread of their stores (i.e. often national). What is more, if online food retail reaches similar levels as experienced in the non-food sector, retailers’ current preference for insourcing last mile deliveries is potentially hindered. Similar to non-food retailers, food retailers might prove unequipped in terms of fleet and staff to execute all home deliveries themselves, representing an interesting development direction for logistics service providers aiming to capture this part of the online retail market. Finally, omnichannel retailers prefer to attract customers to their stores, even
when they order online. Store pick-up possibilities are working well for non-food retailers, among others because of up and cross sell possibilities that are positively received by consumers. For food retail, such possibilities are less of relevance but they still need to allocate staff to the pick-up counter. Adequate lockers equipped for food can be placed outside of retailers’ stores and serve as an alternative to staffed counters. Instead of each retailer designing its own lockers, logistics service providers could develop such facilities, add services to it and even create a broader spread, e.g. in semi-public (e.g. train stations) or private areas (e.g. apartment buildings).

Conclusion

Retail is moving towards an omnichannel retail model, in which offline channels (e.g. physical stores) and online channels (e.g. web-shops) are combined and integrated. It allows consumers to compose a flexible and convenient shopping journey that fits their preferences and needs. From a logistics point of view, organising an omnichannel retail model is challenging: demand streams are separated, while stores still play a prominent role. Given the importance and complexity of logistics in omnichannel retail, it is unclear if the outsourcing tendency that is dominant in retail, continues. Therefore, the objective of this research is to identify in what ways logistics service providers are involved in the logistics operations of omnichannel retailers. To this end, we carried out desk and field research. First, we analysed the scientific information available on omnichannel retail logistics and second, we conducted semi-structured expert interviews with food and non-food retailers that adopt an omnichannel model. Our findings show various strategies for executing fulfilment, internal transport and last mile transport in omnichannel retail. Distinct differences are observed between food and non-food retailers, both in terms of logistics organisation and in outsourcing strategies. Food retailers are inclined to organise fulfilment and last mile activities in-house, while non-food retailers partner closely with logistics service providers. Nonetheless, the store network of non-food retailers is attracting a growing part of logistics activities, which retailers are building themselves. Decisions to insource or outsource are driven by strategic, operational and financial motivations. To sustain their relevance in the omnichannel environment and strengthen their position for the future, we created a competency recommendation framework for logistics service providers. Recommendations are formulated for each of our investigated sectors (i.e. food and non-food omnichannel retail) and
for each investigated supply chain phase (i.e. fulfilment, internal transport and last mile transport), in which service differentiation is proposed as a viable direction for growth. Our findings have strategic importance for retailers that are developing an omnichannel retail model and logistics service providers that (aim to) serve clients and operate activities within the retail sector. Nonetheless, as this research is based on insights from retailers with stores based in the Brussels-Capital Region (Belgium), a future research suggestion entails to test current findings in other contexts and geographical areas.
WHICH LAST MILE OPTIONS ARE OFFERED TO CONSUMERS?
Chapter 2

City logistics in an omnichannel environment. The case of Brussels

Introduction

Shopping behaviour of consumers has changed, affected by and affecting retailers’ business models. Large e-marketplaces dominate online sales and traditional brick-and-mortar retailers have added websites and web-shops to their physical stores (Froger, 2015; Hagberg, Sundstrom and Egels-Zandén, 2016). This new retail paradigm, which has been termed “omnichannel environment”, finds consumers shopping seamlessly and flexibly through a range of online and offline channels and touchpoints, using advanced technologies on smartphones and other devices (Brynjolfsson, Hu and Rahman, 2013; Bell, Gallino and Moreno, 2014a). In the omnichannel environment, the worlds of online and offline converge (Grewal, Roggeveen and Nordfält, 2017).

In practice, omnichannel retail and the use of e-channels in particular, has led to an increase in parcels shipped to consumers’ homes (Galipoglu et al., 2018). Given the concentration of consumers in cities, urban freight systems have to cope with this growing parcel demand. To date, a range of city logistics measures that aim to optimise logistics and transport activities by private companies in urban areas exists (Taniguchi, 2015). Examples include joint delivery systems and alternative vehicle technologies. Although such measures do not change the demand for parcel shipments, they improve efficiency and reduce the adverse impacts of urban freight transport, including business-to-consumer parcel distribution. In fact, several researchers postulated that rising parcel volumes will accelerate implementation of city logistics measures. For example, Visser et al. (2014) foresee opportunities for the use of vehicles powered by alternative fuels and Goodchild (2017) expects an uptake of parcel pick-up models. As research on logistics service providers in the parcel market is limited (Ducret, 2014), little evidence can be found to support this premise. Indeed, opportunities remain to examine the business-related challenges faced by logistics service providers in cities (Rose et al., 2016). By means of a case-study research that focusses on Brussels, Belgium’s largest city and capital, we investigate this link between growing parcel volumes and the introduction of city logistics measures by logistics service providers. With this research, we want to find out how parcel distribution is organised and why logistics service providers (do not) adopt and scale-up particular city logistics measures, exploring their feasibility and implementation potential.

Our research contributes by providing knowledge that enables to rethink parcel distribution in cities, as called for by Allen et al. (2017). The envisioned outcome is adequate policy-making, that sustains and improves urban sustainability and

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quality of life, as well as supports logistics service providers in the parcel market that deal with many operational challenges (e.g. peaks in demand, reduced lead-times, delivery failures) and maladjusted urban infrastructure (Allen et al., 2017). This paper continues with a literature review, providing an overview of city logistics measures. Thereafter, our methodological approach is introduced and research findings presented: the organisation of parcel distribution in Brussels and related implications for policy. Concluding remarks are discussed in the final section.

Literature

City logistics comprises the process of optimising logistics and transport activities by private companies in urban areas (Taniguchi, 2015). Bektaş et al. (2015) capture the concept in three key aspects: (i) it explicitly refers to urban freight transport, (ii) it is based on the idea of an integrated logistics system with consolidation and coordination and (iii) it is aimed at increasing efficiency and reducing environmental damage. By introducing policies and schemes, city logistics encourages fewer vehicles, better utilisation of vehicle capacity and reduction of fuel and energy (Bektaş, Crainic and Van Woensel, 2015).

Several authors have organised the various city logistics measures in distinct categories. Building further on the output of European projects COST 321, BESTUFS and City Ports, Russo and Comi (2010) propose four categories, measures related to (i) material infrastructure, (ii) telematics or intelligent transport systems, (iii) equipment on loading and transport units and (iv) governance of the traffic network, by means of traffic regulations. The authors propose this categorisation of measures as a tool to be used by city authorities, when designing freight transport and logistics regulations (Russo and Comi, 2010). Browne et al. (2012) start from the relationship between five characteristic features of urban freight transport and their negative impacts. These features are: (i) noise levels caused by each freight journey, (ii) air pollutant emissions per vehicle kilometre, (iii) fossil fuel consumption per vehicle kilometre, (iv) total vehicle kilometre and (v) accident risk per vehicle kilometre. To each of these features, the authors match specific initiatives that can reduce impacts. Concluding from this categorisation, Browne et al. (2012) point out the variety of city logistics measures that exists and summarise these measures in three categories: (i) sharing space and time, (ii) encouraging cooperation (also between public and private sector) and (iii) changing behaviour. Stathopoulos et al. (2012) define six broad classes of measures to mitigate freight transport problems: (i) market based measures, (i) regulatory
measures, (iii) land use planning, (iv) infrastructural measures, (v) new technologies
and (vi) management measures.

This brief overview of categorisations demonstrates the wide variety of city
logistics measures that have been introduced, tested and/or implemented in cities.
However, literature has focused mainly on the perspective of local authorities and
policy makers, despite the private sector’s key role in many of these measures. In
response to this, Macharis and Kin (2017) focus on city logistics measures that
explicitly include the stakeholders that are responsible for logistics in cities and
categorise them according to so-called “four As”: (i) awareness, (ii) avoidance, (iii)
act and shift and (iv) anticipation of new technologies.

First, raising awareness on the impact of deliveries can be done by calculating
transport externalities and by participating to programs and certification
standards. Such initiatives can be organised internally (e.g. eco-driving training)
and externally (e.g. in collaboration with customers or supply chain partners). To
Macharis and Kin (2017), pick-up points and lockers are also awareness-creating
measures, as they are more sustainable alternatives to home delivery that businesses
can encourage. Pick-up points and lockers increase consolidation and avoid
delivery failure resulting from receiver absence (Morganti, Dablanc and Fortin,
2014), which makes them equally fit to be categorised under the second category,
avoidance.

Specific avoidance measures include downloading products (e.g. e-books and
music) and 3D-printing, thus removing or heavily reducing the need for transport,
and rethinking the design of packaging, to optimise transport loading. However,
the most conventional approach to avoid redundant vehicle kilometres is bundling
flows to use the available capacity better. To this end, consolidation centres and
micro-consolidation centres are set up. Macharis and Kin (2017) distinguish three
alternative consolidation strategies: encouraging more efficient order behaviour
among receivers, stimulating horizontal cooperation between logistics service
providers and including reverse logistics to optimise return flows.

Third, act and shift measures refer to two types of shifts. The first is shifting from
conventional vehicles to more sustainable modes of transport. Relevant transport
modes that are considered for this purpose are barge, rail and cargo-bike. The
second is shifting transport flows to night, early morning or late evening. These
so-called “off-hour deliveries” reduce fuel consumption, pollutant emissions,
congestion and costs, but are hindered by potential noise nuisances and difficulties
with receiver acceptance (Mommens et al., 2018).

Fourth, anticipation of new technologies encompasses new vehicle technologies,
such as full electric, hybrid electric plug-in, hydrogen and gas-powered vehicles,
but also non-road technologies are included. Such technologies encompass drones,
hybrid airships, hovercrafts and pipelines but their development potential remains unclear. Macharis and Kin (2017) describe an amalgam of other technologies that are of relevance to city logistics (e.g. load matching and routing, radiofrequency identification) and the use of big data analytics. Information from big data analysis can be used to optimise supply chain efficiency, but it also facilitates crowdsourcing in logistics. By means of a web or mobile platform, “crowd logistics” enables non-professionals to carry out professional logistics activities, including parcel delivery. In this way, trips that are made for other purposes (e.g. home–work commute) can be optimised by also carrying parcels for other people (Buldeo Rai, Verlinde, Merckx, et al., 2017).

The online retail market is particularly attractive for providers of city logistics services (Visser, Nemoto and Browne, 2014). Accordingly, logistics service providers in the parcel market are restructuring themselves to tackle the specificities and constraints of urban distribution in this rapidly changing context (Ducret, 2014). Literature on parcel distribution has mainly focused on three city logistics measures: pick-up points and lockers (Morganti et al., 2014; Arnold et al., 2018; Deutsch and Golany, 2018; Vakulenko, Hellström and Hjort, 2018; Xiao, Wang and Liu, 2018), cargo-bikes (Maes and Vanelander, 2012; Schliwa et al., 2015; Wrighton and Reiter, 2016; Conway et al., 2017; Arnold et al., 2018; Zhang et al., 2018) and crowdsourced deliveries (Lee, Kang and Prabhu, 2016; Kafle, Zou and Lin, 2017; Akeb, Moncef and Durand, 2018). As the literature review showed, many other measures exist that could be of relevance for logistics service providers. Therefore, by means of a case-study research focusing on Brussels, this paper investigates how logistics service providers organise parcel distribution and why they (do not) adopt and scale-up particular city logistics measures. To this end, we explore the measures’ feasibility and implementation potential.

Methodology

Research approach
Our review of the literature demonstrates limited knowledge on the link between growing parcel volumes and the introduction of city logistics measures by logistics service providers. Hence, the research question aims to develop propositions on how logistics service providers organise parcel distribution and why they (do not) implement certain city logistics measures. As our research question attends to an open and underexplored topic, we analyse it empirically by means of a case-study. The case-study method is a comprehensive research strategy (Yin, 1984), suitable
when “how” and “why” questions are asked about contemporary events, particularly in emerging fields of research (Yin, 1984; Seuring, 2005).

In this research, we investigate parcel distribution in Brussels, Belgium’s largest city and capital, which we present as a “typical” case (Yin, 1984). Such case stands as an example for a wider group of cases, this being mid to large-sized European cities. In line with global trends, online retail is becoming increasingly important in Brussels. As specific information on city-level is scarce, we rely on country-level information. 60% of Belgians made a purchase in the last twelve months, similar to the European average of 57% (Eurostat, 2018). In 2017, Belgian e-commerce sales grew with 15.6%, capturing 7.3% of total retail trade (Ecommerce Europe, 2018; Statista, 2018b). These numbers are similar to the European average (with a growth rate of 12.4% and a retail trade share of 8.8%) and deviate from Europe’s leading market, the UK (with a growth rate of 8.3% and a retail trade share of 17.8%).

In terms of omnichannel retail, in which e-commerce is combined with other channels, 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 (Ecommerce News, 2018). As omnichannel retail embraces physical stores as part of its comprehensive strategy (Wollenburg et al., 2018), the effect of e-commerce on Brussels’ store network decline might be moderate compared to other European cities. In 2017, Brussels counted 20,696 stores, noting a 8.4% decline since 1997 (Atrium, 2017).

Factors that impact on online sales, next to i) physical store presence, include ii) population age, iii) penetration of online groceries and iv) use of smartphones (Mintel, 2016). Brussels’ population is relatively young, with 41% being 30 years or less (VGC, 2015). Young people are heavy users of internet for retailing, but also older people are becoming more regular online shoppers (Mintel, 2016). Concerning e-grocery, 20% of Belgians use online channels to buy food (Comeos, 2018). Although 25% of Belgians reject this practice, the share of people that did increased with 12% over the last seven years. Also smartphone use increased: 35% of Belgians used it for online purchasing in 2017 and 12% made online purchases by using their smartphone exclusively (Comeos, 2018).

**Data collection**

Case-studies typically rely on archives, interviews, questionnaires and observations to collect data (Eisenhardt, 1989). In line with Yin (1984) and Stuart et al. (2002) that advocate for triangulation, we combined two data collection methods: document analysis and semi-structured expert interviews. We focused our data collection on six logistics service providers that are active in Brussels, so-called
“heirs” (Ducret, 2014). As opposed to the “new players”, heirs are traditional players in the parcel market that have been present in urban distribution since the seventies and eighties, in which they hold a strong position. The group of heirs consists of four types of players: i) national post offices, ii) express transport providers, iii) historic actors of mail-order sales and iv) couriers (Ducret, 2014). All types are represented in our selection of logistics service providers, except type three as there is no such player in Belgium or Brussels. Together, these logistics service providers capture the vast majority of Brussels’ parcel volume (Strale et al., 2015).

In the first phase, we carried out a document analysis. Such analysis comprehends a systematic procedure for reviewing and evaluating printed and electronic documents (Bowen, 2009). We made use of two sources of information: annual reports of the logistics service providers and news articles on the logistics service providers’ city logistics initiatives. The annual reports were retrieved from the logistics service providers’ corporate websites and the news articles were collected on two logistics news portals (Flows.be and Logistiek.nl). These portals are among the most important news providers on logistics in the region. We completed this analysis of 18 annual reports and 175 articles that were published between 2014 and 2017 in the beginning of 2018. The document analysis allowed us to capture current developments and initiatives of the logistics service providers but did not provide insight on individual cities and the actual scale of implementation. It mainly served as thorough preparation for the expert interviews.

In the second phase, we organised semi-structured expert interviews with senior managers from the logistics service providers. The expert-interview is a suitable data-collection technique, because the knowledge of the experts stems from their position within the companies (Creswell, 2003). In March and April 2018, we carried out nine interviews. All interviews were organised in a face-to-face setting, lasting between one hour and one hour and a half. According to literature, six to twelve interviews are sufficient to describe and explore structures for a homogenous group of respondents (Guest, Bunce and Johnson, 2006). One of the logistics service providers included in our research applies a strong merger-and-acquisition strategy to strengthen its position in the parcel market. To obtain a profound understanding of its motivation and activities, we included three interviews with logistics service providers that joined the group. Table 3 provides an overview of the interviews.

We used a data collection instrument (i.e. a “topic list”) to structure the interviews. This instrument was developed based on the literature review and document analysis. After introducing the research scope and purpose, the interviews covered three aspects: i) parcel distribution in Brussels’ omnichannel environment (changes, opportunities and threats), ii) implementation of city logistics measures in Brussels...
(current and planned) and iii) policy-making for parcel distribution in Brussels. We also collected quantitative data during the interviews, including number of parcels, share of business-to-consumer deliveries, share of retail customers, number of vehicles alternative to vans, number of pick-up points and lockers and the evolution of numbers and shares in the past five years. When requested, we worked with data user agreements to sign up the terms of data use and dissemination. During the interviews, we also worked with prompts, or non-scripted questions, to acquire a more detailed and deeper understanding (Leech, 2002).

Table 3. List of respondents.

<table>
<thead>
<tr>
<th>Logistics service provider description</th>
<th>Respondent title</th>
<th>Interview date</th>
</tr>
</thead>
<tbody>
<tr>
<td>New player 1</td>
<td>Founder</td>
<td>13/03/2018</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Pre-test interview)</td>
</tr>
<tr>
<td>Heir 1*</td>
<td>General manager</td>
<td>14/03/2018</td>
</tr>
<tr>
<td>Heir 2</td>
<td>General manager</td>
<td>15/03/2018</td>
</tr>
<tr>
<td></td>
<td>Distribution centre manager</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Customer experience manager</td>
<td></td>
</tr>
<tr>
<td>Heir 3</td>
<td>Public affairs manager</td>
<td>21/03/2018</td>
</tr>
<tr>
<td>Heir 4*</td>
<td>Vice president parcels</td>
<td>26/03/2018</td>
</tr>
<tr>
<td>New player 3*</td>
<td>Corporate operations manager</td>
<td>27/03/2018</td>
</tr>
<tr>
<td>Heir 5</td>
<td>Marketing manager</td>
<td>29/03/2018</td>
</tr>
<tr>
<td>New player 4*</td>
<td>General manager</td>
<td>29/03/2018</td>
</tr>
<tr>
<td></td>
<td>Head of information technology</td>
<td></td>
</tr>
<tr>
<td>Heir 6</td>
<td>Director operations</td>
<td>26/04/2018</td>
</tr>
<tr>
<td>Heir 7</td>
<td>Vice president operations</td>
<td>27/04/2018</td>
</tr>
</tbody>
</table>

* Logistics service providers that belong to the same group.

Prior to the interviews, we tested our data collection instrument in a pilot interview with the founder of an innovative urban freight company in Brussels, that has experimented with business-to-consumer deliveries in the past. Despite not delivering business-to-consumer parcels at this time, the founder has experience and knowledge on both logistics and Brussels and therefore served as an excellent candidate to test and verify the instrument.

Data analysis
To analyse the articles and reports from the document analysis and transcripts from the expert interviews, we used NVivo (http://www.qsrinternational.com/nvivo/nvivo-products.), a computer-assisted qualitative data analysis software (Miles and Huberman, 1994). We applied the software to manage, store, organise and code the data, structure and categorise it and find connections. The interviewer conducted
the analysis of the interviews to ensure that the interview context was captured adequately. Because the document analysis served as interview preparation, we did not combine the data from both data collection efforts in the software. Succeeding data collection and analysis, we organised a dissemination event on 06/06/2018 with the interview respondents and other stakeholders, to present and validate our research findings.

Findings

Parcel distribution in Brussels
Approximately 45,000 business-to-consumer parcels are delivered to the Brussels-Capital Region on a daily basis. One logistics service provider is responsible for a large part of this volume. According to respondents, this figure will grow annually by 20% to 30% over the next years. The group of consumers shopping online increases and consumers shop more frequently. One development that would further spur the process, is the introduction and large-scale adoption of on-demand home delivery services for fast moving consumer goods, as manifested in neighbouring countries UK and Germany by Amazon.

This section covers a complete description of logistics service providers’ perception of the Brussels’ parcel market (unless referenced otherwise) and how they organise the distribution of these parcels. Structured by the four A’s overview of Macharis and Kin (2017), we discuss which city logistics measures are implemented and the arguments behind implementation. Table 4 provides a summary of these findings. We make a distinction between measures that are implemented on a large scale (in dark blue) and on a small scale (in light blue), and between measures that are implemented at the moment (in dark or light blue) and planned for the future (in pink). Some measures from the original four A’s overview are excluded from this section, as they are outside of logistics service providers’ impact area. These measures are downloading, product packaging and 3D-printing. Accordingly, Macharis and Kin (2017) provide examples of Amazon and IKEA, both retailers, in their discussion of these measures.

Today’s parcel distribution market is driven by large marketplaces. There are only few of these marketplaces, but they capture the largest part of sales online. According to The Retail Academy (2018), 3,9% of online shops are responsible for 89% of the online transaction volume. Compared to individual web-shops, such marketplaces have a strong negotiation power towards logistics service providers that distribute their parcels, resulting in lower lead times and delivery prices. What’s
more, to ease hesitation and mistrust of consumers towards online channels, these marketplaces introduced appealing delivery conditions that could compete and even exceed the experience of shopping in physical stores. To consumers, these delivery conditions quickly became part of standard service, pushing other retailers to offer delivery services that are fast, convenient and free as well. “Free shipping” means that retailers are compensating for this, by adding delivery costs to the product price or addressing marketing funds. Resulting from these developments, logistics service providers in the parcel market are struggling to sustain their margins. Accordingly, they emphasize the importance and added value of logistics services to their customers, and the corresponding cost for delivering such service. Most importantly, logistics service providers are focused on optimising the parcel distribution process to decrease the cost for delivering parcels.

Table 4. Overview of the four A’s with respective measures adapted from Macharis and Kin (2017), with dark blue boxes referring to large-scale implementation of measures, light blue boxes referring to small-scale implementation of measures, pink boxes referring to implementation of measures in the future and white boxes referring to measures that are not considered for implementation.

<table>
<thead>
<tr>
<th>Awareness</th>
<th>Avoidance</th>
<th>Act and shift</th>
<th>Anticipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculation tools for CO₂ and external costs</td>
<td>Consolidation centre</td>
<td>Barge</td>
<td>Electric vehicle</td>
</tr>
<tr>
<td>Programmes and certification</td>
<td>Micro-consolidation centre</td>
<td>Rail</td>
<td>Hydrogen vehicle</td>
</tr>
<tr>
<td>Pick-up points and lockers</td>
<td>Receiver behaviour</td>
<td>Cargo-bike</td>
<td>Gas-powered vehicle</td>
</tr>
<tr>
<td>Horizontal cooperation</td>
<td>Off-hour deliveries</td>
<td>Non-road technologies</td>
<td></td>
</tr>
<tr>
<td>Return logistics</td>
<td></td>
<td>Smart locks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Big) data analytics</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crowd logistics</td>
<td></td>
</tr>
</tbody>
</table>

The case-study identified four aspects that determine parcel distribution efficiency: i) volume, ii) stop density, iii) delivery failure and iv) urban regulation. Different city logistics measures are considered and implemented to address these aspects. An overview of our findings is visualised in Figure 7, after which a detailed description follows.

**Volume**

Despite large differences in volume among logistics service providers in Brussels, all players record growth. Increasing delivery volumes and decreasing costs per delivery go hand in hand. Accordingly, logistics service providers are engaged to sustain this growth. Co-distribution of parcels via horizontal cooperation is a way to achieve this. Generally, there is no willingness among logistics service providers

*Helen Buldeo Rai*
to share volumes. Next to barriers of reliability and fair allocation of work and revenues (Cruijssen, Cools and Dullaert, 2007), logistics service providers in the parcel market are averse from sharing data with their competition. Other barriers relate to complication of insurance, competition laws and warranty. Most importantly, as last mile delivery is their core activity, logistics service providers fear quality and service losses when competitors interfere. “You want to distinguish yourself from your competitors and in this way, you give that away”, states one respondent. Despite general rejection, two logistics service providers in Brussels are effectively bundling flows. In practice, a logistics service provider with smaller parcel volumes collaborates with the largest logistics service provider that delivers more profitably, in this way reducing costs for both parties. Nonetheless, horizontal cooperation in Brussels’ parcel market remains small-scale and its sustainability in the long term is unclear.

Parcel volumes grow substantially, but this growth is not spread evenly in time. Particularly challenging are the end-of-year holiday period and imported “shopping frenzies” such as Black Friday (US) and Singles Day (China). On such days, online purchases double, complicating logistics service providers’ staff management. Responding to this matter, crowd logistics is considered for implementation in the future. As business model on its own, crowd logistics is expected to remain small-scale and niche, facilitating primarily home delivery services of independent retail, consumer-to-consumer commerce and on-demand delivery. “With today’s parcel volume and the growth that we see, you need a well-oiled machine for distribution”, which crowd logistics is not, says one respondent. Of interest to logistics service providers is the possibility to add the concept
of crowd to their existing business model. Although there are “believers” and “non-believers” of crowd logistics’ added value and service capacities, some logistics service providers consider complementing their staff with irregular crowd workers to handle fluctuation in demand. What’s clear for both crowd logistics models, is that instead of optimising transport by adding parcels to existing passenger trips, this crowd makes dedicated trips for the purpose of delivery. In this way, it is highly unlikely that the envisioned environmental benefits from crowd logistics will materialise. Nevertheless, large marketplaces are replacing traditional logistics service providers with crowd logistics solutions for distributing their parcel volume in neighbouring countries. For logistics service providers, this is a more stringent argument to embrace crowd logistics than environmental concerns.

Stop density

Logistics service providers are concerned with parcel volume as it enables to optimise delivery routes, improve vehicles' load rates and increase parcel density per stop. Over the years, drop factors in retail declined, as retailers enhanced their valuable urban space for commercial activities at the expense of inventory. The omnichannel environment maintains this trend. Omnichannel retailers ship parcels from distribution centres to stores, from distribution centres to homes, from stores to homes and from stores to stores, increasing fragmentation in distribution and decreasing parcel density. Pushing usage of pick-up points and lockers is a way to accommodate this development in the last and first mile. Irrespective of parcel volume, all logistics service providers are investing heavily in this solution. In the last mile, pick-up points and lockers are alternative locations for home delivery, allowing a bundle of parcels to be delivered at one stop, instead of delivering parcels at several individual stops. This application is discussed most in literature. In the first mile, pick-up points and lockers are a drop-off location for retailers and return location for consumers' unwanted or faulty products. As drop-off location, logistics service providers push store-based retailers that have a small number of parcels to be shipped per day to cover the first mile of parcel distribution themselves. In this way, logistics service providers optimise their stops, in return for discounting the pick-up fee. As return location, logistics service providers consolidate delivery and reverse flows. Although experiments run in other cities with picking up products at consumers' homes, the only return logistics option for Brussels consumers is pick-up points and lockers.

Today, there are 42 automatic lockers and 646 manned pick-up points in Brussels (BIPT, 2018). All logistics service providers have plans for improvement, making it a large-scale implemented measure. These improvements comprise not only proximity, but also flexibility. Most inhabitants have pick-up points in their close
neighbourhood and logistics service providers want to improve their offer with evening and Sunday availability.

**Delivery failure**

“As opposed to stores, consumers’ opening hours are unknown”. Hence, a major obstacle in business-to-consumer parcel distribution is the probability that consumers are not present to receive their parcels when offered. The case-study points to current delivery conditions as key reasons: free shipping and next-day delivery. As consumers do not explicitly pay for delivery, they are insufficiently stimulated to plan their parcel reception. Moreover, delivery is often next-day by default, without the possibility to change or choose a fitting delivery date, which hinders consumers’ planning. Failed first-time delivery attempts lead to inefficiencies for logistics service providers but also displeased consumers, which reflects poorly on retailers in turn. As home delivery increases, so does the number of failed deliveries (Weltevreden, 2008). Thus, to increase the share of successful deliveries, three measures stand out: receiver behaviour (possibly in combination with (big) data analytics), other technologies such as smart locks and pick-up points and lockers.

Much of logistics service providers’ current initiatives focus on getting consumers involved in the parcel distribution process, in this way affecting receiver behaviour. This focus stems from the way distribution is commonly organised. Logistics service providers’ customers are the suppliers of products. Together, logistics service providers and suppliers determine delivery conditions and services in contractual agreements. Accordingly, a formal connection exists between logistics service providers and the suppliers, and the suppliers and their customers, but there is no connection between logistics service providers and the suppliers’ customers, which are the product receivers. This organisation leads to delivery inefficiencies. Verlinde et al. (2012) conceptualised this phenomenon in a business-to-business context, but it also holds strongly for business-to-consumer parcel delivery. This absence of formal connection between logistics service providers and the customers (consumers) of their customers (retailers), results in lacking communication about how the delivery service (in terms of date, time, location) should be executed in order to be successful. This mode of operation is visualised in Figure 8.

To bridge this communication gap between them and the receiving end, all logistics service providers implemented tools by means of (big) data analytics, and all are working on improvements. The most important tools are mobile applications and webpages send by links in text messages or e-mails. They serve three purposes: i) preference selection, ii) status notification and iii) parcel rerouting. First, logistics service providers offer consumers the possibility to entrust their delivery preferences.
Such preferences include a preferred neighbour or specific safe place near their home in case of absence, or a particular pick-up point or locker location where they prefer to be delivered instead of at home. By giving consumers the possibility to complete this information, logistics service providers are less dependent on options that retailers offer and information that they collect. Such preferences can apply by default, but they can also be reported or adjusted for specific deliveries. Second, logistics service providers push delivery status notifications to consumers and allow consumers to pull delivery status information. Such information is both real-time, based on drivers’ routing and last scans, and predictive, based on average routing information. By improving accuracy and detail of this information, delivery success rates increase. Third, logistics service providers offer dynamic rerouting options for parcels. This option allows consumers to change delivery date, time and/or location last minute, when parcels are already en route. In this way, logistics service providers avoid unnecessary stops and can adjust routes accordingly. While communication between logistics service providers and consumers is advantageous for enhancing delivery failure, it also creates expectations and pressure to meet these expectations. One technological innovation has the potential to dissolve the problem of delivery failure completely: the “smart lock”. Smart locks are keyless electronic door locks that are operated through mobile applications on consumers’ smartphones and allow third parties to unlock private delivery locations with a unique, one-time-use digital key (Reyes, Savelsbergh and Toriello, 2017). For parcel delivery, smart locks have been tested on houses and car trunks, to deliver products when consumers...

Figure 8. The common mode of operation within business-to-consumer parcel distribution, characterised by the lack of formal connection between logistics service provider and consumer, adapted from Verlinde et al. (2012).
are not there to receive them. Two logistics service providers with the largest parcel volume have successfully carried out these tests and judge the technology to be ready for implementation. Consumers constitute the main obstacle. At the moment, willingness to adopt smart locks is considered low because of issues with trust, safety and privacy. Ultimately, when delivery still fails, logistics service providers profit from their extensive network of pick-up points and lockers. This network releases them from having to return to consumers’ homes a second and even third time. In fact, “when a consumer is absent the first time, our drivers know chances are small he or she will be there the next day”, summarises one respondent. In this way, pick-up points and lockers fulfil several tasks in optimising parcel distribution.

Urban regulation
Local authorities want to enhance urban quality of life by regulating transport and logistics. In Brussels, a freight transport plan was developed to improve sustainability of the logistics sector. Different stakeholders were included from the beginning of the project, to collaborate and create support (Brussels Mobility, 2013). Such policies and regulations affect logistics service providers that distribute parcels. Within this changing context, they investigate ways to remain efficient, while also improving their environmental and societal impact. Several concepts have been introduced, tested and/or implemented in cities, but so far they have not gained large-scale traction in Brussels.

In terms of vehicles, conventional vans still dominate parcel delivery. The most accepted alternatives to these vans are powered on gas. Several logistics service providers have complemented their fleet with CNG vans, although its share remains limited. Given the way parcel distribution is organised today, logistics service providers do not consider electric vehicles and cargo-bikes as realistic alternatives. Problems noted with electric vehicles are reliability, flexibility and total cost of ownership. Moreover, many of the issues related to urban distribution are irrespective of the vehicle technology (e.g. double parking, congestion). Only logistics service providers that dispose of larger parcel volumes are investigating the options of electric and CNG vans. Challenges concerned with using cargo-bikes are related to size and capacity of the bike, its ability to be used in all weather conditions and finding qualified drivers. Moreover, cargo-bikes are only appropriate for small-sized parcels, which accounts for most of the business-to-consumer deliveries. However, the respondents noted that parcel sizes are growing as consumers are ordering larger products online, including furniture and kitchen appliances.

In terms of facilities, one logistics service provider operates a consolidation centre
located at the edge of the city. So far, the centre is mainly occupied with business-to-business transport, carried out on behalf of long-haul carriers that avoid entering the city. Although its share of business-to-consumer activity is growing, it seems unlikely that logistics service providers in the parcel market will collaborate in joint initiatives that imply sharing and consolidating with competitors. A suggested way forward for viable urban consolidation centres involves collaborating with retailers. In this way, retailers can order large volumes and capture discounts, while storing products that are not immediately needed in the centre’s facility. When required, the consolidation centre replenishes the store on an efficiently organised trip.

On an individual basis, there is great interest in micro-consolidation centres or “micro-hubs”. These are small logistics facilities in city centres, from which local parcel distribution rounds are organised with sustainable vehicles (Janjevic and Ndiaye, 2014). Only in combination with such micro-hubs, cargo-bikes become of interest to logistics service providers. Not only does this combination of measures contribute to urban sustainability, most logistics service providers find it reduces cost and delivery lead times. Counterintuitively, large parcel volumes do not necessarily imply interest in this solution. Contrary, micro-hubs and cargo-bike solutions are being developed by logistics service providers that are predominantly focused on business-to-consumer activities or parcel transport activities (i.e. as opposed to pallet transport) and rely on experiences and expertise acquired within an international group. Micro-hubs are usually small facilities, scattered around the city. Most challenging is finding suitable locations. The facility should have sufficient access, as they are supplied with larger vehicles, and sufficient space, for loading and storing the bikes. Moreover, micro-hubs are ideally located in the middle of the area that captures most deliveries. Two types of micro-hubs are considered: mobile locations, by means of a trailer, and fixed locations, such as parking garages. Logistics service providers are inclined to rent such spaces or employ facilities owned by subcontractors.

Some measures are not considered in Brussels at the moment but could be applicable in the future. These measures include parcel distribution by barge or rail and the use of hydrogen vehicles. Other measures were found less relevant for a context of business-to-consumer parcel distribution in cities, in general. These are calculation tools for CO₂ and external costs, programmes and certifications, off-hour deliveries and non-road technologies. Online retail provides a significant source of income and growth for logistics service providers. Accordingly, they are dedicated towards removing barriers for parcel delivery instead of stimulating resistance, which can potentially be done by reporting on CO₂ emissions and external costs of delivering parcels. Next to this, no programmes or certifications are currently set up by logistics service providers in parcel distribution to raise
awareness. Logistics service providers are however starting the dialogue with their retail customers that next-day delivery at home does not necessarily lead to consumer satisfaction. Alternatives that decrease delivery failure and increase delivery efficiency are proposed instead (e.g. pick-up points, lockers, choice of delivery date). What’s clear, is that consumers have no preference for receiving parcels in the off-hours: very late evening, night or very early morning. Not surprisingly, receiver attitude for off-hour delivery is even more an issue among consumers than it is among businesses, which makes this measure redundant. Non-road technologies are considered for implementation, but neither for parcels nor cities. Drones, most notably, are particularly suitable for delivering urgent, high-value products in low density areas, contrasting with generally non-urgent, low-value parcels distributed in cities. Another technology proposed for urban parcel distribution, albeit road-based, is the delivery robot. Because of cost and unsuitability of urban pavements and roads, delivery robots are not considered for large-scale adoption any time soon.

**Policy implications**

Two ways are suggested in which local authorities can facilitate adoption of city logistics measures for parcel distribution: first, cooperation and information exchange with logistics service providers and second, a harmonised and long-term vision on freight transport policy across cities and regions. Logistics service providers implementing city logistics measures gain from collaboration with local authorities, in particular when experimenting with alternative vehicles (e.g. cargo-bikes) and facilities (e.g. micro-hubs). This collaboration is envisioned to provide both immaterial and material input. In terms of immaterial input, logistics service providers are looking for local knowledge and experience that can be used to define and refine implementation plans. Examples include information on urban design, traffic situation, road works and local regulation. When implementing such city logistics measures, local authorities serve as crucial partner for co-development, evaluation and support. In terms of material input, logistics service providers’ main obstacle is finding appropriate locations. Micro-hubs and cargo-bikes are most interesting when located amidst the area where most parcels go. This is often in highly commercial areas or business districts, where urban space is expensive and scarce. Therefore, logistics service providers look at local authorities to facilitate the search for appropriate spaces, or even to provide spaces themselves that logistics service providers can test and try temporarily. Facilitating urban spaces for city logistics is a way for local authorities to push sustainable urban freight transport and ultimately even to realise shared use of facilities, despite general reluctance among logistics service providers.
To urban authorities, problems with urban freight transport and sustainability are local and need to be addressed with local policies and regulations (Browne et al., 2012). Accordingly, cities restrict access to certain vehicles, in certain zones and during certain times. Policies and regulations thus differ from city to city, despite sharing the same goal. Because of this differentiation in regulation, logistics service providers encounter difficulties in adopting an efficient city logistics model that responds to local restrictions and can be developed nationally. To facilitate adoption of city logistics measures, there is need for a harmonised freight policy plan with a clear long-term vision. More than guiding logistics service providers in a uniform direction, it enables them to counterbalance their investments over a longer period of time. To achieve such urban freight policy plan, collaboration and cooperation between cities and regions is needed.

Conclusion

Consumers live in an omnichannel environment, in which they use both online and offline channels for their shopping activities. The result is a steep increase in parcels that are shipped to consumers’ homes (Galipoglu et al., 2018). Particularly in cities, freight systems have to cope with growing parcel demand. To this end, a range of city logistics measures has been introduced, tested and/or implemented. Such measures are aimed to improve efficiency and reduce the adverse impacts of urban freight transport (Taniguchi, 2015). Rising parcel volumes have been presumed to accelerate implementation of city logistics measures (Visser, Nemoto and Browne, 2014; Goodchild, 2017), but research on the topic remains limited (Ducret, 2014). With this research, we studied this link between growing parcel volumes and the introduction of city logistics measures by logistics service providers. Our goal was to find out how parcel distribution is organised and why logistics service providers prefer particular city logistics measures over others. To this end, we applied a case-study research with focus on Brussels, Belgium’s largest city and capital. Data for the case-study was collected via document-analysis and semi-structured expert interviews with six logistics service providers. Findings demonstrate that distribution efficiency of business-to-consumer parcels is affected by four determinants: parcel volume, stop density, delivery failure and urban regulation. Accordingly, logistics service providers implement city logistics measures that are able to address each of these determinants. We found that parcel distribution in Brussels is dominated by conventional vehicles and modes of operation, but regulations and policies advance the use of micro-
hubs in combination with cargo-bikes in the near future. However, there is no willingness among logistics service providers to share such facilities. City logistics measures that gained most traction so far are pick-up points and lockers and tools to address receiver behaviour. Adoption of city logistics measures can be facilitated by collaboration and information exchange between local authorities and logistics service providers, but a harmonised and long-term vision on policymaking for urban freight transport across cities and regions could be a game-changer. Our research has focused on six logistics service providers, that jointly capture the main share of Brussels’ parcel market. There are more companies active in Brussels, mainly new players with innovative business models. They were excluded from this research as they represent a marginal share of total parcel volume. These players remain important nevertheless, in raising awareness, testing the market and setting example for alternative ways of parcel distribution.

Despite differences among cities in terms of geographic, economic, social and cultural circumstances, parcel volumes and sustainability concerns are developing consistently throughout Europe. Accordingly, logistics service providers in the parcel market face the same issues and adopt similar strategies to handle them (Ducret, 2014). Therefore, theories and insights from this case-study are exemplary beyond Brussels and could be expanded and generalised to other mid to large-sized European cities as well. Nevertheless, future research is needed to validate this assumption and to find out how cities can realise harmonised policy-making for sustainable urban freight transport in the future.
Chapter 3

Crowd logistics: an opportunity for more sustainable urban freight transport?  

Introduction

The distribution of goods in urban areas is a point of departure in many research papers, in which both its essential character and the many sustainability issues it raises, are acknowledged. Essential, because most goods are not consumed where they are produced, which is particularly true for cities, leading to the necessity to transport large amounts of goods and waste into and out of the city (Verlinde, 2015). Urban freight transport contributes to wealth generating activities and the competitiveness of industry (Anderson, Allen and Browne, 2005), but it also generates negative social and environmental impacts. These impacts include, but are not limited to, fossil fuel consumption, greenhouse gas emissions, air pollution, noise, road safety and traffic congestion. Moreover, those performing freight transport operations experience problems that relate to traffic flows, transport policy, loading/unloading and customer service, which are considered negative economic impacts (Allen, Browne and Holguín-veras, 2015). In order to address these issues, many innovative solutions have been introduced. Most proposals concentrate on enhancing either passenger or freight flows. Given the average passenger car occupancy rate of 1.45, driver included (Martins, Bermejo and Souza, 2015), a significant part of the available transport capacities is not exploited (Mladenow, Bauer and Strauss, 2016). The growing interest in shared passenger and freight transportation practices (Chen, Mes and Schutten, 2017) indicates that an important opportunity could be in combining both. Crowd logistics – alternatively termed crowdshipping, crowdsourced delivery, cargohitching or collaborative logistics – is presented as a promising concept as it encourages passengers to use their spare carrying capacity on cars, bikes, buses and planes to carry parcels for other people (McKinnon and Bilski, 2015). Crowd logistics uses the excess capacity on premeditated trips that already take place to make deliveries (Arslan et al., 2016), leading to maximisation of logistics efficiency and reduction of emissions and traffic (McInerney, Rogers and Jennings, 2013; Rougès and Montreuil, 2014; Durand et al., 2014; McKinnon, 2015; McKinnon and Bilski, 2015; Mehnmann, Frehe and Teuteberg, 2015; Arslan et al., 2016; Chen et al., 2016; Mladenow, Bauer and Strauss, 2016; Paloheimo, Lettenmeier and Waris, 2016; Y. Wang et al., 2016; Crainic and Montreuil, 2016; Dörrzapf et al., 2016; Chen, Mes and Schutten, 2017).

Crowd logistics relates to the idea of the physical internet, as well as to the global sharing economy trend. The physical internet is a concept for freight transportation and logistics, aiming to improve efficiency and sustainability of the way physical

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objects are moved, stored, realised, supplied and used all across the world by applying concepts from internet data transfer to real-world shipping processes (Crainic and Montreuil, 2016). The idea is to encapsulate physical objects in modular packets and containers of which the header contains all information required for identifying the packet. These packets and containers are then routed as efficiently as possible so that it absorbs spare capacity in transport systems, ensuring that they get to their destination in time, regardless of the route followed (McKinnon and Bilski, 2015). Crowd logistics relates to physical internet because technology enables passengers to use the capacity in their vehicle more efficiently, by carrying parcels for others. Sharing your vehicle with (freight volume of) others makes crowd logistics also part of a larger trend of sharing, termed the collaborative or sharing economy, which is a fast-growing sector disrupting mainstream industries (Cohen and Muñoz, 2015; Arslan et al., 2016). In the sharing economy, physical assets become services that are redistributed, shared and reused more easily and inexpensively than ever before, thanks to technological advancements (Archetti, Savelsbergh and Speranza, 2016; Arslan et al., 2016). Daveiro and Vaughan (2016) detect a thriving start-up scene for sharing initiatives across Europe and estimate that at least 275 platforms have been founded to date. A survey instructed by the European Commission shows that half of the respondents (52%) have heard of such sharing economy platforms and around two in ten respondents say that they have used them (17%). The most likely users are younger and highly educated respondents who live in urban areas (European Commission, 2016b). The sharing economy affects a variety of sectors, including mobility and transportation, to which crowd logistics belongs.

To date, limited scientific research has been done on the potential economic, social and environmental benefits of sharing economy activity in general and crowd logistics in particular. Primarily practitioners have been showing interest in crowd logistics, resulting in a growing number of start-ups and platforms. Increasingly, concepts are introduced that deviate from the initial idea, to a small extent by allowing considerable detours from the planned journey and, to a larger extent, by depending on dedicated trips. UberRush and Postmates, for example, offer on-demand deliveries. Their couriers make themselves available for a self-chosen period to use their own vehicle to carry out dedicated deliveries (Postmates, 2019; Uber Technologies Inc., 2019b, 2019a). This way of working raises the question which types of crowd logistics concepts have the ability of increasing urban sustainability of both passenger and freight transport.

To address this question, we combined desk and field research. First, we systematically reviewed the available literature to formulate a comprehensive definition of crowd logistics. Second, we defined a set of eighteen criteria that
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characterise the variety of crowd logistics concepts. Theoretical insights were verified with eleven semi-structured interviews with practitioners that expressed an interest in using the crowd in their logistics activities. Third, we used the same body of information to evaluate whether these eighteen characteristics affect economy, society and environment.

This paper covers a literature discussion in the second section, in which the crowd logistics concept is introduced and fit in the four A's of sustainable city distribution framework that classifies innovative city distribution solutions (Macharis and Kin, 2017b). The third section clarifies the methodological approach of the research while the fourth section elaborates on research findings. The fifth section discusses these findings and explains final conclusions.

Literature

Crowd logistics originates from the term crowdsourcing, which covers both the word “crowd” or a mass of people and “outsourcing” or the shift of processes, functions and duties to third parties (Mehmann, Frehe and Teuteberg, 2015). In the transition towards sustainable urban freight transport, crowd logistics has the capacity to contribute. Sustainable development is most commonly defined as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). With this, the joint harmonisation of three issues is implied: economic growth, social equality and protection of environmental resources (Zito and Salvo, 2011). This could also be referred to as the triple-P or triple bottom line of sustainability (People, Profit, Planet) (Soubbotina, 2004). For the urban freight transport system to reach comprehensive sustainable development, necessary requirements are economic development and vitality, social wellbeing and environmental preservation and regeneration (Gudmundsson et al., 2016). In economic terms, the success of many sharing economy initiatives indicates the substantial efficiency gains that can be realised (Demary and Engels, 2016). With regards to logistics, crowd logistics provides consumers access to a more extensive range of products (Botsman, 2014b) and superior delivery service by being faster (Botsman, 2014b; Arslan et al., 2016; Chen, Mes and Schutten, 2017), more flexible (McKinnon, 2015; Mehmann, Frehe and Teuteberg, 2015; Mladenow, Bauer and Strauss, 2016), more convenient (Rougès and Montreuil, 2014), more personal (Botsman, 2014b; Rougès and Montreuil, 2014), traceable in real-time (Hodson, 2013) and better priced (Rougès and Montreuil, 2014; Arslan et al., 2016; Mladenow, Bauer and Strauss, 2016).
Businesses benefit from crowd logistics since it has the potential to reach a large area (Mcinerney, Rogers and Jennings, 2013; Mladenow, Bauer and Strauss, 2016), relies upon a flexible workforce (Carbone, Rouquet and Roussat, 2015) and requires only an asset-light infrastructure that makes investments in vehicle fleet, employees and maintenance redundant (Erickson and Trauth, 2013; Botsman, 2014b; Carbone, Rouquet and Roussat, 2015; McKinnon, 2015; Mladenow, Bauer and Strauss, 2016; Y. Wang et al., 2016). The crowd is motivated by additional earning opportunities that are flexible, personalised and adaptable to their lifestyle (Rougès and Montreuil, 2014; McKinnon, 2015; Mladenow, Bauer and Strauss, 2016). From a social point of view, the local character of crowd logistics is stressed, enabling the crowd to have personal contact with their neighbourhood and empowering communities (Mcinerney, Rogers and Jennings, 2013; Carbone, Rouquet and Roussat, 2015; Mladenow, Bauer and Strauss, 2016). The most significant contributions of crowd logistics are, however, envisioned from an environmental perspective. By utilising existing transportation flows, crowd logistics encourages consolidation (Cohen and Muñoz, 2015), leads to more efficient vehicle loads and routes (Mladenow, Bauer and Strauss, 2016; Paloheimo, Lettenmeier and Waris, 2016) and reduces traffic, congestion and air polluting emissions (Durand et al., 2014; Rougès and Montreuil, 2014; McKinnon, 2015; Arslan et al., 2016; Chen et al., 2016; Y. Wang et al., 2016; Crainic and Montreuil, 2016; Dörrzapf et al., 2016; Mladenow, Bauer and Strauss, 2016; Paloheimo, Lettenmeier and Waris, 2016; Chen, Mes and Schutten, 2017).

Macharis and Kin (2017) propose a classification called the four A’s of sustainable city distribution that clusters innovative concepts based on their primary intention: Awareness, Avoidance, Act and shift and Anticipation of new technologies. It could be argued that crowd logistics complies with all A’s. First, by involving a crowd of randomly united citizens, awareness is created of the challenges that last mile transportation and home delivery impose on the city. E-commerce and omnichannel retail, which integrates online and offline sales channels, stimulate a rising amount of individual parcels and delivery vans (Savelsbergh and Van Woensel, 2016). At the same time, altered mobility, demographic change and increasing employment reduce the possibility to successfully receive deliveries in person (Taylor, 2015). This “online shopping paradox” has substantial consequences regarding environment and quality of life, yet it is unlikely that consumers take these into account when placing orders. Crowd logistics enables consumers to observe the large quantity of parcels that circulates in the neighbourhood, city or region and the spatial opportunities of commuters that move between home and business every day.

Second, by encouraging citizens to make use of the free capacity on a trip that
was intended to be made either way, redundant vehicle kilometres of polluting vans can be avoided. Moreover, as citizens are more flexible and interconnected than traditional logistics service providers, the number of failed deliveries can be reduced. In addition, integrating the crowd with other initiatives such as small load containers and pick-own-parcel stations potentially provides sustainability advantages in the future (Harald et al., 2016; Y. Wang et al., 2016).

Third, as citizens are invited to carry a chosen number of parcels on a chosen time and trajectory, the possibilities for shifting to alternative modes increase considerably. The crowd can opt to deliver a parcel on their daily commute by public transportation or to pick up their neighbours’ parcels and carry out the deliveries by bike or on foot.

Fourth, crowd logistics is an evident example of new technologies anticipation and digitalisation, as it is primarily based on exploiting the potential offered by mobile apps, geo-localisation, communication and navigation tools (Botsman, 2014b; Rougès and Montreuil, 2014). Crainic and Montreuil (2016) discuss crowd logistics as an example of hyperconnected city logistics, in which the physical internet concept is applied to urban environments, resulting in interconnected people mobility and freight logistics in the city.

The crowd logistics concept exploits a new spirit of collaboration and commercialises social networks in a way that can be beneficial from an economic, social and environmental point of view (McKinnon, 2016). However, as leading enterprises (retailers and logistics service providers) are embracing this paradigm shift in the distribution of work, by outsourcing to the crowd in the cloud (Thaker, 2015), much of the thinking and discussion about crowd logistics has developed from the practitioner’s side (Carbone, Rouquet and Roussat, 2015). Examples of such initiatives include Myways, a terminated pilot project of DHL that was launched in Sweden (den Bakker, 2013), bringr, an experiment by the Belgian postal operation bpost (Byl, 2016) and efforts of retailer Walmart in the USA, at first with in-store customers that served as crowd, later on in cooperation with crowd logistics start-ups Lyft, Deliv and UberRUSH (Nassauer, 2016). The latter example demonstrates the importance for businesses starting up in the increasingly competitive delivery service industry to collaborate with traditional or mature companies. The collaboration between fashion e-retailer Zalando and crowd logistics initiative Trunkrs for last-mile deliveries in Amsterdam possibly fosters advantages for Trunkrs, such as brand awareness, consumer trust and user generation (Stil, 2016).

Together with the rise of crowd logistics initiatives, the variety of business models that are applied has grown considerably. Some concepts are dependent on a base of regular and flexible “crowd workers”, others allow (long) detours or encourage...
dedicated trips to deliver parcels. This causes discussion about the true capacities of crowd logistics to enhance urban sustainability. The research therefore aims to identify the characteristics that describe the various crowd logistics concepts and evaluate how these characteristics affect the economic, social and environmental sustainability of the concept. In order to do this, a clear definition of crowd logistics is warranted. However, no attempts have been made so far. The only exception being the definition by Mehmann et al. (2015), who claim that "crowd logistics designates the outsourcing of logistics services to a mass of actors, whereby the coordination is supported by a technical infrastructure. The aim of crowd logistics is to achieve economic benefits for all stake- and shareholders."

Despite the variety of concepts and utilitarian approaches that exist within the realm of crowd logistics, we argue that the objective of economic benefits is too narrow. Therefore, the research aims to develop a suitable and comprehensive definition of crowd logistics that captures current and future state of practice.

**Methodology**

The methodological approach includes both desk and field research by means of a systematic literature review and semi-structured interviews. A systematic literature review is a systematic, explicit and reproducible method for identifying, evaluating and synthesising the existing body of completed and recorded work produced by researchers, scholars and practitioners (Fink, 2013). By reviewing the available scientific literature on crowd logistics, we captured the knowledge that is available to date. We used a spreadsheet file to compose a comprehensive analysis of the crowd logistics descriptions, defining characteristics, involved parties and their activities, strengths and weaknesses. Additionally, the systematic literature review took stock of all crowd logistics examples mentioned, which were examined in an explorative way. Literature was found using Google Scholar, which as an open and extensive database was fit best for researching this novel topic. Furthermore, the online databases of ScienceDirect, Web of Science and Taylor & Francis were checked but did not result in additional material. Several keywords were used and are listed in Table 5.

The search yielded 139 publications, of which twenty-three publications were found twice or more. An additional total of fifty-five publications were found unqualified, as twenty-eight were identified as student thesis; fifty-five were unrelated to the subject or only mentioned crowd logistics in the list of references and two were excluded due to language barriers (Swedish and Finnish). Finally,
eight publications could not be accessed (Table 6). The literature search thus provided an input of forty-two qualified and accessible papers.
Because of the novelty of the topic, the search strategy included journal output but also other types of scientific publications, including conference papers (thirteen), working papers (three), book chapters (three), project reports (one), white papers (one) and semi-scientific magazine articles (two). The nineteen journal publications cover a diversity of journals including Transportation Science, International Journal of Web Information Systems, Journal of Cleaner Production and International Journal of Sustainable Transportation. All publications were written in English except for three (French and German). As far as region is concerned, crowd logistics is researched all over the globe. Although most research is based in Europe (twenty), other frequently found regions include Canada (four), Asia (four) and the USA (four). Four publications are located elsewhere (Australia, South-America and West-Africa). The remaining publications (six) could not be geographically classified.

The crowd logistics phenomenon is relatively new and understudied. As the systematic literature review indicated that sustainability implications are highly dependent on a number of parameters, we identified a need to involve logistics practitioners. Findings of the systematic literature review provided input for the topic list that guided the semi-structured interviews and were also used as probes for follow-up questions. The findings were, however, not shared with the respondents until all interviews were carried out. Afterwards, the results of both literature and interviews were presented in a general meeting. During the interviews, open questions explored a qualified definition for crowd logistics, an analysis of strengths, weaknesses, opportunities and threats (or SWOT) of crowd logistics.


table 5. Literature selection keywords and findings (2 February 2017).

<table>
<thead>
<tr>
<th>Keywords</th>
<th>Total</th>
<th>Keywords</th>
<th>Total</th>
</tr>
</thead>
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<td>37</td>
<td>“Crowdsourced deliveries”</td>
<td>10</td>
</tr>
<tr>
<td>“Crowd logistics”</td>
<td>34</td>
<td>“Crowdsourcing delivery”</td>
<td>18</td>
</tr>
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<td>“Crowdsourced delivery”</td>
<td>33</td>
<td>“Crowdsourcing deliveries”</td>
<td>7</td>
</tr>
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</table>

Table 6. Literature selection exclusion criteria (2 February 2017).

<table>
<thead>
<tr>
<th>Exclusion criterion</th>
<th>Total</th>
<th>Exclusion criterion</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double publication</td>
<td>23</td>
<td>Unrelated subject</td>
<td>25</td>
</tr>
<tr>
<td>Student thesis</td>
<td>28</td>
<td>Inaccessible publication</td>
<td>8</td>
</tr>
<tr>
<td>Language barriers</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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logistics from their company’s perspective, interesting crowd logistics concepts, current and future crowd logistics activities and finally their opinions on the sustainability implications of crowd logistics in general and the importance attached to sustainability issues when developing their own crowd logistics concept. In this way, we verified theoretical insights with the state of practice.

In total, eleven semi-structured interviews were conducted with practitioners: eight logistics service providers, one shipper and two retailers. The practitioners were selected because of their stated interest in integrating or developing crowd-based activities in their logistics operations. Both size and geographical reach of practitioners differs considerably, from family-owned local business to multinational, but all have a headquarters within Flanders and Brussels-Capital Region, Belgium.

In general terms, the interviewed practitioners agreed on the concept definition of crowd logistics. More disagreement was observed concerning the underlying motivations for getting involved in crowd logistics: while shipper and retailers were interested in the added value and service it potentially offers, logistics service providers were motivated by existential considerations and the possibly disruptive character of crowd logistics developments. Practitioners’ interest also differed with regards to specific crowd logistics concepts, which was in line with core activities and company’s mission and vision. For example, a company with strong environmental efforts envisioned a crowd logistics concept in line with these commitments, as opposed to another company in which sustainability is also in its daily activities of minor importance.

Compliant with the crowd logistics concept, we created an adapted stakeholder-framework consisting of receivers that receive the goods, commissioners that send the goods, logistics service providers that execute transportation in the traditional way, platform providers that match all parties and, finally, the crowd. Throughout the interviews, we identified four logistics service providers expressing the ambition to additionally become a platform provider, two platform providers that already host a logistics platform but aim to include the crowd and two logistics service providers and three commissioners that wish to use the crowd without hosting a platform.

Findings

Definition
Following the systematic literature review and the semi-structured interviews,
we identified seven elements that are crucial to crowd logistics, in an attempt to compose a comprehensive definition:

- Technological infrastructure
- Free capacity
- Crowd network
- Undefined character
- External to the company
- Compensation
- Voluntary

First, **technological infrastructure** by means of an accessible platform is critical in crowd logistics, in order to coordinate demand and supply for logistics services. This platform can be accessed in a multitude of ways, such as mobile phone or web browser (Mehmann, Frehe and Teuteberg, 2015), and provides the opportunity to engage a broad spectrum of workers (Taylor, 2015). Critical for future success of crowd logistics is the optimisation technology that supports and analyses (Durand et al., 2014). Practitioners highlighted that information connectivity is the main enabling factor and termed the technological infrastructure element as “online marketplace” or “communication platform”, required to connect flows of goods, information and finances.

Second, crowd logistics implies the use of **free capacity**. Delivery operations are made by using the excess capacity on journeys that are already taking place (Arslan et al., 2016). According to McKinnon and Bilski (2015), harnessing this spare capacity enables to achieve economic and environmental benefits. The interviews, however, nuanced this literature finding by adding that free capacity can also refer to time, instead of volume. Many crowd logistics concepts in which practitioners expressed concrete interest in, consider the crowd as a database of people willing to execute logistics tasks in their free time.

Third element refers to the network. Botsman (2014) proposed a **“network of drivers”**, but this is contradicted both by existing crowd logistics concepts and by the interviews. For example, a number of crowd logistics concepts can be used for logistics services that cover more activities than merely transportation. Trunkrs, a Dutch initiative, appoints neighbours that offer small-scale warehousing services, by collecting deliveries and returns (Trunkrs, 2019). Moreover, Instacart, a US-based on-demand grocery service, provides store picking in addition to home delivery (Instacart, 2019). An interviewed practitioner added that crowd logistics enables commuters that use public transportation to carry parcels for others, thus without them needing to be drivers.

Fourth, the **undefined character** of the crowd, as proposed by different authors (Erickson and Trauth, 2013; Chen et al., 2016; Mladenow, Bauer and Strauss,
The practitioners acknowledged this as an essential element of crowd logistics but indicated that the unknown crowd identity represents a substantial source of stress. Although the platform registers and tracks the crowd, quality and service are more difficult to monitor and cannot be guaranteed.

Fifth, when making use of the crowd, there is no formal hiring process (Martins, Bermejo and Souza, 2015). The crowd does not become an employee but remains external to the company (Durand et al., 2014). For some of the practitioners, this element proved to be motivating as the employer is released from a number of commitments and obligations. Others expressed concerns about excessive forms of flexibility in labour, unfavourable for the labourer.

Sixth, a number of authors state that the crowd receives a micro-payment based incentive or minimal fee in return for their logistics services (Hodson, 2013; Chen et al., 2014; Durand et al., 2014; Rougès and Montreuil, 2014; Archetti, Savelsbergh and Speranza, 2016). While some of the practitioners agreed, the objection against the “minimal” character of the remuneration was recurring. Framed within the convenience economy trend, most practitioners envisioned to engage the crowd in order to improve overall service levels. Thus, if the crowd provides faster delivery, more personal service, flexibility, larger reach or cost-efficiency, it should be paid accordingly. Thus, it can be concluded that an adequate compensation is an essential element of crowd logistics.

Seventh and final, the engagement of the crowd is voluntary, meaning that people self-select logistics services they wish to fulfil (Rougès and Montreuil, 2014; Guo et al., 2015; Mladenow, Bauer and Strauss, 2016). Throughout the interviews, some discussion about this element came to light. While for some practitioners, crowd logistics implies irregular activities, others consider labour on both a regular and irregular basis as fitting. Nevertheless, given the absence of a fixed contract, the voluntary character of the crowd remains a fundamental element.

Although discussion about the crowd logistics concept seems inevitable, we define crowd logistics as “an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis and is compensated accordingly.”

Characteristics
In order to characterise the broad variety of crowd logistics concepts, we identified eighteen characteristics and categorised these in accordance with the involved crowd logistics stakeholders that they relate to. An overview of these characteristics is presented in Table 7, followed by a description of each characteristic.
Table 7. Crowd logistics characteristics.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Receiver</th>
<th>Commissioner</th>
<th>LSP</th>
<th>Platform provider</th>
<th>Crowd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business or consumer</td>
<td>Business or consumer</td>
<td>Third party involvement</td>
<td>Revenue model</td>
<td>Character</td>
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<tr>
<td>Business or consumer</td>
<td>Business or consumer</td>
<td>Third party involvement</td>
<td>Revenue model</td>
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<tr>
<td>Third party involvement</td>
<td>Business or consumer</td>
<td>Third party involvement</td>
<td>Revenue model</td>
<td>Character</td>
<td></td>
</tr>
<tr>
<td>Revenue model</td>
<td>Role</td>
<td>Strategy</td>
<td>Logistics task management</td>
<td>Location dependence</td>
<td></td>
</tr>
<tr>
<td>Character</td>
<td>Transport</td>
<td>Incentive</td>
<td>Motivation</td>
<td>Modal choice</td>
<td></td>
</tr>
<tr>
<td>Location dependence</td>
<td>Transparency</td>
<td>Trust generating mechanism</td>
<td>Cooperation</td>
<td>Marketing</td>
<td></td>
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<tr>
<td>Transparency</td>
<td>Trust generating mechanism</td>
<td>Cooperation</td>
<td>Marketing</td>
<td>Geographical scale</td>
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<tr>
<td>Trust generating mechanism</td>
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<td>Marketing</td>
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<td>Cooperation</td>
<td>Marketing</td>
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<td>Location dependence</td>
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</table>

**Receiver and commissioner**

Although often perceived as a peer-to-peer service concept (Mcinerney, Rogers and Jennings, 2013; Botsman, 2014b; Mladenow, Bauer and Strauss, 2016), crowd logistics can be initiated and destined by both business and consumer. One of the interviewed practitioners preferred to use the term “human-to-human”, thereby indicating that identity of receiver and commissioner is of little relevance. Nonetheless, the **business or consumer distinction** is an important element in the business model.

**Logistics service provider**

Crowd logistics has the crowd in its core, but the mass of individuals is often complemented with professional logistics service providers. As a matter of fact, the most promising crowd logistics start-ups are relying primarily on **third party involvement**: professional couriers who are dedicated to delivery, not only occasional travellers (Rougès and Montreuil, 2014; Qi et al., 2016). As the crowd logistics concept is highly dependent on a large number of people with a generous amount of flexibility (Archetti, Savelsbergh and Speranza, 2016), activating professional third parties is a way to ensure timely completing of tasks (Erickson and Trauth, 2013). The interviews acknowledged this strategy.

**Platform provider**

A number of characteristics allow to typify the platform provider. Rougès and Montreuil (2014) list eight **revenue models**: fixed price, resale margin, financial or matching fee, negotiated price, membership, reward, barter and discount. Designing a qualified model or combination of models is crucial. By applying
game-theory, Kung and Zhong (2016) investigate three pricing strategies and conclude that adopting a membership-based model would be more profitable than the others. For many of the interviewed practitioners, the desirable revenue model was still unclear but has to be in line with the other crowd logistics characteristics. A matching fee was found appropriate for a platform that aims to connect private individuals for the transportation of personal, non-parcel sized goods. A fixed price for every performed task was suggested for a crowd logistics concept relaying primarily on professional drivers. For commissioners facilitating the crowd to collect their neighbours’ order, a percentage of a negotiated price between the parties was found suitable.

The role of the platform is mostly categorised as marketplace. However, depending on other activities the platform provider offers, this role can alter or expand. Carbone et al. (2015) define the difference between platforms in which logistics services are the purpose on the one hand, and are supporting collaboration on the other hand.

Closely linked to platform role is strategy. Although initially framed within the sharing economy concept (Mehmann, Frehe and Teuteberg, 2015), with social relationships at its heart (Carbone, Rouquet and Roussat, 2015), the expansion of more utilitarian approaches urged for a broader definition. The typology of Rouges and Montreuil (2014) includes three distinctions: efficiency versus human, trust versus control and business versus community. Cohen and Muñoz (2015) elaborate on an orientation which is public or private and additionally introduce a hybrid approach. Combining aspects of both, this crowd logistics characterisation framework implements a business-community axis with hybrid strategies in between. The practitioners interviewed referred in most cases to business-oriented strategies, putting emphasis on additional or improved services that could be offered to their customers and cost-efficiency motivations. Two interviewees explicitly expressed interest in a community-inspired concept.

The logistics task management of the platform can be organised in a centralised or decentralised way (Carbone, Rouquet and Roussat, 2015). While a decentralised platform plays only an informative role, a centralised management handles the flows and pushes information to the crowd. Chen et al. (2014) make the difference between large-scale task coordination, where the platform proactively recommends tasks to the crowd in a coordinated way, and predictive crowd-tasking, where the recommendation of tasks is not solely based on current location.

Related to this is the trajectory-dependency condition. A platform can be programmed to match supply and demand based on explicitly inputted trajectories or can be independent from existing trajectories by allowing random matches. Most concepts introduced by the interviewed practitioners require a semi-professional
and regularly active crowd and consequently manage logistics tasks in a centralised and trajectory-independent way. Other concepts use the capacity of trips that are already taking place but allow considerable flexibility with regards to detours. **Transparency** and **trust generating mechanisms** both aim to decrease the safety risks that are inherently related to the crowd logistics concept. According to literature and interviews, insecurities such as increased risk of theft, loss and damage (McKinnon, 2015), privacy concerns (Mladenow, Bauer and Strauss, 2016) and vulnerability to criminal activity (McKinnon, 2015) form major barriers. Also with standard delivery, a certain amount of loss and theft is assumed (Mcinerney, Rogers and Jennings, 2013). In order to respond to these insecurities and reassure users, a number of mechanisms can be introduced: rigorous selection process, feedback system, personal web pages or spaces, secure messaging system, secure online payment system and insurance (Rougès and Montreuil, 2014). All were endorsed by the semi-structured interviews, although there was considerable interest in more advanced control-providing mechanisms such as pre-screening of the crowd. Nevertheless, in a pilot project in Finland, in which crowdsourcing for library deliveries was tested by using the platform PiggyBaggy, no failures, lost or damaged goods were encountered (Paloheimo, Lettenmeier and Waris, 2016).

**Cooperation** within a crowd logistics concept refers particularly to partnerships with IT specialists, investors and most prominently, retailers. According to Mehmann et al. (2015), a crowd logistics concept can be categorised “effective” when five to ten retail partnerships are achieved. For the pioneering Bringbee concept from Switzerland, an insufficient amount of partners caused them to cease activities (BringBee, 2014). Research states that for “click-and-mortar businesses” that have both a physical and online shop, crowd logistics is an effective way to compete with pure e-players. They can employ their often strategically located physical stores as “warehouse”, from which the crowd can realise fast one-hour or same-day deliveries (Botsman, 2014b; Rougès and Montreuil, 2014). Specifically for independent, local businesses the crowd can provide affordable delivery solutions (Dörrzapf et al., 2016; Schreieck et al., 2016) and enable them to widen their markets (Rougès and Montreuil, 2014).

A critical mass of platform-users needs to be acquired by means of effective **marketing** (Rougès and Montreuil, 2014). According to Taylor (2015), the long-term success of crowd logistics concepts depends on attracting a sufficiently large number of participants. Internet advertising, social media and bonus programs are mentioned (Mehmann, Frehe and Teuteberg, 2015). For the practitioners interviewed, a vision on user-acquisition strategies was still unclear. Nevertheless, for the companies that took environmental and social gains into account, the crowd logistics concept itself was seen as an image-improving tool.
Geographical scale concerns the market size and covered distances of the crowd logistics concept. The distinction can be made between intra-urban, inter-urban and global scale on the one hand (Rougès and Montreuil, 2014) and regional, national, international and worldwide scale on the other hand (Mladenow, Bauer and Strauss, 2016). Literature generally limits the crowd logistics concept to city distribution and last mile logistics (McKinnon, 2015; Mehmann, Frehe and Teuteberg, 2015; Slabinac, 2015; Arslan et al., 2016; Chen et al., 2016; Hübner, Kuhn and Wollenburg, 2016; Mladenow, Bauer and Strauss, 2016). The interviewed practitioners, however, expressed interest in concepts in which city logistics is just one component and even concepts that exclude the last mile.

Crowd
To describe the crowd, we identified five characteristics. Character of the crowd can be either private or self-employed. Due to the variety of distinctions, subdividing the crowd is complex but important, as it raises legal issues. Established lines between consumer and provider, employee and self-employed, professional and non-professional provision of services are blurred (European Commission, 2016a). Botsman (2014) divides the crowd in three categories: subcontractors, professional drivers and casual drivers. Subcontractors work for mainstream brands such as DHL, professional drivers are employed by courier companies but dispose of free capacity and casual drivers comprise university students, retirees and freelancers. In the pilot project in Finland, the crowd consisted of both local inhabitants and pizza-deliverers (Paloheimo, Lettenmeier and Waris, 2016). Chen et al. (2016) investigated the possibilities of using taxis and the Dutch initiative Sjipit only accepts independents on its platform, irrespective of their professional activities (Sjipit, 2019).

Until recently, Belgian law was indistinct about the possibilities of remunerating private individuals in return for services. Now, a tax system modification enables individuals to earn up to €5000 per year with digital platforms, without the commitments of self-employment that include a value added tax number and social contributions (Baert, 2016). This modification is in line with the “European agenda for the collaborative economy”. With this document, the European Commission provides legal guidance and policy orientation for the balanced and sustainable development of the sharing economy, in response to the variation of regulatory and tax policies across the EU member states. For the European Commission, setting thresholds under which an economic activity would be considered a non-professional peer-to-peer activity is a suitable way forward. Because of the blurring lines between consumers and businesses, it becomes less clear who represents the “weaker party”. Hence, uncertainty is created as to applicable rights.
and the required level of social protection (European Commission, 2016a). In conclusion, although engaging private individuals in crowd logistics initiatives is permitted, the character distinction remains relevant.

Closely linked to the crowd character is transport fulfilment, being either dedicated or intended. A number of authors (Mcinerney, Rogers and Jennings, 2013; Botsman, 2014b; Durand et al., 2014; Rougès and Montreuil, 2014; Archetti, Savelbergh and Speranza, 2016; Arslan et al., 2016; Paloheimo, Lettenmeier and Waris, 2016) explicitly mention intended fulfilment by referring to pre-existing travel routines (Mcinerney, Rogers and Jennings, 2013), commuting trips (Rougès and Montreuil, 2014) or delivery locations near the own destination (Archetti, Savelbergh and Speranza, 2016). Without the condition of using the existing vehicle flows, unnecessary travels might be induced (Chen, Mes and Schutten, 2017). In the Finnish pilot project, Paloheimo et al. (2016) found that rebound effects, such as drivers traveling longer distances motivated by monetary compensation, can reduce environmental improvement. In accordance with the “free capacity of time” argument, also the interviewed practitioners confirmed that crowd logistics does not have to imply existing travel and expressed interest in dedicated transportation.

Crowd compensation depends on the incentives offered, which can be monetary or non-monetary. As the identity of the crowd is not stable over time, incentivising is challenging (Erickson and Trauth, 2013). Compensation schemes based on the “cost-to-serve” of a customer may be most appropriate (Archetti, Savelsbergh and Speranza, 2016). Other value propositions could be added such as health benefits when soft modes, bikes for instance, are encouraged or because of improved local air quality. In the pilot project in Finland, novelty proved to be an important factor (Paloheimo, Lettenmeier and Waris, 2016). Furthermore, Mladenow et al. (2016) state that many crowdsourcing projects are successful without any monetary compensation at all. All interviewed practitioners agreed on appropriate monetary remuneration of the crowd depending on the service executed. Some interviewees suggested additional non-monetary incentives, such as events to strengthen the crowd’s community feeling. This is in line with the suggestion by McKinnon (2016) to offer the crowd non-pecuniary factors to build critical mass. Although the crowd consists of external and uncontracted individuals, the learning curve argument was mentioned. This indicates the contradiction that logistics practitioners experience between a flexible database of crowd workers that can be employed depending on the exact need and a regular workforce that masters a specific logistics task or delivery route by repeating it. Both ways of task allocation can lead to cost-efficiency but they are difficult to combine.

Another incentive-related question was raised concerning payment per service or payment per hour. Also here, the tax system modification plays an important role.
Now it is possible to compensate private individuals per service whilst before, an hour-based contract was required. Nevertheless, some practitioners who regard the crowd as a flexible workforce, prefer to maintain the currently used compensation system for employees and simply transfer it to the crowd.

Closely related to incentivising the crowd and the concept strategy, is the crowd’s **motivation**. In accordance with the business-community axis, the crowd can have a clear financial stimulus or can be encouraged by sustainability and community matters, including everything in between. As stated by Paloheimo et al. (2016), addressing motives such as schedule fit and ease of use are crucial.

The last crowd characterising element is the **transport mode** that is chosen. In the Finnish crowd logistics pilot, a vital factor of the achieved reduction in resource use and carbon emissions was the fact that most trips were done by bike (Paloheimo, Lettenmeier and Waris, 2016). The Spanish crowd logistics concept, Koiki, facilitates a green delivery service by appointing “Koikis” or individuals that are engaged to receive all the neighbourhood’s parcels and distribute them by foot or by bike when their neighbours are at home (Koiki, 2019). Alternative modes and public transportation should be encouraged (Rougès and Montreuil, 2014). Nevertheless, Rougès and Montreuil (2014) also claim that integration of crowd logistics delivery requirements in the design of, for example, cars, bicycles and trucks would optimise the process. During the interviews, modal choice received little attention from the practitioners, who considered the demanded logistics service as starting point. Nevertheless, transport modes other than van or car were encouraged when fitting.

### Sustainability

Following the systematic literature review and the semi-structured interviews, we determined sustainability implications for each of the defining crowd logistics characteristics. To assess the overall sustainability potential of crowd logistics, we indicate whether a characteristic affects economy, society and/or environment. Table 8 summarises the findings by highlighting the relevant boxes in grey.

**Economic sustainability**

All characteristics that define a certain crowd logistics concept determine the business model and thus impact on its economic sustainability. The business or consumer distinction for receiver and commissioner steers the platform operations and has an impact on the realisation of other characteristics, including strategies for cooperation and marketing. Platform role and strategy establish where the concept is situated on the axis between community-inspired and business-oriented.
Consequently, they have a direct impact on other characteristics such as crowd character and modal choice. Any sustainable business model is dependent on generating sufficient partnerships (cooperation) and users (marketing), in an area that matches the geographical scale on which the crowd logistics concept operates. A sustainable business model depends on well-designed revenue and cost structures (Thaker, 2015). Thanks to the asset-light infrastructure and operational flexibilities of crowd logistics, many authors presume a minimisation of costs (Botsman, 2014b; Durand et al., 2014; Qi et al., 2016). This implies that, as opposed to traditional logistics service providers, no warehouses, vehicle fleet or employed drivers are required (Botsman, 2014b). Nevertheless, an appropriate revenue model needs to take account of the additional costs, such as insurance, software development, training, routing instructions, GPS devices and packets for shipments (Mladenow, Bauer and Strauss, 2016). Designing an effective cost model is a major challenge. It is determined based on crowd characteristics, such as the transport flows, motivation and modal choice (Archetti, Savelsbergh and Speranza, 2016). Existing crowd logistics platforms employ different strategies to incentivise the crowd. The interviewed practitioners also raised a number of possible applications. Individuals that move dedicately or make large detours can be compensated more and monetary, rewarding their flexibility. Vice versa, persuading the crowd to bring along parcels on existing trips could require less earnings or incentives of non-monetary nature. Essentially, addressing the crowd’s motivation is paramount.
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Similar considerations can be made regarding their modal choice. A platform can choose to connect crowd incentives with their chosen vehicle type. For example, more sustainable, more flexible or more spacious vehicles and the costs they bring along (such as fuel costs) can be compensated.

A sustainable concept needs well-preforming service levels. In the case of crowd logistics, this translates to timely, guaranteed and efficient execution of logistics tasks. Performance of the system is largely impacted by time flexibility and stop willingness of the crowd (Arslan et al., 2016). A successful business model therefore requires a large database of individuals, or critical mass, in order to remain competitive during busy times, such as the holiday period (Hodson, 2013; Insel, 2013). Involving professional third parties in case of insufficient or underperforming crowd is important from this perspective. Savelsbergh and Van Woensel (2016) refer to Walmart, that guarantees same-day delivery to online customers and employs both occasional and company drivers. Third party involvement is tightly linked to the character of the crowd, which can be professional, non-professional or both, but the main difference is the engagement of the individuals executing the logistics tasks. This is done in the traditional way in case of third-party involvement and via a marketplace platform in case of the crowd. Service levels also depend on the platform organisation: logistics task management and location-dependence. According to Chen et al. (2017), crowd logistics can be an economic viable and sustainable option, but it depends on the spatial characteristics of the network and drivers’ schedules. A major challenge in this regard is the design of a task-selection that succeeds in minimising time of deliveries while maximising efficiency (Mcinerney, Rogers and Jennings, 2013).

Two characteristics balance between economic and social considerations: platform transparency and implemented trust generating mechanisms. Vague or lacking regulatory frameworks concerning sharing economy platforms and crowd logistics give rise to important liability questions (Mladenow, Bauer and Strauss, 2016). Thus, from a business point of view, user trust, safety and security need to be warranted and preserved. However, matters related to social desirability of information sharing and privacy are pressing.

Social sustainability

As crowd logistics platform users share valuable data (such as their location), privacy is a critical challenge. This has to be handled already in the design stage of the platform creation (trust generating mechanism). Schreieck et al. (2016) list seven principles to respect in this regard: proactive not reactive, privacy as the default, privacy embedded into design, full functionality, end-to-end security, visibility and transparency and respect for user privacy. In order to protect user
data, “hashing” or transforming personal information is proposed for data analysis that aims to optimise the matching process (Schreieck et al., 2016). They also suggest transparency of data storage and processing to tackle privacy questions. The European Commission (2016a) stimulates crowd logistics platforms to comply with the applicable legal framework on the protection of personal data.

De Groen and Maselli (2016) claim that the ongoing digital revolution and crowd platforms are slowly changing labour by intermediating work between individuals online, without the intervention of other people or organisations. For the traditional logistics industry, crowd logistics can be considered disruptive. As numerous start-ups are creating business models based on low cost structure and power of community, business volume of traditional logistics service providers can reduce significantly (Rougès and Montreuil, 2014; Carbone, Rouquet and Roussat, 2015). Even more, as the crowd only works when demand is sufficient (Hodson, 2013), the procedure can be used to replace fixed employees and create cost-efficiency and savings (third party involvement). This again traces back to the blurring lines between professionals and non-professionals in the logistics industry or the character and incentivisation of the crowd. The opportunity to create a customised working schedule that fits other commitments (Rougès and Montreuil, 2014), the ease to convert time and skills into cash (De Groen and Maselli, 2016) and the ability to be in control of amount of work and revenues are key advantages of the system (Botsman, 2014b). Some warn for negative side-effects of such flexibility. Although the crowd participates on a voluntary basis, some crowd logistics initiatives use a casual workforce of self-employed drivers and have been criticised for exploitative practices (McKinnon, 2016). Platforms limit the freedom of the crowd in order to increase efficiency, for example by allocating tasks to workers that are most available or by attaching rating systems to task acceptance levels. Hence, the platform and platform users are far more dominant in setting the conditions for the crowd than the other way around (De Groen and Maselli, 2016). De Groen and Maselli (2016) summarise that the crowd is exposed to financial insecurities, lacking social protection, isolation and stress, blurring lines between the sphere of work and private life, high competition and uncertainties due to short-term schedules. Underpayment and unfulfilled employment conditions could prove to be an unsustainable business model from a social point of view. While these considerations relate to crowd logistics concepts on the business side of the strategic axis, they are less relevant for community-oriented approaches, which are small-scale and less driven by financial motivation.

Finally, the social impact of the crowd’s modal choice concerns the health benefits that result from crowd logistics concepts that stimulate soft transportation modes, such as biking and walking. In the Finnish pilot project, several crowd workers
that used their bikes, declared to participate in the pilot for the sake of exercise (Paloheimo, Lettenmeier and Waris, 2016). Moreover, crowd logistics initiatives that promote the usage of soft modes instead of trucks, vans and cars trigger health benefits for the entire community.

**Environmental sustainability**

Much of the benefits linked to crowd logistics, such as reduction in CO$_2$ emissions, traffic and resource use, are linked to a more efficient usage of loading space. Whether a crowd logistics concept works with existing or dedicated trips has an important influence on its environmental impact (Qi et al., 2016). The platform’s task management and location dependency have the potential to steer this process, as well as the transport behaviour of the crowd itself. It could be argued that trajectory-dependency facilitates the more sustainable use of pre-existing trips while random selection enables additional trips. One interviewee, however, challenged this assumption. Even if a platform focusses on leveraging intended trips, user-friendliness is hindered if tasks are only recommended after executing another task first. The involvement of third parties is per definition relevant in this respect. Professional logistics service providers make dedicated trips and use in most cases a light-freight vehicle (McKinnon, 2016). Nonetheless, traditional logistics service providers can apply considerable experience and volume in order to guarantee efficient aggregation of parcels. In the crowd logistics concept, parcels are processed individually, which might limit the overall positive sustainability impact (Rougès and Montreuil, 2014).

The crowd’s modal choice is also important from an environmental perspective, which favours soft modes, public transportation and clean vehicles. Trip distance is another influencing factor, which relates to the crowd concepts’ geographical scale. Finally, also in the case of environmental impacts of crowd logistics is the crowd’s main motivation decisive. To conclude, only three characteristics, third party involvement, crowd motivation and modal choice, impact sustainability as a whole. Four characteristics, logistics task management, location dependence, geographical scale and transport, have an impact on economic and environmental sustainability. Four characteristics, transparency, trust generating mechanism, crowd character and incentives, need to be taken into account for both economic and social concerns. Then, seven characteristics are important from an economic perspective only: receiver and commissioner identity, revenue model, platform role and strategy, cooperation and marketing.
Conclusion

The goal of this research paper entails to indicate if crowd logistics concepts can increase urban transport sustainability, of both passenger and freight flows. By combining desk (systematic literature review of forty-two articles) and field research (eleven semi-structured interviews), our research concludes with three findings. First, we define crowd logistics as “an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis and is compensated accordingly.” Second, we list eighteen characteristics able to define and describe the broad variety of crowd logistics concepts. These characteristics are categorised per involved crowd logistics stakeholder-group that they relate to, consisting of receivers that receive the goods, commissioners that send the goods, logistics service providers that execute transportation in the traditional way, platform providers that match all parties and the crowd. Third, by matching the characteristics with economic, social and environmental sustainability implications, we allow to assess the overall sustainability potential of crowd logistics initiatives. All characteristics have an impact on the economic sustainability, given that they are vital business model elements. Only three characteristics affect the three pillars of sustainability: third party involvement, crowd motivation and modal choice.

From a research point of view, the findings complement existing literature by combining both theory and practice to provide information on sharing space for passenger and freight transport in general and the novel topic of crowd logistics in particular. From a policy perspective, the research brings evidence that confirms statements of both “believers” and “nonbelievers” in the sharing economy, by listing examples of sustainable and less sustainable concepts. We suggest that policymakers explicitly define the characteristics required for crowd logistics initiatives that can be considered for support. Such characteristics can include optimised transport and a non-professional crowd character. The findings prove insightful for practitioners that aim to set up a crowd logistics initiative as well, as it provides comprehensive understanding of important concept considerations. A sustainable crowd logistics business model provides enhanced service for customers and overall profitability, increases efficiency of vehicle usage and encourages progress in social equity by creating flexible work as opportunity but not as last resort. Overall, the goal of the research is to strengthen insight on crowd logistics as an alternative to inefficient urban freight transport flows and to stimulate the efficient usage of the available transportation resources, by addressing relevant stakeholders such as consumers, businesses, policy-makers and researchers. Future research includes a stakeholder-
analysis to find out for each of the involved stakeholders what type of crowd logistics concept they would support and a sustainability impact assessment of a crowd logistics pilot project. This stage of research explicitly involves the crowd, which is a drawback in the current conceptual research endeavour of a concept that is only starting to develop. Other avenues for future research include the potential of crowd logistics concepts to scale up and become a credible alternative to traditional logistics services and under which conditions this can take place.
Chapter 4

Can the crowd deliver? Analysis of crowd logistics’ types and stakeholder support

Introduction

In recent years, researchers and practitioners alike have been investigating ways to fulfil continuously intensifying consumer expectations of delivery services. In the shopping environment created by e-commerce, multichannel and omnichannel retail, it has become of utmost importance to deliver the right amount of the right product at the right place at the right time in the right condition at the right price and with the right information (Mentzer, Flint and Hult, 2001). According to Xing and Grant (2006), consumers have a number of requirements of the physical distribution service quality of online ordered goods (or e-PDSQ). These requirements relate to four dimensions, being timeliness, availability, condition and return. Timeliness covers reliable, on time and quick delivery of goods. Availability refers to inventory capability and the possibility to track and trace orders. Condition relates to the accuracy and quality of the order and return covers the way the retailer deals with damaged, unwanted or faulty products, which the consumer requires to be convenient and easy (Xing and Grant, 2006). Ocicka and Raźniewska (2016) provide a similar list of e-customer logistics indicators. They add flexibility of the logistics service provider as requirement, or the readiness to realise non-standard deliveries (Ocicka and Raźniewska, 2016). Today's consumer demands more convenience and faster delivery (Goetting and Handover, 2016). In the future, same-day and instant delivery are expected to significantly grow further (Joerss et al., 2016).

Delivery services have an immediate impact on the demand for consumer goods (Agatz, Fleischmann and van Nunen, 2008) and drive logistics operations in the mid- to long-term (Kunze, 2016). Logistics is responsible for the physical realisation of orders to achieve a high-quality customer experience and has consequently emerged as a competitive advantage (Ocicka and Raźniewska, 2016). Therefore, supply chains that were traditionally designed around stores, are now re-engineered in accordance with consumer preferences (Geddes, Williams and Guthmann, 2014). A survey by Eye for Transport questioned four-hundred logistics experts and found that 60,8% describe their supply chain as “consumer-driven”, rapidly replacing the “product-driven” approach (Garner, 2016). Studies conclude that the logistics industry is structuring itself behind a model that is focused on consumers (Garner, 2016; Joerss et al., 2016). Nevertheless, consumer-centric logistics is associated with a number of important challenges, the most significant being shortened lead times. This increases costs and decreases profit

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The importance of logistics as key differentiator, along with consumers' reluctance to pay for better customer service, urges to investigate alternatives. One option that is believed to reduce costs and respond to consumer delivery preferences is crowd logistics. Alternatively termed crowdshipping, crowdsourced delivery, cargohitching or collaborative logistics, crowd logistics is founded in the realm of the sharing economy. In the sharing economy, people's physical assets become services that are redistributed, shared and reused more easily and inexpensively than ever before (Archetti, Savelbergh and Speranza, 2016; Arslan et al., 2016).

In case of crowd logistics, these physical assets are vehicles, such as cars, bikes, buses, trains and planes (McKinnon and Bilski, 2015). People can use their spare carrying capacity on these vehicles to bring along parcels for others, on a trip that was intended to be made anyway (Paloheimo, Lettenmeier and Waris, 2016). Consequently, its efficient and inexpensive character is not only considered as disruptive for the mainstream logistics industry (Cohen and Muñoz, 2015), crowd logistics could also be a sustainable alternative for current urban freight transport (Hübner, Kuhn and Wollenburg, 2016). The large number of small freight volumes and home deliveries in cities contributes to the ever-growing conflict between increasing demand for mobility and limited resources (Chen, Mes and Schutten, 2017). Using spare carrying capacity in vehicles that are driving anyway could decrease the environmental and societal impact of urban freight transport. There are promising examples in that regard. However, a rising number of initiatives apply more business-oriented and utilitarian approaches. Remarkably, the most promising crowd logistics start-ups rely primarily on professional couriers instead of commuters en route (Rougès and Montreuil, 2014). Consequently, questions can be raised about the true potential of crowd logistics to make urban freight transport more sustainable. Our research objective is to identify the various types of crowd logistics initiatives that currently exist. We also aim to find out whether these types are supported by (all or some of) the stakeholders involved. To this end, we apply a multi-methodological approach. A systematic literature review and eleven semi-structured interviews with logistics practitioners allowed us to define five distinct types of crowd logistics. Subsequently, we organised a multi-actor multi-criteria analysis or MAMCA workshop that identified which types are supported most and which types receive least support (Macharis, Kin and Lebeau, 2015). The remainder of the paper is structured as follows. The second section provides an overview of the current scientific literature available on crowd logistics. In the third section, the applied methodology is explained. The results of the research are discussed in the fourth section and the final section draws conclusions.
Crowd logistics facilitates to share excess capacity in vehicles to support delivery operations (Cohen and Muñoz, 2015). It entails the use of this space on journeys that already take place (Arslan et al., 2016). In this way, it can be conceived as an example of people using social networking to behave collaboratively and share services and assets for the greater good of the community, as well as their own personal benefit (McKinnon, 2016). A web- or mobile-based platform has the key function to outsource certain logistics tasks to a crowd network, who are not employed by the company but have free capacity to execute the task (Botsman, 2014b). Buldeo Rai et al. (2017) define crowd logistics as “an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis and is compensated accordingly.” Although scientific research on crowd logistics is limited to date, it is a fast-growing concept with a rising number of initiatives all over the globe. Scholars consider crowd logistics as a possible (although partial) solution to deal with the many sustainability challenges related to urban freight transport.

Literature discusses a number of economic gains. First, research found that substantial cost savings can be realised when there is a large number of people with a generous amount of flexibility available to make deliveries (Durand et al., 2014; Archetti, Savelbergh and Speranza, 2016; Arslan et al., 2016; Chen et al., 2016). As opposed to traditional logistics companies, crowd logistics does not require the asset-heavy infrastructure of warehouses, fuel costs, employed drivers or a vehicle fleet (Botsman, 2014b). Essentially, such firms only need a mobile application and a website (Durand et al., 2014). What’s more, this asset-light model enables crowd logistics initiatives to scale relatively fast when demand grows (Botsman, 2014b). Second, crowd logistics represents an important opportunity for local, often independent retailers. Thanks to the affordable delivery services of the crowd, such shops can leverage their local presence and offer customers same-day or next-day deliveries (Botsman, 2014b; Schreieck et al., 2016). In this way, local shops complement the experience and immediacy of physical retail with the convenience and simplicity of online selling and speedy deliveries (Rougès and Montreuil, 2014). Third, crowd logistics leads to a minimisation of the amount of empty space that is transported by the existing vehicle fleet (Paloheimo, Lettenmeier and Waris, 2016) and facilitates consolidation and optimisation of routes (Cohen and Muñoz, 2015). In this way, fuel efficiency is improved (Paloheimo, Lettenmeier and Waris, 2016). Fourth, companies implementing crowd logistics might create an enhanced
image as a customer- and environment-friendly company (Mladenow, Bauer and Strauss, 2016). Fifth and final, crowd logistics is not only cost-saving for the commissioners of goods deliveries, also consumers that receive the goods profit from faster and more flexible services at a better price.

Resulting from the improved load rate and usage of existing trips, many believe crowd logistics has significant environmental benefits (Arslan et al., 2016; Chen et al., 2016; Y. Wang et al., 2016). First, the integration of personal and freight transport opens up new opportunities for rationalising transport in urban areas, possibly leading to fewer failed deliveries and lower traffic levels, emissions and congestion (Durand et al., 2014; Chen et al., 2016; McKinnon, 2016; Mladenow, Bauer and Strauss, 2016; Paloheimo, Lettenmeier and Waris, 2016). Second, crowd logistics' benefits are not only credited to the principles of utilising existing transportation, they also relate to the promotion of alternative transport modes such as bicycles and public transport (Durand et al., 2014; Rougès and Montreuil, 2014; Dörrzapf et al., 2016; Goetting and Handover, 2016; Paloheimo, Lettenmeier and Waris, 2016).

From a societal point of view, crowd logistics is perceived as an opportunity for the crowd to create a personalised and flexible working schedule, that is adjustable when needed (Chen et al., 2014; Goetting and Handover, 2016). Although McKinnon (2016) points out that this flexibility works both ways – so-called lifestyle couriers adapt their delivery operations to both their life-style and those of their customers – the crowd still controls when they work and how much they earn (Botsman, 2014b). Particularly for students or part-time employees, crowd logistics provides the option to earn extra money without any great effort or compulsory working hours (Goetting and Handover, 2016). Second, as crowd logistics is based on the “power of community”, crowd workers are offered strong social motivations (Mladenow, Bauer and Strauss, 2016). Working within a local neighbourhood, there is personal interaction between crowd and goods receivers (McKinnon, 2016). Evidently, crowd logistics could especially make life easier for the elderly or impaired (Goetting and Handover, 2016). Third, given that some crowd logistics initiatives explicitly promote the use of soft transportation modes, the crowd can experience health benefits, alternatively termed as crowdphysics (Dörrzapf et al., 2016).

Despite the promising sustainability opportunities, crowd logistics is inherently linked to a number of risks. Essentially, crowd logistics is a case of dealing with the unknown (Mladenow, Bauer and Strauss, 2016). Vulnerability to theft, damage, loss and criminal activities is a reason for concern (Mcinerney, Rogers and Jennings, 2013; Hübner, Kuhn and Wollenburg, 2016; Mladenow, Bauer and Strauss, 2016). Other issues relate to privacy, reliability, responsibility and liability
Part 3

Heleen Buldeo Rai

(Erickson and Trauth, 2013; McKinnon and Bilski, 2015; Mladenow, Bauer and Strauss, 2016). Consequently, matters of insurance and related legal regulations are of significant importance (Goetting and Handover, 2016; Y. Wang et al., 2016). Moreover, also technical issues are critical to crowd logistics’ performance. Cutting edge technologies, interfaces and algorithms should be able to protect sensitive data, identify the best crowd workers, ensure the quality and timely completion of the work, create an efficient workflow and better manage the workflow process (Erickson and Trauth, 2013). Most essentially, however, crowd logistics is heavily dependent on a critical mass of platform users and crowd workers (Erickson and Trauth, 2013; Rougès and Montreuil, 2014; Arslan et al., 2016; Goetting and Handover, 2016). Therefore, designing an appropriate and cost-effective compensation scheme is a key challenge (Archetti, Savelsbergh and Speranza, 2016).

Many examples of crowd logistics initiatives exist to date. Founded in Norway, Nimber defines itself as a social delivery service, which offers a number of services such as pet couriers or car part deliveries (Nimber, 2019). The “people powered delivery” of the Dutch PickThisUp focusses on car-owners for transportation of non-parcel sized goods such as chairs and bikes (PickThisUp, 2019). Based in the USA, Hitch explicitly aims to challenge the traditional delivery industry and offers a listing of to deliver items that fit your planned trip (Hitch, 2019). The Spanish Koiki claims to have saved already 2,750 kilograms of CO$_2$ by appointing “Koikis”. They collect all parcels in your neighbourhood to avoid failed deliveries and bring them around when you are at home (Koiki, 2019). These initiatives strongly represent the sense of community that characterises the sharing economy. Yet, while other similar initiatives, such as Bringbee and Myways, have terminated activities, the total number of crowd logistics initiatives continues to grow. Remarkably, the most successful players implement a more business-oriented approach. Examples of such initiatives include UberRUSH, Postmates, Deliv, Tiramizoo, MeeMeep and Trunkrs. They deviate from the initial values of the sharing economy, to a small extent by allowing considerable detours from the planned journey and to a large extent by depending on dedicated trips (Buldeo Rai, Verlinde, Merckx, et al., 2017). Consequently, they raise questions about how sustainable crowd logistics really is.

From a societal point of view, crowd logistics can offer a stepping-stone to better opportunities but it might as well become a poverty trap (McKinnon, 2016). From an environmental perspective, dedicated deliveries and purely financial motives, instead of a crowd consisting of commuters and occasional travellers, may actually increase total trips and traffic levels (Qi et al., 2016). Finally, a number of crowd logistics initiatives raise questions concerning economic sustainability, given their rapid “ramp-up” strategies, under-capitalisation and operating deficits (McKinnon,
The objective of the research is to find out which type of crowd logistics initiative receives most support among the stakeholders involved: the sustainability enhancing community approach, the business-minded approach that guarantees faster and more flexible deliveries or a hybrid model in between. In order to provide answers, we identify the different types of crowd logistics that currently exist and define their key characteristics. Similar to other urban freight transport actions (Behrends, Lindholm and Woxenius, 2008), implementation and long-term success of the novel crowd logistics concept depends largely on the involvement of all required parties. Often, different stakeholders have conflicting views. Therefore, we investigate which types of crowd logistics initiatives the involved stakeholders can support, by taking into account each stakeholders’ interests and objectives.

Methodology

The research applies a multi-methodological approach based on a systematic literature review, semi-structured interviews and a MAMCA. Although scientific research on crowd logistics remains limited, the goal of the systematic literature review was to determine the types of crowd logistics that currently exist. This research method is often used to understand trends, detect gaps in scientific literature and consolidate emerging topics (Lagorio, Pinto and Golini, 2016). We sourced the open and extensive database of Google Scholar and searched by title and subject terms. Table 9 provides an overview of inclusion criteria applied for paper selection.

Table 9. Inclusion criteria for paper selection (2 January 2017).

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keywords</td>
<td>Crowdshipping, &quot;Crowd logistics&quot;, &quot;Crowdsourced delivery&quot;, &quot;Crowdsourced deliveries&quot;, &quot;Crowdsourcing delivery&quot;, &quot;Crowdsourcing deliveries&quot;</td>
</tr>
<tr>
<td>Language</td>
<td>English (39), French (2), German (1)</td>
</tr>
<tr>
<td>Document types</td>
<td>Journal paper (19), conference paper (13), working paper (3), white paper (1), book chapter (3), project report (1)</td>
</tr>
<tr>
<td>Time interval</td>
<td>2013 – 2016</td>
</tr>
</tbody>
</table>

The findings of forty-two papers were analysed using a spreadsheet file. This review enabled us to register defining characteristics of crowd logistics initiatives and list examples of such initiatives around the globe. Additionally, the review provided
input for the topic list that was used to organise the semi-structured interviews. Thirteen logistics practitioners were interviewed on the topic of crowd logistics. The respondents consisted of logistics practitioners with a stated interest to develop logistics activities that involve the crowd. They represented a diverse group of eleven companies: two retailers, one manufacturer and eight logistics service providers. This group varied in terms of core activities, size and geographical presence. Table 10 presents the list of interviewees.

The interviews were conducted face-to-face and typically lasted for forty to sixty minutes. All interviews were organised according to the same topic list, which consisted of open and probing questions to ensure comprehensiveness and clarity of answers. During the interviews, notes were taken in a structured way, based on the findings of the systematic literature review. In addition, all interviews were recorded to complete the notes afterwards. With the interviews, we aimed to identify types of crowd logistics initiatives that are most interesting according to the logistics practitioners. Additionally, we wanted to determine the main underlying arguments and motivations.

Following the findings from review and interviews, we applied a MAMCA by means of an interactive workshop. The workshop took place on June 14th 2016 and made use of the online software developed by Vrije Universiteit Brussel – MOBI. To the workshop, all previously interviewed logistics practitioners were invited, of which 11 attended.

Table 10. List of interviewees and workshop participants.

<table>
<thead>
<tr>
<th>Date</th>
<th>Type of company</th>
<th>Interviewee’s title</th>
</tr>
</thead>
<tbody>
<tr>
<td>29/04/2016</td>
<td>Parcel express company</td>
<td>Operations Director, Marketing Manager</td>
</tr>
<tr>
<td>04/05/2016</td>
<td>Postal operator</td>
<td>Fulfilment Manager</td>
</tr>
<tr>
<td>09/05/2016</td>
<td>Third party logistics</td>
<td>Chief Operating Officer, Distribution Manager</td>
</tr>
<tr>
<td>11/05/2016</td>
<td>Parcel express company</td>
<td>Operations Director</td>
</tr>
<tr>
<td>18/05/2016</td>
<td>FMCG manufacturer</td>
<td>Supply Network Innovation Manager, Supply Network Innovation Head</td>
</tr>
<tr>
<td>19/05/2016</td>
<td>Carrier</td>
<td>General Manager</td>
</tr>
<tr>
<td>20/05/2016</td>
<td>Multi-channel retailer</td>
<td>Head of Online Food Department</td>
</tr>
<tr>
<td>20/05/2016</td>
<td>Multi-channel retailer</td>
<td>Head of Online Non-food Department</td>
</tr>
<tr>
<td>30/05/2016</td>
<td>Third party logistics</td>
<td>Chief Operating Officer, Business Development Manager</td>
</tr>
<tr>
<td>30/05/2016</td>
<td>Transport software company</td>
<td>Product Manager</td>
</tr>
<tr>
<td>06/06/2016</td>
<td>Parcel express company</td>
<td>General manager</td>
</tr>
</tbody>
</table>

*Also attended the MAMCA workshop.
1 Attended the MAMCA workshop but did not participate in the interviews.
which ten participated. Table 10 indicates which interviewees were also workshop participants.

Commonly applied within the context of decision-making, MAMCA is an extension of the traditional multi-criteria decision analysis (or MCDA) and enables to evaluate different alternatives by explicitly accounting for the objectives of the stakeholders who are involved (Macharis and Milan, 2015). Alternatives include policy measures, business concepts, scenarios and technologies. As opposed to other multi-criteria methodologies, MAMCA develops a separate value tree for each stakeholder instead of only one value tree for all stakeholders (Verlinde and Macharis, 2016). MAMCA is developed by (Macharis, 2005) and the different steps are extensively described in previously published research. Since its development, MAMCA has been extended to workshops as a basis for discussion and stakeholder support analysis, mainly within the context of city logistics (Verlinde and Macharis, 2016). Additionally, this extension has shown to improve the understanding of city logistics issues and alternatives among the stakeholders involved (Macharis, Kin and Lebeau, 2015).

With this analysis, our goal was to find out which existing types of crowd logistics, if any, are supported by all stakeholders and to identify how the different types of crowd logistics should be improved to receive stakeholder support.

Findings

The first step of the MAMCA methodology consists of identifying the different alternatives to evaluate. Following the systematic literature review and semi-structured interviews, we defined five most commonly applied crowd logistics types: business marketplace, community marketplace, flex work platform, commissioner platform and logistics marketplace. Table 11 provides a concise overview of these types.

Three key differences can be detected between the five types of crowd logistics initiatives. Firstly, the direction of goods flows, which move from business to consumer (B2C) (2-5), from business to another business (B2B) (1) or from consumer to another consumer (C2C) (2, 5). Secondly, most types (1, 2, 4) entail delivery services but the flex work platform and logistics marketplace envision logistics more broadly by including, for example, in-store picking or small warehousing services. Thirdly, the nature of the crowd is a clear differentiator as it can consist of professional transporters (1), casual non-professionals (2, 4, 5) or regular crowd workers (3, 4). Underlying are the crowd’s motivating incentives,
either monetary, non-monetary or both. For the second step of the MAMCA, the systematic literature review and interviews allowed us to identify six relevant stakeholder groups: platform provider, logistics service provider, commissioner, receiver, society and crowd. The platform provider hosts the crowd logistics platform. This platform connects the commissioner that gives an instruction to send goods, the receiver that receives these goods and the crowd that executes the task. Depending on the platform operation, the commissioner and receiver can be the same. This is the case for PiggyBee, a crowd logistics platform connecting travellers. The commissioner asks travellers that announce their upcoming trip to bring along certain goods in their luggage, which the commissioner ultimately receives (PiggyBee, no date). In other cases, for example bringr, the commissioner is the sender of goods, similarly to the shipper concept that is frequently applied within city logistics research (bringr, 2017). The logistics service provider can be, but is not necessarily, involved in the crowd logistics activities. However, as Rougès and Montreuil (2014) have pointed out, some crowd logistics start-ups rely primarily on professional couriers, that are also employed by traditional logistics service providers. Carbone et al. (2015) also found that much of the crowd logistics activity is developing on the practitioner side, as it presents both a threat to the logistics industry as well as a source of opportunities. Society is the final stakeholder as it is largely impacted by urban freight transport activities and developments such as crowd logistics. The third step consists of defining relevant criteria for each stakeholder and allocate

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**Table 11. Crowd logistics types.**

<table>
<thead>
<tr>
<th>Crowd logistics type</th>
<th>Description</th>
<th>Parameters</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Business marketplace</td>
<td>Connects demand for delivery services to supply of logistics professionals with free capacity, to optimise current and regular B2B goods flows.</td>
<td>B2B</td>
<td>Cargomatic</td>
</tr>
<tr>
<td>2) Community marketplace</td>
<td>Connects demand for delivery services to supply of commuters, to organise and optimise irregular and limited goods flows.</td>
<td>B2C or C2C</td>
<td>Myways</td>
</tr>
<tr>
<td>3) Flex work platform</td>
<td>Facilitates supply of flexible, often pre-screened workers to organise demand for logistics, possibly to complement employees.</td>
<td>B2C or C2C</td>
<td>Postmates</td>
</tr>
<tr>
<td>4) Commissioner platform</td>
<td>Facilitates supply of commuters or workers to organise a commissioner's goods flows in addition to delivery services by traditional logistics service providers.</td>
<td>B2C</td>
<td>Walmart</td>
</tr>
<tr>
<td>5) Logistics marketplace</td>
<td>Connects demand for logistics to supply of the community to organise local goods flows more socially and/or environmentally friendly.</td>
<td>C2C</td>
<td>Koiki</td>
</tr>
</tbody>
</table>
weights to them according to importance. To reach a comprehensive representation of the stakeholders’ objectives, we developed a draft list for each stakeholder group based on the systematic literature review and interviews. Representatives of the platform provider, logistics service provider and commissioner validated the draft list with minor adjustments and weighted their criteria during the interactive MAMCA workshop, by discussing together. To this end, the MAMCA software applies the Analytic Hierarchy Process (AHP) pairwise comparison method (Saaty, 1988), which allows to compare all criteria one-by-one by using a nine point scale. During the workshop, the previously interviewed logistics practitioners acted in the role that related most to the crowd logistics activity their company envisions for the future. The postal operator, for example, was on the verge of launching a crowd logistics platform when the workshop took place and thus took up the role of platform provider. The multichannel retailers showed interest in using a crowd for home deliveries to their customers but did not want to develop these activities themselves. Therefore, they took up the role of commissioner of goods. Three stakeholder groups were not physically represented during the workshop: crowd, receiver and society. Criteria and weights for the crowd were acquired through a mobile delivery platform that was, at the time of research, the only Belgian initiative resembling crowd logistics. We were obstructed to include actual crowd workers as they were all out to perform delivery tasks during our visit to the headquarters. Instead the Business Operations Manager that was in daily contact with the crowd working for his platform, mainly students, completed the criteria validation and weighting. Due to this absence of an active crowd logistics initiative, we based criteria and weights for the receiver and society on previous research. For a city in Belgium that was investigating more sustainable ways to organise its freight flows, we performed a MAMCA in 2016 (Kin, Verlinde and Mommens, 2017). We collected weighted criteria from each relevant stakeholder group. The information of the surveyed retailers and inhabitants was used to provide criteria and weights in our MAMCA for, respectively, the receiver and society. Sixty stakeholders were surveyed, of which two retailers and four inhabitants. Despite the low response rate, sensitivity analyses proved the robustness of the weights for each stakeholder. This choice was made because of the relevant similarities between the two groups. Retailers and receivers cover in both studies the collectors of goods that need their goods delivered in a qualitative and inexpensive way, with care for the environment and society. Similarly, both inhabitants and society want an attractive environment to live in, with access to a broad range of products. Table 12 provides an overview of the list of criteria per stakeholder and the relative weights they received. Some criteria are named the same but differ in meaning, as they are defined from the perspective of a specific stakeholder. For example, for the logistics service provider,
return on investment means a maximal positive difference between revenues and investments for facilitating logistics. For the platform provider, having return on

*Helen Buldeo Rai*
investment is also important, be it from a different reality. Here, the term entails having a maximal positive difference between revenues and investments for launching and managing the platform. The stakeholder-perspective stipulates that there is no overlap between the criteria with respect to content or meaning.

In the fourth step, indicators and measurement methods are linked to the previously defined criteria. Different multi-criteria analysis methods can be used. A certain method is chosen based on the given problem, type of information and desired result (Geudens et al., 2009). We opted for the Preference Ranking Organization METHod for Enrichment Evaluations (or PROMETHEE), presented by Brans (Brans, 1982). PROMETHEE enables to use different types of data (Macharis et al., 2004). Due to the absence of active crowd logistics initiatives, no quantitative data could be measured or collected. Therefore, the stakeholders were asked to perform the evaluation based on their estimation and expertise in the fifth step. Thus, for each of their weighted criteria, stakeholders indicate how they expect that alternative one scores on criterion A by choosing between the following choices: “positive”, “slightly positive”, “neutral”, “slightly negative” or “negative”. The approach applied for weighting the criteria was also used for the evaluation of alternatives. As an outranking method, PROMETHEE computes a net preference flow that measures how each alternative outranks or is outranked by the other alternatives (Macharis and Milan, 2015).

Together, these steps result in a multi-actor view on the five evaluated alternatives, which is the sixth step. Shown in Figure 9, the horizontal axis indicates the six stakeholder groups. The five lines represent the five most commonly applied crowd logistics types. On the vertical axis, we can read how well a certain crowd logistics type scores on the weighted criteria of each stakeholder group and thus, to what extent the alternative contributes to his objectives. The horizontal dotted 0-line represents the current situation or “business as usual”. The serrated lines indicate conflictual views between the different stakeholders.

The analysis indicates that the business marketplace receives most support among all stakeholders. The stakeholders identify the business marketplace as equally satisfying as (commissioners and crowd) or better than (platform provider, logistics service provider, receiver and society) the current situation. In addition, it becomes apparent that the logistics marketplace is evaluated positively by the platform provider, logistics service provider, commissioner and receiver. For the crowd and society, however, this type of crowd logistics corresponds less to their stated objectives. The remaining types of crowd logistics are characterised by high and low peaks, indicating that the community marketplace, flex work platform and commissioner platform are less likely to receive consensus among the stakeholders involved.
In addition to the multi-actor view, a mono-actor analysis is performed (Figure 10). For the logistics service provider, the analysis reveals that the business marketplace fits best with its priority to achieve maximal return on investment. The business marketplace also responds best to the objectives of society because of its expected potential to enhance the living environment. Also platform provider and receiver evaluate the business marketplace positively, as they credit this type of crowd logistics for having the best potential impact on the environment.
Commissioner and crowd estimated other types of crowd logistics as a better fit for their objectives. The commissioner considers a positive environmental effect, with lower prices for delivery services, although a negative impact on society and quality of pick-up is anticipated too. For the crowd, the business marketplace responds to all its objectives but expects the compensation to be low.

Conclusion

Today, logistics has become an important competitive advantage to attract consumers. Crowd logistics is an interesting innovation that can respond to consumers’ delivery expectations, while also being efficient and sustainable. There are examples verifying this claim, but also developments that lead to question it. Therefore, the research investigates which types of crowd logistics activities already exist and which types are supported by the stakeholders involved. We answer these questions by a systematic literature review, semi-structured interviews and a MAMCA. First, we identify five types of crowd logistics: business marketplace, community marketplace, flex work platform, commissioner platform and logistics marketplace. Following the MAMCA, we conclude that all types have potential to be supported by one or more stakeholders. Overall, stakeholders’ estimations of the different crowd logistics types conflict. Two alternatives that score best among all stakeholders are the business marketplace and logistics marketplace. For practitioners, this indicates that a thorough stakeholder analysis is necessary for successful implementation of a crowd logistics initiative. It also indicates which elements of the crowd logistics initiative need adaptation in order to meet stakeholders’ objectives. For the business marketplace, this implies the necessity to guarantee a qualitative pick-up of goods, which is a key concern for the commissioner. It also suggests to provide an adequate compensation for the crowd, which they consider to be low. For policy-makers, the research urges to take into account the diverse realities that exist within the “sharing economy”. Political acceptance is an essential condition for this kind of development (Mehmann, Frehe and Teuteberg, 2015). Many presume that crowd logistics will only continue to grow and will essentially revolutionise the way companies think about delivery services and logistics (Thaker, 2015; Goetting and Handover, 2016). Thus, instead of applying a “one-size-fits-all” regulation, our MAMCA suggests to support the business marketplace and the community marketplace because they have important

7 E.g. findings of chapter 8 build on empirical evidence to demonstrate the circumstances in which crowd logistics is not a sustainable alternative to traditional logistics service providers.
sustainability benefits. Unfavourable initiatives that promise to be unsustainable for environment and society can be targeted with restrictions.

The research is limited by inaccurate representation of three stakeholders. In the next phase of our research, we will collect data of an active crowd logistics platform. This will allow us to include direct input of the stakeholders that were not directly involved at this point and to validate the MAMCA with quantitative input. It will also enable us to perform a sustainability impact analysis of the crowd logistics platform. The outcome of the MAMCA will provide direction as to which type of crowd logistics platform will be chosen for further investigation.
WHICH LAST MILE OPTIONS DO CONSUMERS PREFER?
Introduction

Research on last mile transport investigates the final part of the supply chain from the last distribution centre, consolidation point or local warehouse. It focusses on the ways in which products reach their final destination in the consumer market (Xiao et al., 2017). In times of intensifying retail digitalisation, consumers order more and more products over the internet. As these products are often delivered to consumers’ homes, concerns on last mile sustainability are rising (Allen et al., 2017; Allen, Pieczyk and Piotrowska, 2017). In their review of environmental implications of online business-to-consumer commerce, Mangiaracina et al. (2015) demonstrate that transport has the greatest impact on sustainability. They refer to last mile delivery as most important transport activity, as there are little differences between online and conventional shopping for most of the other transport activities involved. Accordingly, last mile transport is considered as one of the biggest challenges in business-to-consumer e-commerce (Savelsbergh and Van Woensel, 2016).

Next to environmental concerns, last mile transport is also very costly to organise for logistics service providers that carry out these deliveries. Depending on several factors, the last mile accounts for 13% to 75% of total supply chain costs (Gevaers, Van De Voorde and Vanelslander, 2009). Honeywell (2016) estimates that 50% of total costs are attributed to the last mile. These high costs are partly caused by retailers who promise to serve their customers in two days, the next day or even the day of purchase itself. Such short delivery terms hinder efficient routing and consolidation of parcels (Savelsbergh and Van Woensel, 2016). Low delivery location density and logistics facilities remote from the consumer market add to the inefficiencies (Reyes, Savelsbergh and Toriello, 2017). As a consequence, last mile delivery of a product is between five and twenty–three times more expensive for retailers than product purchases in–store (Allen et al., 2017). What is more, consumers are largely unwilling to pay for these delivery services. With an increasing number of retailers that move towards instant and on-demand deliveries, efficiency and sustainability problems might only become larger.

As there is both an environmental and economic need, more efficient and sustainable last mile delivery concepts are being explored. In their review of the impact of home delivery on urban freight transport, Visser et al. (2014) suggest environmentally friendly vehicles (e.g. electric vehicles and cargo-bicycles) and consolidation. Consolidation makes deliveries more efficient, as more drops per
trip reduce the number of vehicle kilometres per delivery (Visser, Nemoto and Browne, 2014). There are several ways to foster consolidation, e.g. longer delivery terms (Boyer, Prud’homme and Chung, 2009) and use of alternative delivery addresses (e.g. parcel pick-up points and lockers) (Edwards et al., 2010; Edwards, McKinnon and Cullinane, 2010). Within the recently conceptualised omnichannel retail model, also retailers’ stores serve as pick-up location (Gao and Su, 2016). Omnichannel retail implies that online channels, such as web-shops, and offline channels, such as physical stores, are integrated (Verhoef, Kannan and Inman, 2015). For consumers, this means that they can use various channels throughout their shopping journey in a flexible, convenient and seamless way that matches their preferences and needs (Peltola, Vainio and Nieminen, 2015; Juaneda-Ayensa, Mosquera and Murillo, 2016). For omnichannel retailers, channel integration provides a response to the fierce competition from online-only players and creates more loyal and profitable customers (Nash, Armstrong and Robertson, 2013; Cao and Li, 2015). Using their store network allows to reduce the number of expensive home deliveries and increase the overall efficiency of their supply chain (Buldeo Rai, Verlinde, Macharis, et al., 2017).

The omnichannel retail model is gaining popularity among retailers. Similar to pure online retailers, who are under pressure to provide efficient delivery in terms of speed, price, service and quality (Conlumino for Barclays, 2014), omnichannel retailers need to figure out how to organise last mile transport flows to their customers, using their store network (Hübner, Kuhn and Wollenburg, 2016). Currently, it is unclear how omnichannel retailers can create a last mile transport offer that is both attractive from a customer point of view and sustainable from an environmental point of view. National and international reports demonstrate the importance of free and fast delivery (MetaPack, 2016; Comeos, 2018), but consumers’ acceptance of more sustainable last mile transport options has not been explored. As consumers are not willing to compromise on quality, cost and convenience when making environment-friendly choices, a comprehensive and industry-specific understanding of consumers’ decision-making process is important (Narula and Desore, 2016).

To this end, we set up a survey among a representative sample of Belgian consumers using choice-based conjoint experiments. By analysing consumers’ preference structures, we identify which last mile attributes need to be combined to reach sustainability from a “planet” and a “profit” point of view.
Two last mile transport options are commonly offered to consumers when they order products online: delivery at home (or any other address of choice) and collection at a local pick-up point or locker. From an environmental point of view, home delivery is considered the least favourable option (Mangiaracina et al., 2015). Several sustainability issues are raised. First, delivery rounds are organised during regular office hours. Most consumers are at work during this time of day, which results in failed deliveries (Visser, Nemoto and Browne, 2014). Exact percentages on the share of product deliveries that fail are scarce and inconsistent. According to Edwards et al. (2009), failure rates can go from as low as 2% to 30%. Other figures are recorded in the UK: 13% to 14% (IMRG, 2014), 25% (McLeod, Cherrett and Song, 2006), 30% (Fernie and Sparks, 1999) and even 60% (Retail Logistics Task Force, 2001). In the Netherlands, deliveries fail in 25% of the orders (Van Duin et al., 2016), while the Belgian postal organisation reports 14% (Gijsbrechts, 2017). The differences in percentages largely depend on logistics service providers’ policies with receivers that are not at home. In general, orders that could not be delivered are dropped off at receivers’ neighbours or at a local pick-up point. However, in 12% of the cases such orders are offered a second time to receivers’ homes (Visser, Nemoto and Browne, 2014). This re-delivery process can be repeated up to four times (Van Duin et al., 2016). In any case, delivery failure rates increase as home delivery grows (Weltevreden, 2008).

Second, retailers often offer next-day delivery as part of their standard service. Fast delivery reduces the opportunity to consolidate orders and organise efficient delivery routes (Allen, Piecyk and Piotrowska, 2017), leading to an increase in vehicles and vehicle kilometres (Verlinde, Macharis and Witlox, 2012). Similar to figures on delivery failure, knowledge on load rates of delivery vehicles is limited. General freight studies refer to percentages less than 30% in an urban context (Gebresenbet et al., 2011) and less than 50% in a nonurban context (McKinnon and Piecyk, 2009). Taking both a volume and a weight perspective, it is commonly acknowledged that vehicles dedicated to home delivery are not fully loaded (Allen et al., 2017; Allen, Piecyk and Piotrowska, 2017). Moreover, vehicles often fail to collect additional volume on their return to the warehouse, resulting in empty running (Edwards, McKinnon and Cullinane, 2011).

Third, home deliveries are mostly carried out with light goods vehicles or vans. These vehicles consume more fuel and release more emissions per metric ton.

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9 Note that this study does not consider consumer transport. Chapter 7 includes consumer transport and empirically demonstrates that stores and collection points are more sustainable last mile options only if consumers’ collection trips are walked, biked or en route of a multi-purpose trip.
moved than larger vehicles (Allen and Browne, 2010). In the UK, the number of licensed vans has increased by 70% over the period from 1995 to 2015 (Allen et al., 2017; Allen, Piecyk and Piotrowska, 2017). The number of vans in Belgium has grown by 55% from 1991 to 2013, while the number of trucks remained stable (Strale et al., 2015). The rise in online shopping is stated as one of the key reasons behind this evolution (Allen et al., 2017; Allen, Piecyk and Piotrowska, 2017).

To respond to these challenges, innovative variations on regular home delivery are being tested. Notable examples to avoid delivery failure include personal reception boxes (Punakivi and Tanskanen, 2002), in-car delivery (Reyes, Savelsbergh and Toriello, 2017) and in-fridge delivery (Bauerová and Klepek, 2017). Such innovations rely on technological smart lock solutions to access boxes, car trunks and even houses. Another solution to increase first-time delivery success entails to offer a pre-agreed appointment or time slot in which the delivery takes place (Van Loon et al., 2015). However, this option is not provided often by logistics service providers as it complicates their routing schedules (Edwards, McKinnon and Cullinane, 2010).

Similarly, solutions have been introduced to increase parcel consolidation. One of these solutions combines efficient routing programmes with delivery-term flexibility from the consumer’s side. Instead of offering next-day delivery by default, retailers offer their customers the option to pick a time slot in which deliveries to their neighbourhood are already scheduled (Cullinane, 2009). This solution opposes the perceived need of companies to deliver faster and faster (Reyes, Savelsbergh and Toriello, 2017). Although consumers’ waiting time increases, it enables more sustainable deliveries and raises awareness of sustainability issues related to delivery at home.

Another solution to increase consolidation is created by parcel pick-up points and lockers, which are mostly located in busy and/or residential areas. Pick-up points are manned and organised in small local shops while lockers are unmanned and serviced by technological solutions such as QR-codes and mobile phones (Visser, Nemoto and Browne, 2014). The main advantage is that 100% of the parcels are delivered (Van Duin et al., 2016), while providing consumers with more locations and time slots to choose from when picking up their parcels (Xiao et al., 2017). By collecting parcels within a certain neighbourhood, such points enable consolidation and efficient routing of delivery vehicles (Allen, Piecyk and Piotrowska, 2017). The negative environmental impact of parcel delivery is even more reduced when consumers visit the pick-up point on foot or by bike and/or combine this trip with other purposes (Xiao et al., 2017).

A similar solution to pick-up points and lockers is offered by so-called omnichannel retailers. Next to delivery at home and pick-up at regular parcel
points, omnichannel retailers allow consumers to pick-up their orders in one of their stores (Gao and Su, 2016). For omnichannel retailers, integrating their store network allows to reduce the number of expensive home deliveries and increase the overall efficiency of their supply chain (Hübner, Kuhn and Wollenburg, 2016). Moreover, consumers are found to prefer this option over regular pick-up points, which are managed by logistics service providers. This is because stores offer advantages such as possibilities to return products and make additional purchases, immediate refund for product returns and specialised product advise (Buldeo Rai, Verlinde, Macharis, et al., 2017).

Alternatives to vans are ubiquitous in urban environments. Most logistics service providers are experimenting with sustainable alternatives such as bikes and electric vehicles. Such vehicles offer many advantages. For example, cargo-bikes are not subjected to congestion and allow to guarantee delivery time accuracy (Gruber, Kihm and Lenz, 2014). In times of increasing environmental awareness at the urban level, electric vehicles often receive more favourable time windows and can access the city’s low emission zones (Quak, Nesterova and van Rooijen, 2016).

Despite many innovations that aim to improve sustainability in last mile transport, actual implementation is still limited. Part of the explanation is that retailers are not offering sustainable options that consumers can choose from, acting as a so-called “filter” on the product and service offer (Kostadinova, 2016). Young et al. (2010) found that consumers make green purchases only if available in a range of options, while Theotokis and Manganari (2015) recommended a system in which the most sustainable option is offered as “opt-in”, to which consumers can deviate by explicitly “opting-out”. Another part of the explanation points to consumers that fail to make sustainable choices even when given the option. Research found that even if consumers are inclined to make an environment-friendly purchase, they are not willing to compromise on quality, cost and convenience (Narula and Desore, 2016). Hence, a comprehensive and industry-specific understanding of consumers’ decision-making process is important.

Various studies have investigated what consumers find important in last mile transport. These studies show that consumers prefer free and fast delivery at home (MetaPack, 2016; Comeos, 2018). Although consumers increasingly attach significance to environmental sustainability in their purchase activities (Bask et al., 2013; Gonzalez-Lafayse and Lapassousse-Madrid, 2016; Quarshie, Salmi and Leuschner, 2016), the topic has received less attention in relation to consumers’ last mile transport decisions. Currently, environmental concerns and arguments seem to play a minor role (Lagey, Cassimon and Verstichel, 2016). With this research, we explore to which extent consumers are willing to adopt last mile options that are more sustainable and how these options should be composed to remain...
attractive. We use choice-based conjoint analysis to examine how consumers trade-off collection and delivery attributes in their choice of last mile transport options when they make purchases online.

Methodology

Choice-based conjoint analysis
Choice-based conjoint analysis is a stated preference technique that simulates a choice situation involving a set of competing alternatives. Various alternatives are composed based on a common set of attributes and presented to respondents. Given this set of attributes, respondents select the option that matches best with their preferences. By observing the preferred alternatives, choice-based conjoint analysis allows to estimate the trade-offs that respondents make among the various attributes. The method has a long track record in measuring preferences and understanding choices and trade-offs that consumers make (Louviere, 1994). A major advantage of choice-based conjoint analysis is the realism it provides in modelling consumers’ decision-making processes (Hair, Black and Babin, 2010). The method has been applied in retailing since the early work of (Green and Srinivasan, 1978). For investigating the importance of sustainability in consumers’ decision-making, it is the most commonly used method (Bask et al., 2013; Lebeau, Macharis and Van Mierlo, 2016).

The selection of attributes is critical in choice-based conjoint design. According to the literature review, many aspects influence the choice for last mile transport options. According to Hair et al. (2010), a maximum of six attributes is recommended. To identify the most relevant attributes, we analysed consumer preference surveys and validated a final attribute set in focus groups with consumers. The survey results were reported in thirty-five national and international reports and published by various parties: logistics service providers (e.g. UPS, PostNord), communication agencies (e.g. Walker Sands, Bizrate Insights), financial agencies (e.g. Barclays), consulting agencies (e.g. McKinsey, KPMG) and associations (e.g. IMRG, Comeos). We collected and categorised all aspects of importance to consumers in last mile delivery in a spreadsheet file. Six focus groups were organised in June and July 2017 in three major Belgian cities: Brussels, Ghent and Antwerp. Each focus group counted four respondents and lasted approximately three hours. These respondents were equally distributed in terms of motivation, frequency and experience with online shopping, their perception of sustainability and also age, gender and language (either French or Dutch). A topic list guided
the conversation in a semi-structured way and introduced several topics, including the respondents’ online shopping journey, perception of the online retail landscape, perception of and expectations about last mile delivery and the future of online retailing. It is considered good practice to introduce focus group discussions at the beginning of a research project that aims to identify factors that influence behaviour, motivation, opinions or feelings and ideas that people have (Krueger and Casey, 2000). Ultimately, we selected four attributes: “delivery price”, “delivery term”, “delivery reception” and “return possibility”. Delivery location and delivery time were grouped into one attribute or “composite factor” (Green and Srinivasan, 1978) that we named “delivery reception”, as both aspects are linked. For example, delivery in a parcel locker allows for 24/7 pick-up possibilities and a slotted two hour-delivery timeframe is only relevant for delivery at home (or any other fixed address). Similarly, the “return possibility” attribute combines both the return location and price.

Several last mile transport aspects were ultimately excluded from our final selection as they were considered less relevant for consumers: delivery information, delivery vehicle, delivery flexibility, executing logistics service provider and aspects related to sustainability. Remarkably, our focus groups showed that consumers do not feel responsible for enhancing sustainability but instead expect businesses – including retailers and logistics service providers – to act in a sustainable way.

Table 13 lists our final set of attributes and their possible values or “levels”. These levels were selected to reflect a realistic last mile offer in omnichannel retail. Similarly to attributes, the number of levels should be limited to ensure an efficient design. Moreover, levels need to be both communicable and actionable (Hair, Black and Babin, 2010). In this respect, communicable levels enable respondents to understand them in the same way and evaluate them correctly, while actionable levels allow them to be put into practice. As some attributes could be unclear for respondents, specifically “loyalty programme” and “time slot”, we added a short description below every choice task. A loyalty programme is offered by the retail group, based on purchase frequency and/or purchase amount, and offers free deliveries and returns. The time slot represents a period of time in which the delivery takes place, in this case of two hours.

**Utility computation**

Different estimation methods are available to model preferences using the collected data. We applied the multinomial logit model, which is the most frequently used model in choice-based conjoint studies. This model is highly versatile and based on sound theoretical assumptions (Rao, 2014). In this way, consumer utility values are calculated. Utility values indicate the relative importance of attributes’ levels.
and illustrate the extent of desirability for a certain attribute level: the higher the utility, the more desirable the attribute level. Levels with high utilities have a large positive impact on influencing respondent’s choices (Hair, Black and Babin, 2010).

**Survey sample and design**

A large retail group in Belgium is expanding its online activities for non-food products. In accordance with the omnichannel retail model, its online channel will be integrated in the retail group’s dense store network. For the group, sustainability and customer service are key values and drive internal and external actions and operations. Therefore, last mile transport options offered to their customers should be attractive from a consumer point of view and sustainable from a “green supply chain” point of view. This is important, as sustainability initiatives ultimately depend on customer support (Quarshie, Salmi and Leuschner, 2016). The green supply chain concept integrates environmental considerations into supply chain management, including product design, manufacturing processes and delivery of products to consumers (Srivastava, 2008).

The choice-based conjoint analysis is based on a survey conducted among a sample of one-thousand consumers. The sample is representative for the Belgian population according to age, sex, degree, language, family composition and social class (CIM, 2017). The survey was administered online by using Sawtooth software (www.sawtoothsoftware.com/). Web-based surveys are efficient and convenient (Bask et al., 2013). It allowed us to reach an appropriate sample size and sample

---

Table 13. Attributes and levels.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Delivery price</th>
<th>Delivery term</th>
<th>Delivery reception</th>
<th>Return possibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free</td>
<td>Delivery price</td>
<td>Delivery term</td>
<td>Delivery reception</td>
<td>Return possibility</td>
</tr>
<tr>
<td>Free as from €25</td>
<td>Free</td>
<td>Within two hours</td>
<td>Address of choice, during the week (9a-18u)</td>
<td>Free, retail group’s store (during opening hours)</td>
</tr>
<tr>
<td>Free as from €50</td>
<td>Free</td>
<td>Tomorrow</td>
<td>Address of choice, during the weekend (9u-18u)</td>
<td>Free, pick-up point (during opening hours)</td>
</tr>
<tr>
<td>Free as from €75</td>
<td>Free</td>
<td>Day after tomorrow</td>
<td>Address of choice, during the weekend (9u-18u)</td>
<td>Free, parcel lockers (24/7)</td>
</tr>
<tr>
<td>£2.95</td>
<td>Free as from €25</td>
<td>Within 1 to 3 days</td>
<td>Address of choice, during two- €2, retail group’s store (during opening hours)</td>
<td></td>
</tr>
<tr>
<td>£5.95</td>
<td>Free as from €75</td>
<td>Within 3 to 5 days</td>
<td>Retail group’s store (during opening hours)</td>
<td>£2, pick-up point (during opening hours)</td>
</tr>
<tr>
<td>Free with a loyalty programme</td>
<td>Minimal 3 days, but delivery date of choice</td>
<td>Pick-up point (during opening hours)</td>
<td>£2, parcel lockers (24/7)</td>
<td></td>
</tr>
<tr>
<td>Free with a loyalty programme</td>
<td>Minimal 5 days, but delivery date of choice</td>
<td>Parcel lockers (24/7)</td>
<td>Free with a loyalty programme, retail group’s store (during opening hours)</td>
<td></td>
</tr>
</tbody>
</table>
composition within a limited timeframe. To reach the envisioned target group, three selection criteria were applied: all respondents are older than eighteen, made an online purchase in the last year and endorse the retail group. In total, 13% of respondents were rejected from the final sample because of this third criterion. Accordingly, they did not receive access to the remainder of the survey. The data collection was in collaboration with a recognised market research company (iVOX). Preceded by a technical pre-test with one-hundred respondents, the survey ran two weeks (from 18 September 2017 until 29 September 2017).

We organised the survey in three parts. In the first section, screener questions were asked to reject respondents based on the previously defined criteria. This part also contained questions on socio-demographics to compose the sample. The second section was dedicated to behaviour, preferences and experiences with regard to online shopping: purchase frequency, product types, online stores and order collection and delivery. In this section, we also proposed statements related to last mile transport: twelve on innovations (including crowd logistics) and nine on sustainability (including electric vehicles). The third section comprised the on-screen choice tasks, providing a realistic last mile offer from which respondents could choose. To generate the various choice tasks, it was necessary to make several decisions concerning the choice-based conjoint design: number of alternatives, number of choice tasks and the method for generating the choice tasks. Figure 11 illustrates an example of a choice task included in the survey.

Figure 11. Screenshot of a choice task.

<table>
<thead>
<tr>
<th>Delivery price</th>
<th>Delivery term</th>
<th>Return possibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free</td>
<td>Within two hours</td>
<td>Free, pick-up point (during opening hours)</td>
</tr>
<tr>
<td>€2,95</td>
<td>Within 1 to 3 days</td>
<td>€2, retail group’s store (during opening hours)</td>
</tr>
<tr>
<td>Free with a loyalty programme</td>
<td>Tomorrow</td>
<td>€2, parcel lockers (24/7)</td>
</tr>
</tbody>
</table>

Given current market conditions, would you really choose this option?

Yes

No

*PTL: Loyalty programme = offered by the retail group based on purchase frequency and/or purchase amount. Time slot = period of time in which the delivery takes place.*

Heleen Buldeo Rai
First, the number of alternatives presented in a choice task needs to be decided. More alternatives provide richer trade-offs but reduce the design’s efficiency. An increasing number of alternatives also require more efforts by respondents. Following the recommendation by Hair et al. (2010), we include three alternatives per choice task. Second, similar considerations have to be made regarding the number of choice tasks. Generally recommended is not to exceed ten to fifteen choice tasks, as it does not provide additional insights into the preference structure of respondents (Hoogerbrugge and van der Wagt, 2006). We decided to present respondents with eight choice tasks, given that the survey also included additional questions. Third, choice tasks are composed by combining levels from each attribute. In our design, no pairs of levels were prohibited from occurring together. The method for choice task generation needs to take two key principles into account: orthogonality and balance (Hair, Black and Babin, 2010). Orthogonality of the design means that no correlation should exist among the levels of an attribute. The balance of the design means that each level of an attribute should appear the same number of times. We used the balanced overlap option provided by Sawtooth software to generate the choice tasks.

Findings

Attitudes of consumers
To evaluate consumers’ attitudes towards sustainability in last mile transport, we proposed nine statements. These statements capture general attitudes (statements one to three) and attitudes towards delivery characteristics with a positive environmental effect (statements four to nine). These delivery characteristics comprise the use of parcel pick-up points (Edwards et al., 2010; Edwards, McKinnon and Cullinane, 2010), consolidation of parcels and longer delivery terms (Boyer, Prud’homme and Chung, 2009) and the use of environmentally friendly vehicles (Visser, Nemoto and Browne, 2014). Figure 12 illustrates responses on these statements. These responses are useful for interpreting the choice-based conjoint analysis. Moreover, attitudinal insights are important, as intentions to perform a certain behaviour can be influenced by attitudes (Ajzen, 1991).

The results of the survey show that approximately half of consumers take their environment into account when making a purchase and agree that achieving less vehicle kilometres for last mile deliveries is important. Consumers attach more importance to reducing vehicle kilometres in general (52,5%) as compared to reducing vehicle kilometres in their specific neighbourhood (48,5%). Therefore, we
assume that consumers experience limited nuisances from local delivery activities. Nevertheless, in line with Macharis and Milan (2015), the results show that consumers are concerned about the overall negative impacts of these activities. A reduction in vehicle kilometres is feasible by decreasing home deliveries in favour of pick-up points and increasing delivery times. Survey results indicate that 56.2% and 44.6%, respectively, of consumers are willing to contribute to this. However, consumers are not willing to pay for deliveries that employ more sustainable alternatives to standard delivery vans, such as electric vehicles (57.1%) or cargo-bicycles (55.2%). Research shows that consumers tend to resist new technologies that are considered alien or unproved (Egbue and Long, 2012). In line with deliveries with conventional vehicles (Allen et al., 2017; Allen, Piecyk and Piotrowska, 2017), consumers’ willingness to pay is low. In total, 70.9% of consumers want all products of the same order delivered together, but only 60.5% is prepared to wait longer.

Among the survey results, we detect a high percentage of neutral responses to the statements (29% on average). Consequently, we assume that interest in and/or knowledge about sustainability in last mile delivery among consumers is low. Research has shown that knowledge is an important predictor of green consumer behaviour (Kostadinova, 2016). Possibly, it indicates that (a part of) consumers can be convinced to make more sustainable choices. This interpretation is in line with the green and social delivery report published by (B2C Europe, 2018), which

Figure 12. Consumers’ attitudes towards sustainable last mile transport. All statements were measured on a Likert-type scale ranging from 5=strongly agree to 1=strongly disagree.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree and disagree</th>
<th>Neutral</th>
<th>Agree and strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>As far as possible, I take my environment into account when I make a purchase.</td>
<td>17,2</td>
<td>37,4</td>
<td>45,4</td>
</tr>
<tr>
<td>It is important for me that less kilometres are driven for my parcels.</td>
<td>13,9</td>
<td>33,7</td>
<td>52,4</td>
</tr>
<tr>
<td>It is important for me that less kilometres are driven in my neighbourhood for my parcels.</td>
<td>14,9</td>
<td>36,6</td>
<td>48,5</td>
</tr>
<tr>
<td>I am willing to collect my parcels in a parcel point if less kilometres are driven.</td>
<td>17,1</td>
<td>26,7</td>
<td>56,2</td>
</tr>
<tr>
<td>I am willing to wait longer for my parcels to arrive if less kilometres are driven.</td>
<td>28,9</td>
<td>26,5</td>
<td>44,6</td>
</tr>
<tr>
<td>It is important for me that the products that I order together, are delivered together.</td>
<td>10,3</td>
<td>18,8</td>
<td>70,9</td>
</tr>
<tr>
<td>I am willing to wait longer for my parcels, if my parcels are delivered together.</td>
<td>17,4</td>
<td>22,1</td>
<td>60,5</td>
</tr>
<tr>
<td>I am willing to pay more for a sustainable delivery with an electric vehicle.</td>
<td>17,4</td>
<td>22,1</td>
<td>60,5</td>
</tr>
<tr>
<td>I am willing to pay more for a sustainable delivery with a cargo-bicycle.</td>
<td>55,2</td>
<td>30,3</td>
<td>14,5</td>
</tr>
</tbody>
</table>
demonstrates that many consumers lack knowledge on the environmental impact of deliveries, but are willing to choose sustainable alternatives when negative impacts are explained.

### Consumers' choice behaviour

As the findings reported in this section were analysed for the whole sample, analysis is based on 8,000 choice tasks. The examined model was statistically significant relative to the fixed model, using a chi-square test \((p=0.001)\). Consequently, respondent choices are significantly affected by the attribute composition presented (Hosmer and Lemeshow, 2013). Table 14 shows the utility of attribute levels and the relative importance of attributes in percentages. Together, these findings represent what consumers view as best last mile option.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Attribute levels</th>
<th>Utility of attribute levels</th>
<th>Standard error</th>
<th>Relative attribute importance (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery price</td>
<td>Free</td>
<td>1,24960</td>
<td>0,00998</td>
<td>53,47</td>
</tr>
<tr>
<td></td>
<td>Free as from €25</td>
<td>0,55657</td>
<td>0,00991</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free as from €50</td>
<td>-0,07456</td>
<td>0,03358</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free as from €75</td>
<td>-1,02177</td>
<td>0,04448</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€2,95</td>
<td>-0,17266</td>
<td>0,03399</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€5,95</td>
<td>-1,03270</td>
<td>0,04484</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free with a loyalty programme</td>
<td>0,49552</td>
<td>0,03093</td>
<td></td>
</tr>
<tr>
<td>Delivery term</td>
<td>Within two hours</td>
<td>-0,08625</td>
<td>0,03471</td>
<td>13,67</td>
</tr>
<tr>
<td></td>
<td>Tomorrow</td>
<td>0,22022</td>
<td>0,03301</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day after tomorrow</td>
<td>0,14189</td>
<td>0,03110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Within 1 to 3 days</td>
<td>0,18667</td>
<td>0,03288</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Within 3 to 5 days</td>
<td>-0,07804</td>
<td>0,03418</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimal 3 days, but delivery date of choice</td>
<td>-0,02114</td>
<td>0,03388</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimal 5 days, but delivery date of choice</td>
<td>-0,36335</td>
<td>0,03571</td>
<td></td>
</tr>
<tr>
<td>Delivery reception</td>
<td>Address of choice, during the week (9u-18u)</td>
<td>0,20582</td>
<td>0,03335</td>
<td>12,64</td>
</tr>
<tr>
<td></td>
<td>Address of choice, during the week (18u-22u)</td>
<td>0,14333</td>
<td>0,03305</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address of choice, during the weekend (9u-18u)</td>
<td>0,08163</td>
<td>0,03360</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address of choice, during two-hour time slot</td>
<td>0,13788</td>
<td>0,03220</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retail group’s store (during opening hours)</td>
<td>-0,20334</td>
<td>0,03515</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pick-up point (during opening hours)</td>
<td>-0,03140</td>
<td>0,03364</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parcel lockers (24/7)</td>
<td>-0,20334</td>
<td>0,03591</td>
<td></td>
</tr>
<tr>
<td>Return possibility</td>
<td>Free, retail group’s store (during opening hours)</td>
<td>0,24136</td>
<td>0,03288</td>
<td>20,21</td>
</tr>
<tr>
<td></td>
<td>Free, pick-up point (during opening hours)</td>
<td>0,41717</td>
<td>0,03240</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free, parcel lockers (24/7)</td>
<td>0,23179</td>
<td>0,03257</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€2, retail group’s store (during opening hours)</td>
<td>-0,30370</td>
<td>0,03539</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€2, pick-up point (during opening hours)</td>
<td>-0,25181</td>
<td>0,03526</td>
<td></td>
</tr>
<tr>
<td></td>
<td>€2, parcel lockers (24/7)</td>
<td>-0,44561</td>
<td>0,03651</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free with a loyalty programme, retail group’s store (during opening hours)</td>
<td>0,11078</td>
<td>0,03304</td>
<td></td>
</tr>
</tbody>
</table>

Table 14. Attribute levels utilities and relative attribute importance percentages.
The most important attribute to consumers is delivery price (53.47%). The second most important feature is return possibility (20.21%), followed by delivery term (13.67%) and delivery reception (12.64%). Consumers’ preference goes out to free, next-day delivery to an address of choice, on regular office hours during the week and with a free return possibility in a local pick-up point. This agrees with current preference figures of collection and delivery alternatives in Belgium (Comeos, 2018).

Next to free delivery, consumers indicate a positive preference for a minimal purchase amount of €25 that allows free delivery, the lowest purchase amount among the price levels, and free delivery using a loyalty programme. This finding is in accordance with Xing et al. (2010), who point out the increasing price sensitiveness of consumers in the retailing market. Loyalty programmes’ importance has increased in the last few years (Hagberg, Sundstrom and Egels-Zandén, 2016). Internationally, consumers are found to use and appreciate such programmes and want free or quick delivery as a reward (MetaPack, 2016). At the time of research, loyalty programmes were just gaining ground in Belgium. Consumers avoid high minimal purchase amounts (€75) and high delivery prices (€5,95).

The results for the delivery-term attribute show a preference for levels that allow faster deliveries, including delivery tomorrow, day after tomorrow and within one to three days. Preference decreases as delivery terms increase. Most unfavourable to consumers is a delivery term that can take at least five days, despite the possibility to freely choose a delivery date within this term. Clearly, consumers do not mind unknown delivery dates. Accordingly, a study found that 73% of Belgian consumers do not consider this as a limitation of online shopping (bpost, 2017). Moreover, the results indicate that consumers have no preference for instant orders that are delivered within two hours, which contradicts recently formulated expectations (Dablanc et al., 2017). Also contrary to assumptions made by Agatz et al. (2013), consumers have no distinct preference for slotted deliveries.

For receiving deliveries, consumers prefer an address of choice. Only small preference differences are detected among the exact delivery times. Delivery during the week or the weekend, during regular office hours or after and during a slotted two-hour or unknown timeframe, consumers appear to be indifferent. In comparison, they avoid collecting parcels in one of the retail group’s stores or parcel locker boxes.

The results for the return possibility attribute point out that consumers strongly prefer to return unwanted or faulty orders free of charge, or free by employing a loyalty programme. Returning goods in a pick-up point is valued most, next to stores of the retail group or parcel locker boxes. Consumers avoid paying for their order returns, in particular when the return location is a locker.
In accordance with the above analysis, delivery price is by far the most important factor in consumers’ choice behaviour for last mile options, the other attributes are less sensitive. Creating a last mile offer that is both attractive and sustainable requires investigating the trade-offs that consumers make in a more detailed way. To this end, we carry out market simulations. Simulation is one of the key features of conjoint analysis (Rao, 2014). It is used to predict individual choices under hypothetical scenarios, entered in the simulator as full-profile descriptions. Individuals’ utility functions are used to compute preferences for each of the competing items (Green and Srinivasan, 1978). In this way, simulation helps in answering various “what-if” questions based on conjoint data (Rao, 2014).

We undertake this market simulation using several scenarios that we developed based on consumers’ most preferred last mile option that acts as base scenario. These scenarios are formulated as more sustainable variations on the base scenario. To guarantee attractivity of the last mile options, we retain free of charge order delivery and return. Six scenarios are tested:

1. Scenario 1 is the base scenario consisting of next-day delivery on an address of choice during the week (9u-18u), with return possibility in a pick-up point.
2. In scenario 2, orders are delivered on an address of choice during the week (9u-18u) and returned in a pick-up point, although consumers have to wait one to three days.
3. In scenario 3, orders are delivered on an address of choice during the week (9-18u) and returned in a pick-up point, although consumers have to wait three to five days.
4. In scenario 4, orders are delivered next day and returned in a pick-up point, although consumers need to collect their orders in a pick-up point.
5. In scenario 5, orders are delivered next day and returned in a pick-up point, although consumers need to collect their orders in the retail group’s store.
6. In scenario 6, orders are delivered next day on an address of choice during the week (9u-18u), although consumers need to return their orders in the retail group’s store.

The results of these simulations are shown in Table 15.

Table 15. Market simulation.

<table>
<thead>
<tr>
<th>#</th>
<th>Scenario description</th>
<th>Share of preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Base scenario</td>
<td>81,42%</td>
</tr>
<tr>
<td>2</td>
<td>Base scenario with variation on delivery term “within 1 to 3 days”</td>
<td>81,09%</td>
</tr>
<tr>
<td>3</td>
<td>Base scenario with variation on delivery term “within 3 to 5 days”</td>
<td>78,22%</td>
</tr>
<tr>
<td>4</td>
<td>Base scenario with variation on delivery reception “pick-up point”</td>
<td>78,92%</td>
</tr>
<tr>
<td>5</td>
<td>Base scenario with variation on delivery reception “retail group’s store”</td>
<td>76,92%</td>
</tr>
<tr>
<td>6</td>
<td>Base scenario with variation on return possibility “retail group’s store”</td>
<td>79,63%</td>
</tr>
</tbody>
</table>
The simulation results demonstrate that 81.42% of consumers would choose for the most preferred base scenario. The fifth scenario is preferred least: 76.92% of consumers would choose this option, while preference shares for the remaining scenarios are in between. The difference in preference share between the most and least preferred scenario is 4.5%. This fairly small difference confirms the fact that consumers are largely indifferent towards delivery term and delivery reception conditions when delivery and return are free. Accordingly, consumers are willing to wait longer for their orders to arrive or collect their orders themselves instead of dedicated delivery to an address of choice.

Our research contributes to current literature on sustainable last mile transport, by demonstrating that consumers are in fact making trade-offs in their choice of last mile transport options. This contradicts Gevaers et al. (2009), who state that consumers do not make trade-offs that are able to improve environmental issues related to the last mile. Our research also has practical implications. For omnichannel retailers with a dense store network, the results indicate that consumers accept their store network as pick-up and return locations, allowing retailers to create a more efficient and sustainable supply chain in which their online and offline activities can be combined.

Retailers with an omnichannel retail model offer their customers complete flexibility throughout their shopping journey (Piotrowicz and Cuthbertson, 2014). Accordingly, retailers offer several last mile options to their customers, instead of merely one option as investigated in this research. Agatz et al. (2013) advocate for delivery service differentiation coupled with dynamic pricing, to exceed the one-size-fits-all strategy that is unable to serve a heterogeneous consumer market (Agatz et al., 2013). Moreover, not only consumers differ, but also their purchases are characterised by variations that influence the delivery needs at hand (bpost, 2017). In line with this argument, we propose omnichannel retailers to apply appropriate mechanisms to steer consumers towards a last mile option that is more sustainable. An example of such strategy is a combination of free order collection in-store and a small charge for delivery to an address of choice, or slow delivery free of charge to an address of choice and fast but paid delivery to an address of choice. In this way, a sustainable last mile transport offer for omnichannel retail can be created, while still capturing the interest of consumers.

10 Additional latent class analysis confirms the limited heterogeneity or taste variation in the dataset, as the relative chi-square value is highest (160.78) for one segment and lowest for five segments (46.91) (Sawtooth Software, 2004).
Conclusion

Last mile transport is a critical part of the supply chain and entails the various ways in which products reach the end-customer in the consumer market. Not only is it a very costly process for retailers and logistics service providers to organise, its environmental impacts are also significant. Home delivery is considered the worst last mile option, but several more sustainable alternatives exist, including local pick-up points and lockers. Retailers that adopt an omnichannel model add their stores as an alternative location for consumers to collect (and return) their online orders. By means of a survey with choice-based conjoint experiments, this paper investigates to which extent consumers are willing to adopt last mile options that are more sustainable and how these options should be composed to remain attractive. Results show that almost one third of consumers reflect a neutral attitude towards sustainability in last mile transport, indicating low interest in and/or knowledge about this topic among consumers. It also provides an opportunity to convince consumers to choose for more sustainable last mile options. Although the research shows that consumers’ preference goes out to free, next-day delivery to an address of choice, on regular office hours during the week, they are willing to collect their orders themselves or wait longer for their order to arrive when delivery and return are free. The research confirms that consumers accept omnichannel retailers’ store network as pick-up and return locations, allowing retailers to organise their supply chain in a more efficient and sustainable way.
Chapter 6

Are consumers interested in a crowdsourced last mile?\textsuperscript{11}

Introduction

The retail space has transformed dramatically since and along with the development of internet. At first, perception was that online channels would replace physical stores and retail centres completely. Soon after, it became clear that both internet-based businesses and store-based retail models could coexist and even merge, bringing forth retail models that have been termed “multichannel retail” and “omnichannel retail” (Verhoef, Kannan and Inman, 2015). In both models, retailers offer their customers a combination of online channels (e.g. social media, web-shop, mobile shop) and a physical presence (e.g. stores). While multichannel retail focuses on managing and optimising the performance of each channel individually, omnichannel retail concentrates on integrating activities within and across channels (Ailawadi and Farris, 2017). In this way, omnichannel retail corresponds to consumers’ shopping behaviour, in which they switch between several retail channels and use these channels simultaneously and interchangeably (Peltola, Vainio and Nieminen, 2015).

Retailers setting up an omnichannel model face several issues, logistics being one of them. Since the key design variable in omnichannel retail is the level of integration between online and offline flows, a redesign of the supply chain is apparent (Melacini et al., 2018). It requires to comprehensively merge front-end and back-end systems and develop new logistics concepts, e.g. home delivery, store pick-up and return handling (Hübner, Wollenburg and Holzapfel, 2016b). Particularly challenging is the last link of the supply chain that directly connects the many “product-to-consumer” paths that are possible within omnichannel retail, with the receiving end-consumer (Fernie and Sparks, 2009). This concept of omnichannel retail’s last mile is important yet challenging, because of its impact on consumer satisfaction (Murfield et al., 2017), its high costs (Ishfaq et al., 2016) and its environmental implications (Melacini and Tappia, 2018).

To alleviate (part of) the last mile challenge, several innovations are introduced as promising. Wang et al. (2018) list delivery by drone, electrification of the delivery fleet and self-collection in automated lockers as notable examples. One stream of innovation is considered interesting thanks to its scalability potential, i.e. crowdsourced logistics or “crowd logistics” (Botsman, 2014b; Castillo, 2018). This concept is growing, both in terms of attention received and initiatives generated, and belongs to the realm of the “sharing economy” (Borsenberger, 2017). The central idea of the sharing economy is the optimisation of under-used assets – both physical (e.g. cars, apartments) and intangible (e.g. skills, knowledge) – by

sharing them through digital platforms (Benkler, 2004). Applied to the last mile, crowd logistics calls on individuals whose self-assessed, amateur logistics skills are not certified, to perform logistics services on an ad-hoc basis (Carbone, Rouquet and Roussat, 2017). This concept is commonly thought of as “Uber for logistics” (Castillo, 2018), yet encompasses a wider variety of logistics services, including in-store picking and warehousing (Carbone, Rouquet and Roussat, 2017).

Accordingly, retailers are exploring the crowd’s potential in terms of feasibility, viability and service quality for their last mile operations. Yet guidance on capturing value through crowd logistics is underdeveloped (Castillo et al., 2017). Therefore, it is important to take consumers’ preferences and perceptions into account as well. Sharing practices are anything but new, but it differs significantly from the “stranger-sharing” that is required in crowd logistics concepts (Sundararajan, 2016). As consumers are increasingly defining and dictating a last mile that suits them (Savelsbergh and Van Woensel, 2016) and crowd logistics’ success rests on the inclusion of relevant stakeholders (Lim, Jin and Srai, 2018), our objective is to capture consumers’ attitude towards crowd logistics and to identify which crowd logistics services are considered of interest. In this way, we wish to contribute to this growing field of research at the crossroads of consumer perspectives and logistics trends.

This paper covers an overview of the literature on crowd logistics in the second section. We focus in particular on services that the crowd provides at the final supply chain link of the last mile. In the third section, our methodological approach is clarified. Results of our research are discussed in the fourth section, by means of a descriptive analysis in the first part and a cluster analysis in the second part. In the fifth section, we discuss our results in terms of contributions to research, management and society, and end with concluding remarks in the final section.

**Literature**

In accordance with the diverse needs of retail’s last mile (Lim, Jin and Srai, 2018), crowd logistics provides a variety of services. To structurally identify these services, we consult the Google Scholar database using several keywords, i.e. “crowd logistics”, “crowdshipping”, “cargohitching”, “cargo hitching”, “crowdsourced logistics” and “last mile”. On March 7th 2019, this search yielded 209 results. Taking into account only peer-reviewed articles dedicated to our research topic (i.e. crowdsourced last mile in business-to-consumer retail), we are confined to a selection of 31 references.
While most studies are focused on crowdsourced (1) transport and delivery (Devari, Nikolaev and He, 2017), other services studied in literature are (2) picking (Mehmann, Frehe and Teuteberg, 2015) and (3) warehousing (Akeb, Moncef and Durand, 2018). First, concerning transport and delivery, several models are studied, with variations on transport mode (e.g. public transport, bike, passenger car) (Qi et al., 2016; Serafini et al., 2018) and inclusion of automated lockers that serve as drop-off location for the crowd and pick-up location for receivers (Gatta et al., 2018). Examples of crowdsourced transport and delivery services include Postmates (US) and Parcify (formerly known as bringr, Belgium). Second, concerning crowdsourced picking, the crowd not only picks-up and delivers online orders to end-consumers, but also ventures in-store to search and collect the items that they desire. Examples of such services include Instacart (US) and Algel (Germany). Third, concerning crowdsourced warehousing, the crowd opens up their homes to store parcels awaiting collection by neighbours (in case of delivery) and logistics service providers (in case of returns). Akeb et al. (2018) refer to this type of service as “neighbour relays”. Examples include ViaTim (the Netherlands) and Drivoo (France). According to Carbone et al. (2017), urban deliveries for stores and services yields most potential for the future. Although most crowd logistics initiatives focus on the last mile, some studies discuss concepts that cover other parts of the supply chain, e.g. long-distance transport (Carbone, Rouquet and Roussat, 2017; Frehe, Mehmann and Teuteberg, 2017) and upstream operations (Castillo et al., 2017). In sum, Carbone et al. (2018) conclude that crowd logistics fulfils the same five functions as found in companies’ logistics systems: locating items, transport, inventory, storage and information management (Carbone, Rouquet and Roussat, 2018).

Crowd logistics aims to create a so-called “win-win-win-situation” (Kunze, 2016), as it provides revenues for platform provider and crowd, as well as flexible, convenient, personal and easy last mile services for retailers and receiving end-consumers. However, literature points to several issues associated with crowdsourced logistics, including security, safety, privacy, reliability and accountability (Mladenow, Bauer and Strauss, 2016; Devari, Nikolaev and He, 2017; Frehe, Mehmann and Teuteberg, 2017). Whether consumers accept crowd logistics services, depends on several factors, including service offer and service quality (Dayarian and Savelsbergh, 2017; Punel, Ermagun and Stathopoulos, 2018). Platform providers attempt to enhance trust in crowdsourced logistics to overcome these concerns, by (1) implementing rating and insurance systems (Carbone, Rouquet and Roussat, 2017; Devari, Nikolaev and He, 2017), (2) offering real-time tracking and communication (Gatta et al., 2018), (3) checking crowd’s credentials (Carbone, Rouquet and Roussat, 2017), (4) diffusing the service (Mehmann, Frehe and Teuteberg, 2015;
Punel, Ermagun and Stathopoulos, 2018) and (5) creating a feeling of community (Carbone, Rouquet and Roussat, 2017). Yet despite these efforts, perception of risk is still high. In this regard, the undefined character of the crowd, although an essential element of crowd logistics, is a substantial source of stress (Buldeo Rai, Verlinde, Merckx, et al., 2017). Devari et al. (2017) conclude that it is important for individuals to know to or from whom they deliver or receive their orders. In fact, a survey in the US shows that over 30% of respondents would prefer to deliver to people they know (Le and Ukkusuri, 2018). Accordingly, different types of crowd are studied in literature (overview in Table 16). Next to (1) an undefined crowd that is studied the most, also the potential of (2) retailers’ employees, (3) retailers’ customers and (4) receivers’ acquaintances (e.g. friends, neighbours) are investigated. For example, retailer Walmart (US) experimented with their employees and customers as crowd and Apporto (Belgium) relies on retail customers. Examples of platform providers working with an undefined crowd are ample and include Parcify (Belgium) and Postmates (US). ViaTim (the Netherlands) and Friendshippr (United Arab Emirates) are initiatives that focus on receivers’ acquaintances.

Table 16. Types of crowd.

<table>
<thead>
<tr>
<th>Type of crowd</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retailers’ employees</td>
<td>(Le and Ukkusuri, 2018)</td>
</tr>
<tr>
<td>Retailers’ customers</td>
<td>(Hübner, Kuhn and Wollenburg, 2016; Savelbehr and Van Woensel, 2016; Dayarian and Savelbehr, 2017)</td>
</tr>
<tr>
<td>Platform providers’ crowd</td>
<td>(Mehmann, Frehe and Teuteberg, 2015; Archetti, Savelbehr and Speranza, 2016; Kunze, 2016; Mladenow, Bauer and Strauss, 2016; Qi et al., 2016; Y. Wang et al., 2016; Punel and Stathopoulos, 2017; Buldeo Rai, Verlinde, Merckx, et al., 2017; Carbone, Rouquet and Roussat, 2017, 2018; Castello et al., 2017; Dablace et al., 2017; Frehe, Mbadmann and Teuteberg, 2017; Buldeo Rai et al., 2018a; Gatta et al., 2018, 2019; Gidowska, Viana and Pedrosa, 2018; Le and Ukkusuri, 2018, 2019; Punel, Ermagun and Stathopoulos, 2018; Buldeo Rai and Verlinde and Macharis, 2018a; Serafini et al., 2018; Van Duijn et al., 2018; Ermagun and Stathopoulos, 2018; Zhang et al., 2019)</td>
</tr>
<tr>
<td>Receivers’ acquaintances</td>
<td>(Buldeo Rai, Verlinde, Merckx, et al., 2017; Devari, Nikolaev and He, 2017; Akeb, Moncef and Durand, 2018)</td>
</tr>
</tbody>
</table>

Different stakeholders have important roles to play in determining how the last mile is coordinated and executed (de Souza et al., 2014). Research has so far concentrated on the crowd, e.g. their perceptions, preferences and willingness to be involved in the last mile. In contrast, the role of receiving end-consumers has been touched upon but remains largely unexplored. Notable exceptions are Gatta et al. (2019) and Punel et al. (2018), although both studies focus on crowdsourced delivery only. Taking the perspective of receivers allows to determine the overall acceptability of crowd logistics (Punel and Stathopoulos, 2017). What’s more, Van...
Duin et al. (2018) state that receivers’ opinions affect the decisions of logistics service providers and retailers higher up in the supply chain. Therefore, our objective is to capture consumers’ attitude towards crowd logistics and to identify which crowd logistics services are considered of interest, by means of a survey among a representative sample of consumers in Belgium.

Methodology

To address the objective of this research, we partnered with a large retail group in Belgium that is expanding its online activities for non-food products. The retail group aims to integrate its online channel in its dense network of stores, in accordance with the omnichannel retail model. We set up a survey among a sample of one-thousand consumers. The sample is representative for the Belgian population according to age, sex, degree, language, family composition and social class (CIM, 2017). Using the online survey software Sawtooth, the survey was administered online (www.sawtoothsoftware.com/). Web-based surveys are efficient and convenient and allow to reach an appropriate sample size and composition within a limited timeframe (Ritter and Sue, 2007). To collect the sample, we applied three selection criteria: all respondents are older than 18, made an online purchase in the last year and endorse the retail group. In total, 13% of initially contacted respondents were rejected from the final sample because of this third criterion. We collected the data in collaboration with a recognised market research company (iVOX). Preceded by a technical pre-test with 100 respondents, the survey ran two weeks (from 18 September 2017 until 29 September 2017). The survey was organised in three parts. The first section covered socio-demographic screener questions, to reject respondents based on the previously defined criteria. The second section included questions on e-commerce behaviour, preferences and experiences, i.e. purchase frequency, product types, online stores and order collection and delivery. We also proposed statements related to the last mile: twelve questions on innovations (including crowd logistics) and nine on sustainability. The third section comprised on-screen choice tasks for respondents to compose an ideal yet realistic last mile offer. The results of the third section are presented in Buldeo Rai, Verlinde and Macharis (2018b). Accordingly, the results featured in this article are based on respondents’ (1) socio-demographics, (2) e-commerce behaviour, preferences and experiences, (3) perceptions on last mile innovations and (4) perceptions on last mile sustainability. This is in accordance with related research, including Punel et al. (2018) who included respondents’ average number
of online orders and “eco-friendliness” to study determinants of crowdshipping use and Gatta et al. (2019) who investigated demand and supply for crowdshipping with public transport, partly based on behavioural statements. For all perception questions, respondents were asked to rate their level of agreement from “strongly disagree” to “strongly agree” and their level of interest from “very uninteresting” to “very interesting” on a five-point Likert-type scale.

In accordance with findings from the literature review, three types of services and four types of crowd are assessed, i.e. (1) transport, (2) picking and (3) warehousing and (1) an undefined crowd, (2) retailers’ employees, (3) retailers’ customers and (4) receivers’ neighbours. The remaining questions cover innovations that are gaining ground in industry as well, and query information, flexibility and services related to the last mile. All last mile innovation questions are listed in Table 17.

Table 17. Questions on perception related to last mile innovations.

<table>
<thead>
<tr>
<th>Question categories</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowd logistics</td>
<td>Receiving my order from an employee of the retailer from which I bought the product online and who lives in my neighbourhood.</td>
</tr>
<tr>
<td></td>
<td>Receiving my order from a customer of the retailer from which I bought the product online and who lives in my neighbourhood.</td>
</tr>
<tr>
<td></td>
<td>Receiving my order from a non-professional driver, via a reliable mobile or web platform.</td>
</tr>
<tr>
<td></td>
<td>Picking-up my order from someone who lives in my neighbourhood, via a reliable mobile or web platform.</td>
</tr>
<tr>
<td>Information</td>
<td>Receiving a notification when my order is sent for delivery.</td>
</tr>
<tr>
<td></td>
<td>Receiving a notification one hour before delivery of my order.</td>
</tr>
<tr>
<td></td>
<td>Receiving a notification when the payment of my returned order is reimbursed.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Being able to adapt the moment of delivery, even when the order is already placed.</td>
</tr>
<tr>
<td></td>
<td>Being able to adapt the location of delivery, even when the order is already placed.</td>
</tr>
<tr>
<td></td>
<td>Being able to receive my order on my geolocation, meaning where I’m located at the time of delivery, instead of a fixed address.</td>
</tr>
<tr>
<td>Services</td>
<td>My own logistics service provider, who manages, collects and delivers my orders all at once, when and where it suits me.</td>
</tr>
<tr>
<td></td>
<td>An annual subscription programme at a fixed price, that offers free deliveries and other advantages.</td>
</tr>
</tbody>
</table>

We analysed the survey results by means of a descriptive analysis and a cluster analysis using statistical software SPSS (https://www.ibm.com/analytics/nl/nl/technology/spss/).
Findings

Descriptive analysis

The majority of consumers (58.5%) orders at least every three months a product online, one fifth (21.5%) monthly and a minority (5.4%) weekly. 6% of consumers uses the internet less than once a year to make a purchase. Our analysis shows a connection between purchase frequency and consumers’ age, in which younger consumers are likely to use the internet more often for their purchases (p=0.000).

The most popular products among consumers are clothing, shoes and accessories (23.4%), electronics (12.1%) and beauty and healthcare products (12%). Alcoholic beverages (1.8%), food (3.7%) and furniture and decoration (3.9%) are bought the least. This list of product categories was based on the annual e-commerce survey of Comeos, representative of Belgian commerce and services (Comeos, 2018).

Consumers receive their orders at home (67%). Most used alternatives to home delivery are collection points (11.5%) and workplaces (5.9%). To 10.1% of consumers, their selected delivery location depends on what suits them at the moment of purchase. Retailers’ stores (following an omnichannel retail model, 4.3%) and automated lockers (0.5%) are used the least. Despite its omnipresence, one fourth of consumers (24.7%) has had a negative experience with delivery at home. Not surprisingly, consumers that had a negative home delivery experience are more frequent e-shoppers (p=0.000). When consumers miss a delivery because they are absent (i.e. delivery failure), they prefer to pick-up their order in collection points (47.4%) or at someone who lives in their neighbourhood (30%). 15.2% prefers to get the order redelivered at home.

Figure 13 visualises consumers’ interest for last mile innovations covered within our survey. For a clearer result description, we aggregated the five-point Likert-type scale to three points by creating a negative pole (“very uninteresting” and “uninteresting”), a neutral pole (“uninteresting nor interesting”) and a positive pole (“interesting” and “very interesting”). What’s clear from the analysis is that consumers’ interest for crowd logistics is low. Among all crowd logistics variations, most interest goes out to order pick-up at a neighbour (i.e. neighbour relays; 27.1%) and order reception from retailers’ employees (25.5%). One fifth of consumers (21%) is interested in receiving an order from non-professional drivers, the most conventional type of crowd logistics. Remarkably, only a minority of consumers (13.8%) is interested in receiving an order from retailers’ customers. In comparison, consumers have more interest in last mile options that enhance order delivery information: 88.6% of consumers are interested to receive a notification when an order is sent, 79.4% of consumers is interested to receive a notification an hour before the order arrives and 79.4% of consumers is interested to receive

Hleen Buldeo Rai
a notification when a returned order is reimbursed. There is also interest among consumers in a more flexible last mile: 77.2% of consumers would like to be able to adapt the moment of delivery and 72.2% of consumers would like to be able to adapt the location of delivery, even if the order is already placed and in transit.

**Figure 13. Consumers’ perception of last mile innovations.**

<table>
<thead>
<tr>
<th>Logistic</th>
<th>Very Interested</th>
<th>Uninterested</th>
<th>Neither Interested nor Interested</th>
<th>Very Uninterested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving my order from an employee of the retailer from which I bought the product online and who lives in my neighbourhood.</td>
<td>31.2</td>
<td>43.3</td>
<td>25.5</td>
<td></td>
</tr>
<tr>
<td>Receiving my order from a customer of the retailer from which I bought the product online and who lives in my neighbourhood</td>
<td>51.6</td>
<td>33.8</td>
<td>13.8</td>
<td></td>
</tr>
<tr>
<td>Receiving my order from a non-professional driver, via a reliable mobile or web platform</td>
<td>42.3</td>
<td>36.7</td>
<td>21.0</td>
<td></td>
</tr>
<tr>
<td>Picking up my order from someone who lives in my neighbourhood, via a reliable mobile or web platform</td>
<td>39.8</td>
<td>33.1</td>
<td>27.1</td>
<td></td>
</tr>
<tr>
<td>Receiving a notification when my order is sent for delivery</td>
<td>78.9</td>
<td>11.5</td>
<td>9.4</td>
<td></td>
</tr>
<tr>
<td>Receiving a notification one hour before delivery of my order</td>
<td>9.4</td>
<td>11.5</td>
<td>79.4</td>
<td></td>
</tr>
<tr>
<td>Receiving a notification when the payment of my returned order is reimbursed</td>
<td>9.3</td>
<td>11.5</td>
<td>79.4</td>
<td></td>
</tr>
<tr>
<td>Being able to adapt the moment of delivery, even when the order is already placed</td>
<td>16.0</td>
<td>12.8</td>
<td>71.2</td>
<td></td>
</tr>
<tr>
<td>Being able to adapt the location of delivery, even when the order is already placed</td>
<td>16.0</td>
<td>15.9</td>
<td>68.1</td>
<td></td>
</tr>
<tr>
<td>Being able to receive my order on my mobile device, meaning where I’m located at the time of delivery, instead of a fixed address</td>
<td>35.7</td>
<td>30.5</td>
<td>33.8</td>
<td></td>
</tr>
<tr>
<td>My own logistics service provider, who manages, collects and delivers my orders all at once, when and where it suits me</td>
<td>34.7</td>
<td>33.8</td>
<td>31.5</td>
<td></td>
</tr>
<tr>
<td>An annual subscription programme at a fixed price, that offers free deliveries and other advantages</td>
<td>45.6</td>
<td>27.7</td>
<td>26.7</td>
<td></td>
</tr>
</tbody>
</table>

Cluster analysis

Given consumers’ limited interest in a crowdsourced last mile, we want to identify the type of consumer that is interested, by means of a cluster analysis. We carry out a two-step cluster analysis based on four variables, i.e. the crowd logistics related Likert-type questions in our survey. Together, these questions compose a consistent and reliable scale (Cronbach’s Alpha=0.799) (Field, 2018). Based on consumers’ responses on all questions in the scale, clusters are formed based on
similarity (Field, 2000). To this end, we performed a two-step cluster analysis, as it provides the capability to automatically find the optimal number of clusters and handles large data sets (SPSS, 2009). The silhouette measure of cohesion and separation, a goodness-of-fit measure, is 0.318 which indicates a fair clustering solution (Mooi and Sarstedt, 2011). The analysis revealed four clusters. Each cluster captures significant differences among the variables, which was also confirmed by chi-square tests. The question on retailers’ customers has greater importance for the clustering solution and the question on neighbour relays has less importance.

Figure 14. Consumers’ perception of crowd logistics.

Based on their interest in crowd logistics, we identified four clusters: (1) the interested (19.2%), (2) the neutrals (29.3%), (3) the uninterested (22.8%) and (4) the very uninterested (28.7%). Respective to the research objective, we concentrate on the interested cluster and how it differs from the remaining clusters. Throughout all clusters except for the neutrals, consumers prefer a crowdsourced solution that involves delivery by retailers’ employees. Consumers from the neutral cluster, however, expressed least interest in this concept. Instead, neighbourhood relays for collection are most interested to them.

Consumers interested in crowd logistics shop more frequently online: 32.8% of this cluster makes at least a monthly purchase, which is higher than neutral (23.5%), uninterested (25.9%) and very uninterested (27.5%) consumers. Figure
15 also shows that this type of consumers makes more use of home deliveries than consumers from other clusters. Remarkably, consumers interested in crowd logistics have a distinct preference for picking-up their order at a neighbour's...
house in case of delivery failure: 42.7% in comparison to 28% (the neutral), 31.1% (the uninterested) and 22.6% (the very uninterested). Consumers from other clusters give preference to pick-up at collection points, as visualised in Figure 16. Accordingly, consumers interested in a crowdsourced last mile are more community-oriented.

The survey also queried other last mile innovations, related to information, flexibility and services. Consumers interested in crowd logistics express more interest in these innovations. As Figure 17 shows, differences with consumers from other clusters are most striking for the last mile services included, i.e. having an own logistics service provider (following a logistics-as-a-service concept) and subscriptions that offer free deliveries. Consumers interested in crowd logistics also express more interest in a flexible last mile, i.e. the ability to change delivery moment and location while orders are in transit and the ability to receive orders at their geolocation.

Figure 17. Clusters’ perception of last mile innovations (aggregated “interested” and “very interested”).

The interested cluster has a more positive attitude towards last mile sustainability, as illustrated by Figure 18. Although the differences are less articulate as compared to the last mile innovations, consumers interested in a crowdsourced last mile state more than consumers from other clusters to take their environment into account when making a purchase. More than other consumers, they attach importance to traversing less kilometres for their orders and are more willing to pay for sustainable
deliveries by bike and electric vehicle. Nonetheless, they are less willing to collect their orders at a collect point, even if this reduces the number of kilometres traversed for their order. Overall and among all clusters, environmental concerns are not a priority to consumers.

Figure 18. Clusters’ perception of last mile sustainability (aggregated “agree” and “strongly agree”).

Despite the meaningful differences we found between the cluster interested in a crowdsourced last mile and the other three clusters, no distinct socio-demographic variations could be identified. All four clusters have a similar division in terms of consumers’ age, sex, degree, region and household situation.

Discussion

This research contributes to the growing body of literature on the last mile in general and crowdsourcing in the last mile in particular, by explicitly accounting for consumers’ preferences and perceptions. The perspective of receiving end-consumers remains largely unexplored in last mile research, despite considerable advancements in the theorisation of both the last mile and last mile service innovations. Nonetheless, consumers are critical components to consider,
particular in the broader context of online retailing (Wang, Yuen, Wong, & Teo, 2019). Accordingly, incorporating studies on consumer behaviour in last mile research is timely and pressing (Wang et al., 2018). For crowd logistics in particular, the lack of consumer perspective has been demonstrated as well, among others by Gatta et al. (2019) and Punel et al. (2018). Yet, understanding consumer behaviour allows to estimate crowd logistics’ overall acceptability (Punel and Stathopoulos, 2017) and obtain realistic assumptions and results for optimisation models (Punel, Ermagun and Stathopoulos, 2018).

An additional way in which our research extends current crowd logistics literature, is by exploring three types of services (i.e. transport, picking and warehousing) and four types of crowd (i.e. an undefined crowd, retailers’ employees, retailers’ customers and receivers’ neighbours). Several studies have shown the potential of such alternative concepts (Hübner, Kuhn and Wollenburg, 2016; Savelsbergh and Van Woensel, 2016; Buldeo Rai, Verlinde, Merckx, et al., 2017; Dayarian and Savelsbergh, 2017; Devari, Nikolaev and He, 2017; Akeb, Moncef and Durand, 2018; Le and Ukkusuri, 2018). For example, Dayarian and Savelsbergh (2017) showcase the benefits in terms of cost and service quality of allowing in-store customers to carry out deliveries and Akeb et al. (2018) demonstrate the feasibility and desirability of crowdsourced warehousing by neighbours (so-called “neighbour relays”) to avoid delivery failure. In this way, our research goes beyond the investigation of transport services by an undefined crowd, which is the crowd logistics concept that has received most attention so far. What’s more, acceptability of such concepts by the different stakeholders involved remains a major concern (Akeb, Moncef and Durand, 2018).

Hence, the results presented in our study contribute to filling these gaps. Our analysis shows that, although crowd logistics captures generally limited interest among consumers, neighbour relays receive most support. In this concept, the crowd uses their homes for collecting the neighbourhood’s online orders. Consumers who are not present at the time of delivery, can request to deliver their orders to this crowdsourced collection point and pick it up when it fits their schedule. In this way, the service provided in these neighbour relays is more flexible, personal and local as compared to the service of traditional collection points.

Accordingly, the results of our study have managerial implications as well. The last mile challenge – characterised by its high and disproportionate cost, environmental impact and importance to consumer satisfaction – requires service improvements and innovations. As formulated by Lim et al. (2018), there is an immense research scope at the intersection between the last mile and the sharing economy. Empirical studies in particular are critical to understand how retailers can effectively employ crowdsourcing for the last mile, integrate crowdsourcing into their existing last
mile operations (Lim, Jin and Srai, 2018) and capture value through crowd logistics (Castillo et al., 2017). Consumers motivate the development of crowd logistics services and determine their diffusion (Wang et al., 2018). In doing so, their preferences and perceptions affect the decisions of logistics service providers and retailers higher up in the supply chain (Van Duin et al., 2018). Thus, understanding consumers’ needs and expectations is vital from a business point of view (Punel, Ermagun and Stathopoulos, 2018).

Our research demonstrates the potential of including neighbour relays and delivery by retailers’ employees in the last mile operations. In contrast, the crowd logistics concept that has been developed most in practice (and by extension studied in research) facilitates deliveries by an undefined crowd. This gap between the concept that businesses prioritise and the concept that consumers prefer, indicates future development potential for crowdsourcing in the last mile. In addition, our research shows the consumer profile businesses need to envision for their crowd logistics initiatives: i.e. frequent and community-oriented e-shoppers that strongly prefer home delivery and have a positive attitude towards innovations and sustainability-enhancements in the last mile. In this way, it confirms existing research on crowdsourced deliveries by an undefined crowd, in which Punel et al. (2018) found that a strong sense of community and environmental concern determine interest in crowd logistics.

In turn, this research contributes to knowledge that could strengthen the uptake of crowd logistics in the last mile and ultimately, contribute to a more sustainable logistics system. In this way, the societal contribution of this research can be framed. Although crowd logistics does not necessarily imply sustainability improvements (Paloheimo, Lettenmeier and Waris, 2016; Buldeo Rai, Verlinde and Macharis, 2018a), understanding consumers’ preferences and perceptions contributes to unlocking the optimisation and efficiency potential of crowdsourcing in the last mile.

**Conclusion**

In today’s omnichannel retail space, retailers are continuously exploring solutions to make the last mile more cost-efficient, sustainable and satisfactory to consumers. One innovation that is considered in this respect, is crowdsourced logistics or “crowd logistics” (Botsman, 2014b). This concept calls on individuals and their self-assessed, amateur logistics skills to perform logistics services on an ad-hoc basis (Carbone, Rouquet and Roussat, 2017). While research has focused on
this crowd of individuals (e.g. their perceptions, preferences and willingness), the role of receiving end-consumers remains largely unexplored. Nonetheless, crowd logistics’ success depends on consumers’ acceptance. Consumers’ opinions also affect logistics decisions taken higher up in the supply chain. To capture consumers’ attitude towards crowd logistics and to identify which crowd logistics services are considered of interest, we set up a survey among a representative sample of consumers in Belgium. Overall, consumers’ interest in crowd logistics remains limited. Most interest is captured by a crowdsourced concept that includes collection at neighbours (“neighbour relays”) and delivery by retailers’ employees. The most conventional crowd logistics concept that relies on non-professional drivers attracts somewhat lower levels of interest. The research suggests that consumers have little interest in a crowd that consists of retailers’ customers. Despite this general lack of interest, a cluster analysis revealed that 19.2% of consumers interest can be captured by a crowdsourced last mile. These consumers are more frequent online shoppers and active users of delivery at home. Additionally, they prefer to rely on their neighbours in case of delivery failure. Interested consumers show more interest for last mile innovations and have a more positive attitude towards sustainability-enhancements when ordering online. A large group of consumers (29.3%) take a neutral stand towards crowdsourcing the last mile, which could indicate potential for retailers to unlock when they consider crowd logistics for their last mile operations.
WHAT IS THE ENVIRONMENTAL IMPACT OF THE LAST MILE IN OMNICHANNEL RETAIL?
Chapter 7

How does consumers’ omnichannel shopping behaviour translate into travel and transport impacts? Case-study of a footwear retailer in Belgium

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 (Bell, Gallino and Moreno, 2013; Rosengren et al., 2018). 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 (Peltola, Vainio and Nieminen, 2015).

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 (Cook, 2014; Schoutteet et al., 2017). In the process model for customer journeys developed by Lemon and Verhoef (2016), 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 (2014) 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 (Bell, Gallino and Moreno, 2013, 2018a). Consumer surveys demonstrate that about 38% of US consumers (UPS, 2016) and 64% of Belgian consumers (bpost, 2017) 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 (Lazaris and Vrechopoulos, 2013; Frazer and Stiehler, 2014; Park and Kim, 2018). What’s more, understanding these patterns allows to gain insight in the transport flows related to shopping, that induce significant environmental consequences (Russo and Comi, 2010; Comi and Nuzzolo, 2016; Hagberg and Holmberg, 2017; Arnold

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et al., 2018), both locally (e.g. air pollution, congestion, noise) and globally (e.g. climate change emissions) (Browne et al., 2012). 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.

**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 (McKinnon et al., 2010) and transport is believed to have the biggest impact (Edwards, McKinnon and Cullinane, 2010; Mangiaracina et al., 2015). Although transport by both end-consumers and logistics service providers is important in such analysis (Russo and Comi, 2010), Van Loon et al. (2015) 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 January 9th 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. The first section discusses twenty-one peer-reviewed journal articles that comprehensively deal with transport and logistics related to the purchase of physical products. The second section covers a review of twenty-four journal and conference articles on omnichannel retail developments and how they affect consumer behaviour.

Environmental assessment of retail-related transport and logistics

We reviewed twenty-one articles reporting on the environmental impact of retail-related transport and logistics. While the oldest study dates back to 2005 (Browne et al., 2005), the majority of studies was published in 2009 (Cullinane, 2009; Edwards and McKinnon, 2009; Velásquez, Ahmad and Bliemel, 2009; Weber et al., 2009; Weltevreden and Rotem-Mindali, 2009) and 2015 (Carling et al., 2015; Laghaei, Faghri and Li, 2015; Mangiaracina et al., 2015; Van Loon et al., 2015). Apart from conceptual studies reflecting on available knowledge and literature on the topic (Cullinane, 2009; Velásquez, Ahmad and Bliemel, 2009; Edwards, McKinnon and Cullinane, 2011; Van Loon et al., 2014; Mangiaracina et al., 2015; Pålsson, Pettersson and Winslott Hiselius, 2017), the product-specific case-study approach is common. In particular, clothing (Browne et al., 2005; Wiese, Toporowski and Zielke, 2012; Mangiaracina et al., 2016; Hirschier, 2018) and electronics (Weber et al., 2009; Carling et al., 2015; Melacini and Tappia, 2018) are investigated most. Specifically analysed in these studies are greenhouse gas emissions, carbon emissions or CO₂ emissions (Velásquez, Ahmad and Bliemel, 2009; Edwards and McKinnon, 2009; Edwards, McKinnon and Cullinane, 2010, 2011; Wiese, Toporowski and Zielke, 2012; Kellner and Igl, 2012; Brown and Guiffrida, 2014; Van Loon et al., 2014, 2015; Carling et al., 2015; Laghaei, Faghri and Li, 2015; Belavina, Girotra and Kabra, 2016; Mangiaracina et al., 2016; Melacini and Tappia, 2018) and energy consumption, energy usage or energy demand (Pålsson, Pettersson and Winslott Hiselius, 2017). Some studies analysed both (Browne et al., 2005; Weber et al., 2009; Hirschier, 2018). 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 (Browne et al., 2005; Kellner and Igl, 2012).

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) (Browne et al., 2005; Weber et
al., 2009). In response, Velásquez et al. (2009) suggest to incorporate consumer habits and Cullinane (2009) 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 (2009) 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 (Wiese, Toporowski and Zielke, 2012; Brown and Guiffrida, 2014; Mangiaracina et al., 2015; Van Loon et al., 2015; Hischier, 2018) and even “browsing-only” shopping trips, in which consumers travel to stores for the sole purpose of product research (Edwards and McKinnon, 2009; Edwards, McKinnon and Cullinane, 2010, 2011; Carling et al., 2015). Van Loon et al. (2014) 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 (Van Loon et al., 2014; Pålsson, Pettersson and Winslott Hiselius, 2017). 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 (Kellner and Igl, 2012; Laghaei, Faghri and Li, 2015; Belavina, Girotra and Kabra, 2016; Mangiaracina et al., 2016; Melacini and Tappa, 2018). Nevertheless, all studies highlight the importance of including consumer transport to the overall comparison of retail systems.

**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 (Cook, 2014; Schoutteet et al., 2017). In the omnichannel environment, various channels can be used for each activity, which is illustrated in Figure 19. 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) (Park and Kim, 2018).

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 (Fulgoni, 2014), 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 (Fulgoni, 2014; Hoehle et al., 2018).

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 (Bell, Gallino and Moreno, 2014b). 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 (Bell, Gallino and Moreno, 2013). 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” (Gao and Su, 2016). Building further on the example of eyewear, consumers can upload their picture to test out various pairs, employ digital avatars for fitting (Rigby, 2011; Gao and Su, 2016) or make use of options created by augmented reality (Brynjolfsson, Hu and Rahman, 2013). 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 (Verhoef, Kannan and Inman, 2015) and materialises in two phenomena: “showrooming” and “webrooming”. When showrooming, consumers carry out research activities in-store using their

Figure 19. Five phases of the omnichannel path-to-purchase, adapted from Schoutteet et al. (2017). Arrows in solid lines represent fixed phases, arrows in dotted lines represent flexible phases.
smartphone, specifically looking for lower priced items online. Fulgoni (2014) 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 (Gao and Su, 2016). Contrary, webrooming implies online research activities, while still making the actual purchase in-store (Verhoef, Kannan and Inman, 2015). Compared to showrooming, webrooming is the most common practice (Lazaris et al., 2014; UPS, 2016; bpost, 2017).

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 (Picot-Coupey, Huré and Piveteau, 2016) and “showrooms” (or also termed “zero-inventory stores” or “guide shops”) (Bell, Gallino and Moreno, 2018b, 2018a). In case of shopping online, computers and tablets are common, but also smartphones have become ubiquitous, enabling shopping anytime and anywhere (Brynjolfsson, Hu and Rahman, 2013). Responding to this on-the-go shopping behaviour, retailers implemented “virtual stores” (Rigby, 2011), 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 (Piotrowicz and Cuthbertson, 2014). 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 (Melacini et al., 2018). Next to screens, retailers are introducing other advanced technologies, e.g. self-service kiosks equipped with RFID-systems, digital signage, informative touch points and contactless technologies for mobile payments (Savastano, Barnabei and Ricotta, 2016).

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” (Hübner, Holzapfel and Kuhn, 2016) or “BOPS”, which stands for “buy-online-and-pickup-in-store” (Gao and Su, 2016). 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 (Melacini et al., 2018). 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.
These deliveries can be sourced from three types of location: retailers’ distribution centre, retailers’ supplier by means of drop-shipping and retailers’ store (Hübner, Holzapfel and Kuhn, 2016; Bayram and Cesaret, 2017). 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 QR-codes, or similar solutions (Melacini et al., 2018). Because of this variety of reception options, adequate and efficient distribution systems are key in omnichannel retail (Hübner, Holzapfel and Kuhn, 2016; Hübner, Wollenburg and Holzapfel, 2016a).

Depending on the product type, a significant share of orders is returned. Product returns, often approaching 30% and as high as 40% for clothing retailers, are a major burden for retailers (Bell, Gallino and Moreno, 2018b). Accordingly, returns management has become a top priority for many retailers (Daugherty, Bolumole and Grawe, 2018). 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 (Bernon, Cullen and Gorst, 2016).

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 (Edwards, McKinnon and Cullinane, 2010; Wiese, Toporowski and Zielke, 2012). 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 (Rizet et al., 2010). 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.
Methodology

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 (Ecommerce News, 2018). Footwear is a “considered purchase” or “experience good”, where consumers feel the need to touch and feel before buying (Pålsson, Pettersson and Winslott Hiselius, 2017). 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. (2011), “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 (Yin, 1984), suitable when “how” and “why” questions are asked in emerging fields of research (Yin, 1984; Seuring, 2005). In omnichannel retail research, the case-study approach is common. See for example (Bell, Gallino and Moreno, 2013, 2014b, 2018a; Gao and Su, 2016; Picot-Coupey, Huré and Piveteau, 2016).

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%.

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 August 8th 2019). The survey was designed in Qualtrics software and spread among 80,000 customers who made a purchase after August 15th 2018. The retailer sent out the survey invitation with link to the software on October 31st 2018 (to 20,000 customers) and November 13th 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 (Edwards, McKinnon and Cullinane, 2011; Lemon and Verhoef, 2016). 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 (Sheehan, 2001). Several factors that impact on response rates are discussed in literature, including survey length, respondent contacts, compensation and salience (Sheehan, 2001). 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 (Wåhlberg and Poom, 2015). When comparing our sample to the population of customers, both are spread in terms of age and geography, while women are overrepresented (90% in sample and 92% in population).

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 (Primerano et al., 2008). When the shopping activity trip was complemented with other activities, only a share of total trip distance should be allocated to the shopping activity (Edwards, McKinnon and Cullinane, 2011). Different approaches are found in literature to determine this share. Browne et al. (2005), for example, assume that trips have two purposes and allocate half of the trip’s energy use to the shopping activity. Edwards and McKinnon (2009) allocate a quarter of total distance to shopping and Wiese et al. (2012) include only trips in which shopping was the main reason. A commonly accepted approach lacks (Primerano et al., 2008; Reumers et al., 2016). In this research, total trip distance was determined by respondents’ home postal code, store location and activity postal code. Similarly to Brown and Guiffrida (2014), 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 (Boussauw, 2011). 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 \(\text{CO}_2\)) or pollutants (e.g. \(\text{NO}_x\) and \(\text{PM}_{10}\)) (Gonzalez-Feliu, 2018). In this research, we focused on external transport costs generated by \(\text{CO}_2\) emissions, the common approach in this stream of research (see literature review). As stated by Bickel and Friedrich (2005), “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 (Mommens et al., 2018). This Transport Agent-BAsed Model uses the open-source software MATSim (MATSim, 2014) and is based on the work of Schröder and Liedtke (2014) and Schröder et al. (2012). 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
Environmental sustainability of the last mile in omnichannel retail

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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. (2015) demonstrated that it is a fairly good one. CO$_2$ emission factors and monetary values are derived from international reports (Otten, ’t Hoen and den Boer, 2015, 2017; Delhaye et al., 2017). 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.

Findings

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.

Omnichannel shopping behaviour

Combining literature and survey results, we derived six omnichannel shopping behaviour profiles, as visualised by Figure 20. Although there is no such thing as “typical” shoppers (Edwards, McKinnon and Cullinane, 2010), specific multichannel segments can be identified that differ in terms of consumer characteristics (Lemon and Verhoef, 2016). Segmentation among consumers is essential in this type of research (Edwards, McKinnon and Cullinane, 2011). 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.

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 (Lemon and Verhoef, 2016). 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.

Figure 20. Six omnichannel shopping behaviour profiles.

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 21 illustrates the shares of consumers belonging to each of these 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.

Figure 21. Classification of consumers into omnichannel shopping behaviour profiles.

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).

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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. (2005) apply a distance of eleven kilometres for the UK and fifteen kilometres for France (covering shopping and another activity) and Edwards et al. (2010) 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 (Cullinane, 2009; Edwards, McKinnon and Cullinane, 2010). 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 18 provides an overview of mean (\(\mu\)), median (Q2) and quartile (Q1, Q3) distances and transport modes. For receiving and returning activities, we added information on location as well.

**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 22 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.

Figure 22. Total external transport cost for CO\(_2\) emissions per omnichannel shopping behaviour profile.
Table 18. Travel information for all omnichannel shopping behaviour profiles.

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<tr>
<th></th>
<th>The Traditional Shopper</th>
<th>The Online Shopper</th>
<th>The Research Shopper</th>
<th>The Ship-from-Store Shopper</th>
<th>The Showroomer</th>
<th>The Click-and-Collect Shopper</th>
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<td>Q1=4.2 km</td>
<td>Q1=4.7 km</td>
<td>Q2=4.7 km</td>
<td>Q2=4.0 km</td>
<td>Q2=4.0 km</td>
<td>Q2=4.0 km</td>
</tr>
<tr>
<td></td>
<td>Q2=10.2 km</td>
<td>Q2=11.0 km</td>
<td>Q2=8.9 km</td>
<td>Q2=6.8 km</td>
<td>Q2=8.8 km</td>
<td>Q2=8.8 km</td>
</tr>
<tr>
<td></td>
<td>Q3=21.5 km</td>
<td>Q3=15.4 km</td>
<td>Q3=6.4 km</td>
<td>Q3=11.7 km</td>
<td>Q3=11.7 km</td>
<td>Q3=11.7 km</td>
</tr>
</tbody>
</table>

µ = mean distance. Q1 and Q3 = quartile distances. PT = public transport (i.e. bus or tram). CP = attended or unattended collection point.
In line with common findings in literature (Pålsson, Pettersson and Winslott Hiselius, 2017), “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 (2012) 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 (Van Duin et al., 2016) and 2% to 30% in the UK (Edwards, McKinnon and Cullinane, 2009).

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 22, that are based on median distances (Q2), with lower quartile (Q1) and upper quartile (Q3) distances. Figure 23 visualises the result of the sensitivity analysis.

Figure 23. Sensitivity analysis on total external transport cost for CO₂ emissions per omnichannel shopping behaviour profile.

The sensitivity analysis confirms and supports the conclusions that can be derived from Figure 22. In line with these results, we find that “the online shopper” produces the lowest external CO₂ 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 (Weber et al., 2009; Edwards, McKinnon and Cullinane, 2011; Bernon, Cullen and Gorst, 2016; Park and Kim, 2018; Rosengren et al., 2018). 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 19 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 19. Opportunities to reduce the environmental impact of omnichannel retail transport.

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

Heleen Buldeo Rai
Conclusion

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\textsubscript{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\textsubscript{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.
Chapter 8

Shipping outside the box. Environmental impact and stakeholder analysis of a crowd logistics platform in Belgium

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Introduction

Freight transport to, from and within urban areas is necessary for the city to provide in its functions. This includes, but is far from limited to, replenishing stores, hospitals, offices and production plants and managing waste. In the current context of ongoing retail digitalisation, a growing number of products is ordered online and transported directly to consumers, often to their homes (Frehe, Mehmann and Teuteberg, 2017). Parcel transport and express deliveries are some of the fastest growing industries in urban transport (Arvidsson, Givoni and Woxenius, 2016). Accordingly, the number of vehicles for parcel deliveries is expected to increase (Allen et al., 2017).

Although approximately 20% of urban traffic is related to freight transport and service trips, it contributes significantly more to the negative side-effects of urban traffic than passenger related transport (Verlinde, 2015). Such side-effects comprise social (people), environmental (planet) and economic (profit) impacts. Social impacts include physical consequences of pollutant emissions on public health, environmental impacts include pollutant emissions and the use of non-renewable natural resources and economic impacts include congestion and decreasing urban accessibility (Quak, 2008). According to Gevaers et al. (2011), the last mile or the transport between warehouse and end-destination is the most expensive leg of the freight transport chain (between 13% and 75% of the total transport cost of a product). All three elements need to be considered to reach a more sustainable last mile (Lindholm, 2012).

More efficient and sustainable concepts have been introduced to accommodate parcel transport in cities. Some of these concepts are alternatives to home delivery such as click-and-collect, parcel points and lockers points. By delivering larger volumes of parcels to a smaller number of locations, they reduce environmental impact and unit cost (Allen et al., 2017). Nonetheless, consumers are inclined to select “delivery at home” in the online check-out process (MetaPack, 2016). A concept that can improve transport efficiency and sustainability, while still bringing parcels to consumers’ homes, is “co-transportation”. Arvidsson et al. (2016) present this idea as the main approach to alleviate the last mile problem. It promotes the shared use of resources for passenger and freight transport in urban areas (Arvidsson, Givoni and Woxenius, 2016). One promising application for co-transporting parcels, is crowd logistics. Alternative terms for the concept are crowdshipping (Dayarian and Savelsbergh, 2017), crowdsourced delivery


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Crowd logistics is part of the bigger “sharing economy” trend, which allows people to enhance the use of resources through the redistribution, sharing and reuse of excess capacity in goods and services (Arslan et al., 2016). Central to crowd logistics is the shared use of excess capacity in vehicles to deliver goods (Cohen and Muñoz, 2015). The idea is to carry parcels for others along the way of an existing vehicle trip, ideally with minimal detour (Paloheimo, Lettenmeier and Waris, 2016). One notable example is people’s spare vehicle space when they commute from home to work (and back). In this way, they reduce the vehicle activity required for parcel deliveries and accordingly enhance social, environmental and economic sustainability (Allen et al., 2017). Based on a six weeks trial of crowdsourced library deliveries in Finland, Paloheimo et al. (2016) demonstrate an absolute reduction of natural resource use and environmental impact. However, the impact on sustainability is dependent on several factors, including the crowd’s modal choice and consolidation of parcels (Rougès and Montreuil, 2014; Dablanc et al., 2017). Moreover, rebound effects of crowd logistics, such as dedicated vehicle trips, might possibly increase its impact (Qi et al., 2016). Crowd logistics is expected to bring economic benefits for all stakeholders involved (Frehe, Mehmann and Teuteberg, 2017) and contribute to a more liveable and sustainable urban environment (Kafle, Zou and Lin, 2017). As urban parcel volumes continue to grow at an unprecedented rate, it is important to investigate and verify these claims.

To this end, we analysed the environmental performance of an operational crowd logistics platform and how it affects the main stakeholders. For this, we used data generated by the platform for one year (June 2016 until July 2017) and surveys with the platform users and logistics experts. Based on this data, we calculated the environmental impact for the crowd logistics platform and compared it to more traditional ways of parcel transport. This input we used to execute a stakeholder analysis, for which we applied the multi-actor multi-criteria analysis (or MAMCA) methodology. The need for field-based pilot studies that validate crowd logistics’ feasibility, efficiency and sustainability has been acknowledged in research (Erickson and Trauth, 2013; Rougès and Montreuil, 2014; Carbone, Rouquet and Roussat, 2017; Punel and Stathopoulos, 2017). Also highlighted is the importance of taking the perspective of the different stakeholders involved in the crowd logistics process. Carbone et al. (2017) mention logistics firms and individuals within the crowd. Punel and Stathopoulos (2017) refer to receivers, drivers, senders, service company operators and policy-makers. We address the research by answering the following question: “How can crowd logistics contribute to sustainable last mile parcel transport, with regards to the environment and the
stakeholders involved?”. Our research contributes by using real user-data of a crowd logistics platform, which is necessary to make accurate impact estimations and by comprehensively taking into account all relevant stakeholders, which has been neglected in research so far. The goal is to find out whether the marriage of sharing economy and e-commerce, as formulated by Qi et al. (2016), is able to deliver on all claimed merits. This paper covers a review of current literature on crowd logistics in the second section. The third section introduces the materials and methods that we used, while the fourth section elaborates on our research findings. The fifth section discusses these findings and the final section ends with conclusive remarks and directions for future research.

Literature

Only a small number of studies within literature is dedicated to the topic of crowd logistics. A comprehensive search on the scientific databases Scopus, Web of Science and Google Scholar yielded twenty-seven relevant research papers on September 15th 2017. We used “crowd logistics”, “crowdshipping” and “crowdsourced delivery” as search words. In the next section, we discuss the concept of crowd logistics, its impact and the research methods used in literature.

The concept of crowd logistics

Crowd logistics is “an information connectivity enabled marketplace concept, that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis and is compensated accordingly” (Buldeo Rai, Verlinde, Merckx, et al., 2017). The majority of crowd logistics initiatives started in the US, but platforms are emerging all over the world (Punel and Stathopoulos, 2017), making it a “global phenomenon” (Carbone, Rouquet and Roussat, 2017). In China, over 200 mobile applications for improving freight efficiency have been introduced to the market (Li and Yu, 2017). Crowd logistics initiatives can offer different logistics services, such as storage, local delivery, freight shipping and freight forwarding (Carbone, Rouquet and Roussat, 2017). Our focus goes out to local delivery. Five stakeholders are directly related to crowd logistics: commissioners that order parcel shipments, receivers that receive the parcels, platform providers that coordinate supply and demand, logistics service providers that execute parcel transport in the traditional way and the crowd. Depending on the platform operation, the commissioner
and receiver can be the same. In other cases, the commissioner is the sender of goods, similarly to the shipper concept that is frequently applied within logistics research (Buldeo Rai et al., 2018b). The platform and its provider are of major importance to crowd logistics. Typically, platform providers are either large players such as Amazon and DHL or start-ups like Deliv and Postmates (Rougès and Montreuil, 2014). Because much of the crowd logistics activity is developing on the practitioner side, logistics service providers are stakeholders as well (Carbone, Rouquet and Roussat, 2017). Rougès and Montreuil (2014) point out that some crowd logistics start-ups rely primarily on professional couriers, that also work for traditional players. Key stakeholder is the crowd, whose identity differs according to the platform. It can consist of students (Marcucci et al., 2017), taxi drivers (Chen et al., 2016), pizza delivery (wo)men (Paloheimo, Lettenmeier and Waris, 2016), retailers’ loyal customers (Verheyen, 2016; Dayarian and Savelbergh, 2017) or your friends and acquaintances (Devari, Nikolaev and He, 2017). The final stakeholder is society, as it is impacted by all transport-related externalities, including those produced by crowd logistics (Buldeo Rai, Verlinde, Merckx, et al., 2017).

Crowd logistics platforms ship to individual households (business-to-consumer), between businesses (business-to-business) or between consumers (consumer-to-consumer, alternatively also termed as peer-to-peer). In the matching and pricing process of parcel shipments, the challenge is to preserve balance between offering the crowd sufficient delivery trips and keeping the platform economically viable (Schreieck et al., 2016). Some platforms use an algorithm to match shipments with the crowd, others allow users to post their shipments and planned trips on a virtual showcase and wait for a response (Schreieck et al., 2016; Marcucci et al., 2017). Platforms can be accessed in a multitude of ways, often via mobile phone applications or web-browser (Frehe, Mehmann and Teuteberg, 2017). Typically, each shipment is associated with a single parcel (Kafle, Zou and Lin, 2017). The evaluation of the crowd’s logistics performance relies on the feedback that receivers and commissioners leave on the platform. Often, feedback is given by comments or rating systems based on points or stars (Carbone, Rouquet and Roussat, 2017). Among the variation in business models that are applied, Frehe et al. (2017) extract a holistic business model for crowd logistics. The basis is formed by two elements: first, service provision by the crowd that is mediated by the platform provider and second, information and value flows, that result in customer service improvement and economic benefit for crowd and platform provider (Frehe, Mehmann and Teuteberg, 2017). Crowd logistics’ aim is to create disruptive business models that are more efficient and lower-priced, based on a lean structure and the power of the community (Rougès and Montreuil, 2014).
The impact of crowd logistics

A trial with crowdsourced library deliveries in Finland shows an absolute reduction of natural resource use and environmental impact (Paloheimo, Lettenmeier and Waris, 2016). However, literature shows that three factors determine whether crowd logistics has a positive or negative impact on the environment. First is the crowd’s transport behaviour. Reducing empty kilometres always results in less CO₂ emissions (Li and Yu, 2017), traffic levels and resource use (Marcucci et al., 2017). Consequently, whether the crowd takes parcels along on a trip they planned to do anyway or makes dedicated delivery trips, influences the environmental impact of the crowd logistics concept (Qi et al., 2016). According to Rougès and Montreuil (2014), the most promising crowd logistics start-ups hire professional couriers or people who are dedicated to delivery, instead of relying on commuters or occasional travellers. In line with this finding, Marcucci et al. (2017) showed that dedicated trips are required by all online food platforms they investigated. Second is the consolidation of parcels. Crowd logistics platforms look for spare transport capacity for each parcel individually, while traditional logistics service providers create full truck loads for a single client or consolidate volumes of several clients in one vehicle. Amazon, for example, offers a crowd logistics service that makes use of dedicated vehicle trips (Allen et al., 2017). However, their large number of orders allows them to consolidate at least three to five deliveries per trip before a delivery vehicle leaves the urban warehouse (Dablanc et al., 2017). Therefore, less vehicle trips are required as opposed to other retailers that use the crowd for only one parcel per trip. Third factor is the crowd’s modal choice (Buldeo Rai, Verlinde, Merckx, et al., 2017). Clean fuel vehicles are a possible solution (Lin, Zhou and Du, 2017) and many concepts involve the use of bicycles or delivery on foot. Yet as volumes rise and time becomes even more critical, it seems likely that other transport modes will also grow (Dablanc et al., 2017).

The positive environmental impact of crowd logistics is thus up for debate, but the concept also raises questions with regards to its impact on other stakeholders. Key stakeholder is the crowd (Marcucci et al., 2017). Literature shows that a large number of people are willing to act as crowd. A survey in the city of Alexandria (US) found that 72% of respondents would agree to perform a shipment for their friends (Devari, Nikolaev and He, 2017) and a survey in Rome (Italy) demonstrated that 87% of students is willing to act as crowd, given an adequate compensation (Marcucci et al., 2017). According to DHL, the millennial generation of consumers is most inclined (Gesing, 2017). Typical for the crowd logistics concept is the absence of an employment contract, which complicates the crowd’s working conditions, work-life balance and fair pay (De Groen and Maselli, 2016).

For commissioners that require parcels to be transported, the benefits of crowd
logistics could be considerable, in particular for companies within the retail sector. They can benefit by reducing transport costs for same-day and last mile deliveries (Mladenow, Bauer and Strauss, 2016). Carbone et al. (2017) expect great potential for large e-tail players such as Amazon, while others argue that crowd logistics’ best fit could be with small and medium sized businesses (Schreieck et al., 2016; Lin, Zhou and Du, 2017). Particularly local shops need to be able to offer their customers quick and free deliveries in order to compete with competition from online. Such retailers have a weak bargaining position towards traditional parcel delivery companies (Verheyen, 2016). Often, they cannot afford to hire a professional company for (express) deliveries or to implement an own delivery network. A match is also envisioned between crowd logistics and the local food market, as farmers are relying primarily on other outlets to sell their products (Lin, Zhou and Du, 2017). Possibly, crowd logistics represents an affordable and appropriate solution for these players to reach their end-consumer (Schreieck et al., 2016).

Taking the perspective of the parcel receivers allows to determine the overall acceptability of crowd logistics (Punel and Stathopoulos, 2017). Receivers expect faster, more personalised and cost efficient delivery services, which crowd logistics could offer (Rougès and Montreuil, 2014). At the moment, receivers are less of a driving force in shipment decisions that retailers and logistics service providers make, but e-developments in retail are expected to make their role more important (Punel and Stathopoulos, 2017). In line with existing literature on freight delivery preferences, Punel and Stathopoulos (2017) found that receivers attach most importance to shipment cost.

The platform provider’s role eliminates the need for asset-heavy infrastructure, including warehouses, vehicle fleets, fuel costs and employed drivers. Instead, they rely primarily on technology, which enables low overhead costs and the possibility to scale relatively fast when demand grows (Botsman, 2014b). The platform provider’s most important component is the crowd. Trust, publicity and usability of the crowd are three influencing factors (Devari, Nikolaev and He, 2017). The success of the platform depends largely on a sufficiently large and dense local crowd network (Carbone, Rouquet and Roussat, 2017). But as the crowd often signs up with multiple platforms, it can be difficult to ensure sufficient capacity, especially in peak periods (Joerss et al., 2016). To maintain a sustainable crowd level, choosing an appropriate compensation scheme is critical (Archetti, Savelbergh and Speranza, 2016). Acceptability of the incentive depends on the type of crowd that the platform uses. To an in-store customer, the incentive for delivering an online order can be small, while independent drivers will be more expensive (Dayarian and Savelbergh, 2017). Compensations are typically (small) monetary rewards,
For logistics players, the development of crowd logistics could create opportunities to interact with the crowd and integrate crowd logistics systems (Carbone, Rouquet and Roussat, 2017). As some large logistics service providers are not well suited for express deliveries in urban settings (Lin, Zhou and Du, 2017), the crowd can be used to execute the final part (Y. Wang et al., 2016). This also allows to reduce and even eliminate their fleet and fleet maintenance (Lin, Zhou and Du, 2017). However, crowd logistics can also be considered a threat for logistics service providers. As numerous start-ups are creating business models based on a low cost structure and the power of community, business volume of traditional logistics service providers can reduce significantly (Buldeo Rai, Verlinde, Merckx, et al., 2017).

Crowd logistics in research
Research on crowd logistics is developing among researchers. Currently used methodological approaches of qualitative nature include interviews, literature reviews and document analyses. Surveys and vehicle routing simulations are the most commonly applied quantitative methods.

The study of crowd logistics is challenging due to novelty, lack of operational uniformity and lack of consolidated, real-world systems that disseminate operational data (Punel and Stathopoulos, 2017). Some crowd logistics initiatives are still experimental, others have failed and new ones emerge every day (Carbone, Rouquet and Roussat, 2017). Consequently, a popular approach within the crowd logistics literature is document analysis. This approach entails to collect information of operational crowd logistics platforms online and analyse the documents in a systematic way. Carbone et al. (2017), Li and Yu (2017), Mladenow et al. (2016), Rougès and Montreuil (2014) base their findings on this approach. Other researchers selected a more traditional analysis of scientific literature, as they applied a broader scope in their work. Kunze (2016) envisions the future of urban logistics in 2030 and Arvidsson et al. (2016) investigate synergies in passenger and freight transport. Both studies discuss crowd logistics as an application of interest. Interview approaches are often applied in triangulation with another methodology. To evaluate business models in crowd logistics, Frehe et al. (2017) interviewed experts working within (crowd) logistics companies and analysed documents from several crowd logistics platforms. Marcucci et al. (2017) also investigated existing initiatives and organised interviews with students to determine their willingness to act as crowd. Focusing on on-demand delivery in Europe, Dablanc et al. (2017) surveyed instant delivery workers and scanned websites and blogs of
delivery platforms. Finally, to identify the factors that determine crowd logistics’ sustainability potential, Buldeo Rai et al. (2017) systematically analysed the available scientific literature and interviewed logistics experts. Surveys are also used in crowd logistics literature. Punel and Stathopoulos (2017) use stated choice scenarios and discrete choice models to determine consumers’ acceptability and preferences for crowd logistics. Devari et al. (2017) conducted a survey as well, which they used as input for routing simulations. Vehicle routing simulations are commonly done to investigate various aspects of different crowd logistics concepts. Wang et al. (2016) simulate a large-scale crowd logistics concept in which a pool of citizens is used to perform last mile deliveries. Research by Arslan et al. (2016) and Archetti et al. (2016) investigates a similar concept but they consider a fleet of capacitated vehicles and drivers next to the available crowd in their simulations. Presenting another take on the concept, Dayarian and Savelsbergh (2017) explore the possibility of using in-store customers to deliver other people’s online purchases, while Kafle et al. (2017) consider a crowd of cyclists and pedestrians to assist truck carriers in the last and first leg of parcel transport. More in detail, Qi et al. (2016) focus on the crowd’s incentivisation and the size of the optimal service zone. Other novelties that are introduced in this literature include the concept of a pocket switch network (Zhang et al., 2017), a comparison between delivery paradigms for same day deliveries (Lin, Zhou and Du, 2017) and using taxis for product return flows (Chen et al., 2016).

The algorithms that are applied in such simulations are based on predictions of human mobility. Increasing the uncertainty of individuals thus decreases the practical performance of such algorithms (Zhang et al., 2017). The individuals who make up the crowd, are a priori unknown which means that their behaviour cannot be fully predicted (Mladenow, Bauer and Strauss, 2016). Using real user-data of operational crowd logistics platforms is necessary to make accurate conclusions with regards to its impact. Paloheimo et al. (2016) were the first to conduct such a study based on a crowd logistics trial for library deliveries in Finland. The trial finished in April 2014, while the number of and variety in crowd logistics initiatives continued to grow substantially.

None of the aforementioned studies considers the crowd logistics concept from a comprehensive stakeholder perspective. Often, only one point of view is taken into account, most commonly the crowd or the commissioner. Less focus is allocated to the platform provider. Receivers, traditional logistics service providers and society in general are also mentioned as stakeholders of relevance but are usually not included in research (Buldeo Rai, Verlinde, Merckx, et al., 2017). The research presented in this paper thus fills two gaps in literature and responds to an increasing need to understand the crowd logistics phenomenon and its impact.
Methodology

To determine the impact of crowd logistics, we collaborated with an operational crowd logistics platform in Belgium. The platform is part of a large Belgian company that offers a variety of logistics services and was launched in June 2016 in three of Belgium’s largest cities (Antwerp, Ghent, Brussels). From these cities, commissioners can ship parcels to everywhere in the country. The platform is primarily used for business-to-consumer shipments, which is the most promising segment within the crowd logistics realm (Rougès and Montreuil, 2014). The platform is recognised as a sharing economy platform by Belgian law. The Belgian government defined a specific tax regime that allows the crowd to earn up to €5,000 in one year, without the need to become self-employed. On these revenues, the crowd pays a 10% tax rate which is considerably lower compared to general labour income taxes (Federale Overheidsdienst Financiën, 2017). Within the limitations stipulated by this regulation, everyone can act as crowd. Accordingly, on the studied platform, 95% of the crowd falls under this category, while 5% is categorised as a professional driver. The platform is also freely available for commissioners, both private and professional. It determines the price for delivery based on parcel size and distance. This sum is largely transferred to the executing crowd worker, a fixed percentage is refrained for the platform operation.

To gain insight in crowd logistics’ environmental impact on the one hand and the involved stakeholders on the other hand, we applied two methods. First, we calculated the external costs for delivering one parcel in different scenarios: when it is delivered by the crowd (in the crowd logistics scenario) and when it is delivered in more traditional ways (in two “business as usual” scenarios). Second, we applied the MAMCA methodology to identify for each stakeholder to what extent and based on which argumentation the three scenarios are supported. These methods are considered complementary, as the results of the external cost calculations serve as input in the MAMCA. Thus, given the externalities caused and the stakeholder support received, we identify how crowd logistics can contribute to sustainable last mile parcel transport.

Environmental impact analysis

To determine the environmental impact of crowd logistics, we carried out an analysis of external transport costs. As stated by Bickel and Friedrich (2005), “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 these costs for the usage phase of vehicles and apply a gate-to-gate approach, where the analysis covers two given...
Environmental sustainability of the last mile in omnichannel retail

points in the supply chain (Tan and Culaba, 2002). This is a commonly applied method in transport sustainability analysis (see for example De Clerck et al. (2018) and van Lier et al. (2014)).

We made use of several types of data. The crowd logistics platform under study collects data from commissioners, receivers and the crowd to initiate, facilitate and successfully complete parcel deliveries. These data are stored in a database per registered transaction and cover over 2,000 trips, carried out between June 2016 and July 2017. The database includes origin-destination data, date and time references, information on parcel size, price paid for the transport and performance ratings provided by commissioners and receivers.

We also surveyed the users of the platform to explore their platform usage. With brief surveys sent by e-mail, we reached 31% of the crowd, 22% of commissioners and 14% of receivers. In our environmental impact calculations, we used the results of a survey question asked to the crowd, addressing the nature of their last parcel delivery trip for the platform under study. The results indicate that 52.50% of the crowd’s trips are driven for delivering the parcel only. Only 15% of the deliveries are made on an existing trip and 32.50% of deliveries are made on a detour longer than fifteen minutes driving. Based on these findings, we exclude 15% of total trips from our calculations. As these trips are carried out for another purpose and delivering the parcel did not induce changes in travel, we consider these trips as direct gains of the crowd logistics concept. Similarly, 32.50% of total trips are included only half, because the crowd made a detour for delivering the parcel. The dedicated trips are included completely.

In the transport sector, externalities are primarily related to the impact of climate change emissions, air polluting emissions, accidents, noise, congestion, soil contamination, disruption of the ecological system, infrastructural damages and visual intrusion (van Lier, De Witte and Macharis, 2014). We consider the first five externalities in our research (specifically CO₂, PM, SO₂, NOₓ, accidents, noise and congestion), because these are considered most important. Other external cost categories have been left out of the calculations as accurate and scientifically validated figures are not yet available (Maibach et al., 2008; Gibson et al., 2014). We calculated these externalities based on best practices for marginal external cost calculations currently available in economic literature. We made use of several reports to obtain the external cost unit values per vehicle kilometre: “STREAM goods transport Goederenvervoer 2016” (Otten, ’t Hoen and den Boer, 2017), “STREAM Personenvervoer 2014” (Otten, ’t Hoen and den Boer, 2015), “Internalisering van externe kosten van transport in Vlaanderen” (Delhaye et al., 2017) and “Update of the Handbook on external costs of transport” (Gibson et al., 2014). When available, we used figures applicable for a Flemish (region in
To enable comparison between a crowd logistics scenario and more traditional ways of parcel transport, we defined two reference scenarios. The first scenario (“business as usual” 1 or BAU 1) is based on a parcel route of a traditional logistics service provider, who delivers parcels to consumers’ homes. Such logistics service providers consolidate their parcels in a dense network that is organised in the most optimal way. From a logistics service provider with a strong position in the Belgian parcel market, we received average data on distance, number of parcels, start-time and end-time for a parcel delivery route in the Antwerp region for 2017. Antwerp is the most common departure location of the crowd logistics trips in our database. Two arguments urged us to define a second reference scenario (BAU 2). First, the platform data show that the crowd logistics platform under study is mainly used for on-demand parcel shipments, which considerably reduces the opportunity to consolidate. Second, it also indicates that the crowd’s most transported products are fragile and unpackaged, including flowers and groceries, as opposed to generally well-packaged parcels that logistics service providers deliver. Therefore, BAU 2 is defined based on the results of a survey question asked to the parcel shipment commissioners: “In what way would you have sent your last shipment, if (the crowd logistics platform under study) was not available?”. Results indicate that 67.65% of respondents would deliver the parcel themselves, 8.82% would ask their customers for parcel pick-up, 17.65% would use a traditional parcel service provider and 5.88% would order an express delivery service. Accordingly, BAU 2 is a combination of the two other scenarios. In 82.35% of the trips, the parcels are processed in an individual way, similar to the crowd logistics scenario. Commissioners, consumers and express delivery services are assumed to execute the delivery and pick-up of the parcel for this purpose only. In 17.65% of the trips, the parcels are processed in a consolidated way as they are delivered by a traditional parcel service provider, similar to the BAU 1 scenario.

Numerous influencing parameters have to be taken into account when performing a detailed external cost estimation (van Lier, De Witte and Macharis, 2014). Not all required data were available, which urged us to develop assumptions. A first assumption relates to trip distance. For the crowd logistics platform under study, the average trip distance for delivering a parcel from point A to point B is 16.5 kilometres. A cluster analysis on the trip distances in the database shows that short distances up to 17 kilometres account for 70% of shipments. The remaining shipments cover maximum 55 kilometres (24%) or maximum 150 kilometres (6%). For BAU 1, we received data from the aforementioned logistics service provider on average distance for a parcel route departing from their warehouse. Assumptions for BAU 2 are based on the commissioners’ answers on a survey question on
which solution they would have used for the parcel shipment as an alternative to crowd logistics. When customers would have picked up the parcel (8,82%) or commissioners would have delivered the parcel themselves (67,65%), we assume local shopping, but we have no exact information on travelled distances. Therefore, the distance is based on the average number of kilometres within the shortest distance cluster of the crowd logistics platform. When commissioners would have outsourced to a traditional parcel service provider (17,65%), we take the average distance of BAU 1 and when they would have outsourced to an express delivery service (5,88%), we take the average distance of the crowd logistics scenario, given the on-demand delivery service performed.

A second assumption relates to the transport modes used. The platform data indicate that the crowd uses motorised vehicles only. More specifically, 90,10% of the crowd logistics trips is done by regular passenger car and 9,90% by van. For passenger cars, we used external cost figures for average vehicle occupancy rate, EURO norm, year of construction and weight class. For vans, we used figures for a small type of van, categorised as “light transport”. This category includes equipment, furniture, mail and textiles transport. For the reference scenarios, we consider the usage of vans in BAU 1. In BAU 2, we assume that consumers drive a passenger car, while the other parties dispose of a van. We have no information on fuel type for passenger cars, so we used figures from MIRA (2015). According to their data, 61,01% of people in Flanders drive diesel cars, 37,63% have gasoline cars and 1,36% belongs to another category. For sake of simplification, we assumed a 60–40 division for diesel and gasoline. For vans, this division is not made as it is not supported by the reports that we used.

Third, assumptions were made for the parameters that influence different external cost categories. Share of kilometres that is assumed to be driven during daytime and night-time is given for each scenario (relevant for external noise costs). Platform data indicate that 5,38% of crowd logistics trips occur before 7:00 and after 19:00, which is categorised as ‘night’. BAU 1 and 2 trips are assumed to occur during daytime business hours. This share is further divided between the share of kilometres that is driven during peak and off-peak periods (mainly relevant for noise and congestion). Crowd logistics trips are mainly executed during the day and in weekends, which results in 82,80% off-peak trips. BAU 1 routes start during peak hours and end in off-peak hours. For BAU 2, the same division is assumed. Infrastructure type concerns the type of environment in which the trips occur (relevant for accidents, noise, congestion and emissions). We consider an urban environment in all scenarios. Following the OESO classification, 100% of the crowd logistics trips start in urban areas, while 98,53% also end here. BAU 1 scenario represents a parcel route in the Antwerp region and BAU 2 scenario
combines values of the two other scenarios. Road types are determined based on trip distances, where the share of long distances in the crowd logistics scenario explains the small difference between scenarios (6% of trips are up to 150 kilometres). A supplementary distinction is made for congestion between free flow, near capacity and over capacity traffic, in line Gibson et al. (2014). All parameter values are checked for consistency. Table 20 provides the division of kilometre shares over the relevant parameters for all scenarios.

Table 20. Share of vehicle kilometres.

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Time of day</th>
<th>Traffic type</th>
<th>Infrastructure type</th>
<th>Congestion</th>
<th>Road type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Night</td>
<td>Peak</td>
<td>Off-peak</td>
<td>Urban</td>
</tr>
<tr>
<td>Crowd logistics</td>
<td>94.63%</td>
<td>5.38%</td>
<td>17.20%</td>
<td>82.80%</td>
<td>100%</td>
</tr>
<tr>
<td>BAU 1</td>
<td>100%</td>
<td>0%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>BAU 2</td>
<td>100%</td>
<td>0%</td>
<td>50%</td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Stakeholder analysis**

To determine the support among stakeholders for crowd logistics, we applied the MAMCA methodology. MAMCA is designed for solving issues in which multiple parties are involved (stakeholders), who all take different considerations into account (criteria) to evaluate the various solutions that exist (scenarios). The methodology is frequently used for transport-related evaluations and specifically for innovative solutions (Balm et al., 2014). Its approach, value and drawbacks are extensively described in literature (Macharis, 2005; Macharis et al., 2012; Macharis, Turcksin and Lebeau, 2012). As opposed to other multi-criteria methodologies, MAMCA develops a separate value tree for each stakeholder instead of only one value tree for all stakeholders and represents their goals and objectives in a visual way (Macharis, Turcksin and Lebeau, 2012). Since its development, MAMCA has been extended to workshops as a basis for discussion and stakeholder support analysis, mainly within the context of urban freight transport (Verlinde, 2015).

The methodology consists of several steps. First, scenarios are defined. We used the same scenarios as developed for the environmental impact analysis. We contextualised them in the current context: a society in which sharing economy initiatives are growing, both in Belgium and abroad. Different platforms are launched, capturing interests from citizens and businesses alike. To respond to this development, the Belgian government implemented a legal framework. In both reference scenarios (BAU 1 and 2), traditional logistics service providers distribute
There is no crowd logistics platform available as alternative. Contrary, in the crowd logistics scenario, the crowd is connected to a platform and distributes parcels.

Second, stakeholders and their criteria are determined. We used the same set of stakeholders as Buldeo Rai et al. (2017). To allocate criteria to these stakeholders, we made use of the existing literature. These criteria were validated by a panel of ten logistics experts with an interest in crowd logistics. This panel also determined the criteria importance by allocating weights. Weight allocating is facilitated by the Analytical Hierarchical Process (AHP) based pairwise comparison tool that MAMCA offers (Saaty, 1988). For three stakeholders we had to implement a different weighting approach. The crowd was asked to weigh the criteria in the survey while for society and receiver we used weights determined in previously executed studies with a similar focus on sustainable goods transport (Kin et al., 2016). Table 21 presents criteria and weights for each stakeholder.

### Table 21. Stakeholders, criteria and weights.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Platform provider</th>
<th>Logistics service provider</th>
<th>Commissioner</th>
<th>Receiver</th>
<th>Crowd</th>
<th>Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happy crowd</td>
<td>38,24%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good service</td>
<td>27,36%</td>
<td></td>
<td>19,11%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear legislation</td>
<td>2,05%</td>
<td></td>
<td></td>
<td></td>
<td>21,43%</td>
<td></td>
</tr>
<tr>
<td>Maximal profit</td>
<td>13,82%</td>
<td></td>
<td>9,47%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Return on investment</td>
<td>8,89%</td>
<td></td>
<td>51,15%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Care for environment</td>
<td>3,85%</td>
<td>3,44%</td>
<td>20,76%</td>
<td>34,38%</td>
<td>16,33%</td>
<td></td>
</tr>
<tr>
<td>Care for society</td>
<td>5,79%</td>
<td>2,33%</td>
<td>13,51%</td>
<td>27,51%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy employees</td>
<td>14,51%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>13,79%</td>
<td></td>
<td>23,75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative delivery</td>
<td>29,29%</td>
<td></td>
<td>14,37%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative pick-up</td>
<td>22,64%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remuneration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22,45%</td>
<td></td>
</tr>
<tr>
<td>Good platform operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20,41%</td>
<td></td>
</tr>
<tr>
<td>Good working environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19,39%</td>
<td></td>
</tr>
<tr>
<td>High traffic safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28,34%</td>
<td></td>
</tr>
<tr>
<td>Consumer goods offer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11,59%</td>
<td></td>
</tr>
<tr>
<td>Good accessibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26,06%</td>
<td></td>
</tr>
<tr>
<td>Good air quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24,74%</td>
<td></td>
</tr>
<tr>
<td>Minimal noise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9,27%</td>
<td></td>
</tr>
</tbody>
</table>

Third, scenarios are evaluated based on the criteria of each stakeholder. Platform data, surveys and external cost calculations were used to support the evaluation, as well as additional information such as average delivery prices from logistics service providers and express services. To combine these different data types, we
translated all information to a nine-point scale, which is also based on the AHP methodology. In this method, the relative performance of one scenario is compared to another scenario.

Findings

Environmental impact analysis
The results of the environmental impact analysis show that using crowd logistics for urban parcel transport does not avoid external costs (Figure 24). There is a large difference in external costs between BAU 1 and the other two scenarios, which is a direct consequence of the number of kilometres that are driven per parcel. In BAU 1, this number is very small, as traditional logistics service providers consolidate and deliver parcels on a route that is organised as efficiently as possible. In the crowd logistics scenario and the BAU 2 scenario, parcels are handled in a more individual and ad hoc way, resulting in higher vehicle-kilometres per parcel.

Figure 24. External cost calculation per parcel.

Differences between the crowd logistics scenario and the BAU 2 scenario can be explained by vehicle-kilometre and vehicle type. On the one hand, BAU 2 performs better regarding congestion and accidents. These externalities are determined by the number of vehicle-kilometres. This number is larger in the crowd logistics scenario because more than half of the trips are dedicated to delivering a parcel, instead of
another purpose. On the other hand, the crowd logistics scenario performs better regarding climate change emissions, air polluting emissions and noise. This can be clarified by the fact that the crowd uses passenger cars, which are generally less harmful for the environment than vans when taking these external cost categories into account.

Figure 25 shows the sensitivity of external costs for the crowd logistics scenario on three variables. These variables are trip distance per parcel (sensitivity scenario 1 or s1), number of parcels per trip (s2) and share of existing trips, in which a parcel is delivered on a trip for another purpose (s3). It allows to assess the impact of these variables on our results.

This sensitivity analysis shows that decreasing trip distances is the least favourable way to reduce crowd logistics’ externalities. By making the crowd’s trips five times shorter, similar values as BAU 1 are approached but not improved. Moreover, with an average trip distance of 16.5 kilometres for delivering a parcel from point A to point B with the crowd logistics platform, the most interesting opportunity created by reducing this distance with a factor five is shifting towards more sustainable transport modes, such as bicycles.

Sensitivity scenario two indicates that increasing the number of parcels per trip to ten, leads to the same external costs per parcel as caused by the BAU 1 scenario. Increasing the critical mass of parcels and commissioners on the crowd logistics platform offers more consolidation possibilities. Nevertheless, it still implies a
multiplication of current number of parcels per trip with a factor ten, which can only be achieved when facilitated or even pushed by the platform.

Finally, sensitivity scenario three, in which the share of efficient trips where the crowd takes parcels along an existing trip is increased, has the largest potential. The external costs can be reduced to similar levels as BAU 1, if the number of dedicated trips would be reduced to zero and the number of trips with a detour longer than fifteen minutes would represent only 6% of the crowd's trips. Also in this case, critical mass active on the platform and facilitation by the platform are vital.

**Stakeholder analysis**

The result of the stakeholder analysis is depicted by the multi-actor view in Figure 26. This figure is interpreted as follows: the stakeholders are represented by vertical lines and the scenarios are displayed as horizontal line graphs. The intersection of the horizontal scenario lines with the vertical stakeholder lines shows to what extent the scenario contributes to the criteria of this stakeholder.

It can be concluded that for the stakeholders crowd, commissioner and platform provider, the crowd logistics scenario performs better than the reference scenarios, BAU 1 and 2. For the crowd, the graphical representation shows that this scenario receives considerably more support than the others. For them, the crowd logistics scenario creates opportunities that are not present in the other scenarios. From the survey we found that the crowd is positive towards their working environment,
the platform operation and their remuneration. When the crowd is satisfied, so is the platform provider, as ‘happy crowd’ is their most important criterion. Based on the performance ratings that the platform logs, the crowd provides service levels that are slightly better compared to satisfaction scores of traditional logistics service providers. This is the platform provider’s second most important criterion. For commissioners, delivery quality and price are important objectives, to which the crowd logistics scenario responds well. The traditional parcel delivery scenario, BAU 1, appeals most to the logistics service provider, although the differences are not distinct. For receiver and society, BAU 1 also complies best with their criteria. This can be explained by their criteria, in which high weights are allocated to environmental and societal considerations. This is true for receivers to a lesser extent and society to a higher extent.

Research has demonstrated that consumers attach increasing importance to environmental and societal considerations, yet an important difference exists between stated preferences and actual purchase decisions (Nielsen, 2015b). Taking this knowledge into account, next to the fact that we obtained receivers’ criteria weights from a secondary source, we applied a sensitivity analysis on the multi-actor result for this stakeholder. We lowered the weights for the criteria “care for environment” and “care for society” at the benefit of their other criteria (“price” and “qualitative delivery”), from respectively 34.38% and 27.51%. When both criteria weights are reduced to 19.32%, the crowd logistics scenario becomes the scenario that responds best to the receiver’s criteria (Figure 27). This indicates that crowd logistics platforms are smart to focus on service and price minded receivers.

Figure 27. Multi-actor view sensitivity analysis.
Discussion

Our research shows that crowd logistics has the potential to contribute to sustainable last mile parcel deliveries, but current platform use by the crowd prevents the concept from yielding the envisioned environmental benefits. Opposing previous research, crowd logistics does not reduce vehicle kilometres travelled (Kafle, Zou and Lin, 2017), improve efficiency of parcel deliveries as compared to traditional logistics service providers (Allen et al., 2017) and its environmental footprint is not more sustainable (Chen et al., 2016). At the basis of this result lies the high share of dedicated trips that the crowd undertakes for delivering parcels, instead of leveraging existing trips for other purposes. In this way, our research confirms assumptions by Lin et al. (2017) and Qi et al. (2016), that vehicle detours and additional trips prevent crowd logistics from abating emissions, despite the initial premise of the sharing paradigm. This finding is in line with previous statements, that the most promising crowd logistics initiatives are relying primarily on dedicated drivers (Rougès and Montreuil, 2014). Environmental benefits are directly proportional to the saved distances (Paloheimo, Lettenmeier and Waris, 2016). Growth in the platform’s number of shipments and crowd network could result in more unconsolidated and ad hoc deliveries, thus more negative environmental consequences. Alternatively, it could also result in a critical mass allowing a better match between parcel destinations and existing crowd trips. An important role is to be played by the platform provider. This stakeholder can adjust the platform operation in a way that steers efficient use of vehicle space or launch an incentivisation scheme which encourages to deliver more parcels or reduce the number of dedicated trips.

Despite the fact that environmental and societal objectives are not met, our research is the first to demonstrate that there is an interest among a range of stakeholders in a concept like crowd logistics. Specifically, platform providers, commissioners and crowd are found to support the concept. To the crowd, it offers a way to complement their regular revenues in a flexible, easy and social way. The case in Belgium demonstrates that an adequate legal framework can prevent the replacement of regular employees by crowd. Commissioners that were not adequately served yet by the current logistics market, gain access to fast and affordable delivery services, as increasingly asked for by consumers. Carbone et al. (2017) suggest oversized or non-standard items. Our data indicate that flowers, plants and groceries are the main shipment categories. In this way, our research confirms previous statement that crowd logistics does not result in unfair competition for traditional logistics service providers (Paloheimo, Lettenmeier and Waris, 2016). Rather, platform providers address latent needs. Nevertheless, following the stakeholder analysis,
we cannot confirm that logistics service providers are inspired to interact with or integrate crowd logistics systems, as stated by Carbone et al. (2017). Possibly, current reluctance will change in the future. For receivers and society, a strong connection exists between social sustainability and environmental sustainability, a finding that is in line with Marcucci et al. (2017). Receivers are found to support crowd logistics if they are oriented towards service and price, instead of committed to sustainable objectives. Consequently, using a crowd logistics concept for parcel deliveries does not seem to be the way forward to create an image of environmentally-friendly company, as suggested by Mladenow et al. (2016).

Literature considers the potential for integrating passenger and freight flows to be the largest in cities (Li and Yu, 2017). However, the considerable difference that we found between the kilometres driven per parcel by parcel service providers on the one hand and the crowd on the other hand suggest future research to focus on the development of crowd logistics in more rural areas. Researchers have pointed out economic opportunities (Erickson and Trauth, 2013), but also environmental arguments can be made. Traditional logistics service providers have developed a dense network in urban areas which allows them to consolidate and organise more efficient parcel routes. This makes it difficult for crowd logistics to provide a more efficient and sustainable alternative, in particular when the crowd makes (large) detours or dedicated trips. Shipments to areas where logistics service providers are less present might be the most promising context for leveraging the crowd’s spare space.

Our research discusses an impact analysis of a specific type of crowd logistics that is focused on on-demand business-to-consumer deliveries. Other types of crowd logistics exist and have been discussed in literature (Carbone, Rouquet and Roussat, 2017). Such types have a different set of characteristics, which potentially makes them a better match for generating environmental benefits. One example could be business-to-business deliveries, in which professional drivers employ the platform to increase their vehicle load rates.

Conclusion

This paper covers an impact analysis of an operational crowd logistics platform, focusing on environmental impact and multi-stakeholder support. Our research demonstrates that over half of the trips that the crowd makes are dedicated to delivering parcels, which increases its environmental impact far beyond the impact of traditional parcel deliveries. Crowd logistics could offer a more eco-friendly
alternative to traditionally organised urban parcel transport only if the crowd actually optimises existing trips. Despite the fact that environmental and societal objectives are not met, crowd logistics receives support from the main stakeholders: platform providers, commissioners and the crowd. Our research indicates that people are willing to spend free time and/or share spare vehicle capacity to earn a (small) financial incentive. To achieve environmental sustainability, the platform provider has a critical role. His platform needs to facilitate capacity optimisation and reward crowd that leverages existing trips. For such platform to become a credible alternative, a critical mass of platform users is required. This includes both crowd and commissioners. Future research is needed to investigate if other types of crowd logistics are better fit to improve environmental consequences of goods transport. Most potential might be in rural transport or business-to-business flows, instead of last mile transport for parcels.
CONCLUSIONS, FINDINGS AND DISCUSSION

The impact of omnichannel retail on the last mile, and on the last mile’s environmental sustainability

This PhD research focusses on the environmental sustainability of the last mile in omnichannel retail. In this context, the last mile refers to transport and logistics processes in the final phase of the supply chain, which starts at the last distribution centre and ends at the consumer’s home. In omnichannel retail, retailers combine and integrate online (e.g. web-shop) and offline (e.g. store) channels. This retail model emerged as the sector’s response to radically transformed consumer behaviour, brought about by internet-based retailing (Beck and Rygl, 2015; Verhoef, Kannan and Inman, 2015). Omnichannel retail developments add complexity to the last mile, activating multiple inventory locations as shipment point (e.g. distribution centres, retail stores) and integrating multiple consumer locations as destination point (e.g. homes, collection points) (Lim, Jin and Srai, 2018). Given the lack of knowledge and understanding about the increasingly complex last mile in today’s omnichannel retail space, its importance in determining the more sustainable retail model (i.e. online or offline) and its relevance in supply chain sustainability research, the objective of this PhD is to understand the impact of omnichannel...
Part 6

Heleen Buldeo Rai

retail on the last mile, and on the last mile's environmental sustainability.

To this end, it is necessary to determine omnichannel retailers’ strategic choice to insource (using their own vehicle fleet), outsource (to logistics service providers) and/or crowdsourcer (to non-professional individuals) the last mile and the last mile options each provider offers. As consumers are increasingly defining and dictating a last mile that suits them, it is important to identify which of these last mile options attract consumers’ preferences. Building on this knowledge, the environmental impact of the last mile in omnichannel retail can be assessed. The research objective is translated into four research questions:

RQ1 Are omnichannel retailers insourcing, outsourcing or crowdsourcing the last mile?
RQ2 Which last mile options are offered to consumers?
RQ3 Which last mile options do consumers prefer?
RQ4 How do the last mile options in omnichannel retail impact on environmental sustainability?

This thesis consists of six parts: while the first part sets the scene for the research and introduces the research objective, the research questions and the structure of this PhD thesis, the second, third, fourth and fifth part are linked to the research questions. The second part deals with insourcing, outsourcing and crowdsourcing strategies of omnichannel retailers regarding their last mile (chapter 1), while the third part investigates which options are offered to consumers (chapters 1 until 4). The fourth part covers consumer preferences for these last mile options (chapters 5 and 6) and the fifth part discusses the environmental impact of the last mile in the omnichannel retail environment (chapters 7 and 8). This sixth part summarises the findings of the different chapters to answer the research questions, which is followed by a discussion on research contributions. The research does not provide a clear-cut answer on whether online retail or in-store retail is more sustainable, instead it uncovers the complexity of the omnichannel retail environment and the various ways in which it affects last mile sustainability. The importance of three stakeholders and the interfaces among them – retailers, logistics service providers and consumers – is demonstrated by means of a comprehensive framework (in Figure 28 and Figure 29) that lists the critical factors that need to be considered when assessing the environmental sustainability of retail's last mile. To conclude, practical implications and limitations of the research are discussed, as well as avenues for future research.
Findings

RQ1 Are omnichannel retailers insourcing, outsourcing or crowdsourcing the last mile?

In answering the first research question, chapter 1 builds on a review of the literature on omnichannel retail logistics and outsourcing strategies in retail, as well as semi-structured interviews with nineteen decision-makers from retailers that are leading the omnichannel development in Belgium. Three retail sectors were selected (i.e. fashion, electronics and food) on the basis of online penetration. While fashion and electronics products represent the online categories that are bought the most, food and groceries comprise the online category that is bought most recurrently (DPD Group, 2017; Comeos, 2018). Half of the identified retailers from the fashion and electronics sector could be encouraged to participate in the study and all relevant grocery retailers took part. Best practices in omnichannel retail are still in development (Snoeck and Neerman, 2017).

In analysing the research findings, a distinction is made between the sectors of food (i.e. mainly groceries) and non-food (i.e. fashion, electronics). While both sectors differ in terms of share of online sales in total sales (i.e. a few percentages for groceries and on average 14% for fashion and electronics, according to our sample of sixteen retailers), distinct differences were found in their organisation of the last mile as well. Omnichannel food retailers are inclined to insourcing the last mile. This decision is driven by strategic and operational considerations. Strategically, such retailers consider logistics as a key competency that is part of their core business. Accordingly, they build on experience and expertise that external parties can hardly match. Operationally, insourcing allows to keep close control. Logistics capability and performance are vital to sensitive products such as food. The transfer of online orders takes place on consumers’ doorstep, which is a critical moment in the online purchase journey and demands couriers to deliver impeccable service, express the retailer’s brand and evoke feelings of trust.

In contrast, omnichannel non-food retailers are outsourcing the last mile to specialised logistics service providers. Motivations behind this decision are operational and financial in nature. Operationally, third parties’ service offer and service quality are considered adequate and convenient. Financially, the pool of logistics service providers to choose from is large (especially when compared to food retail), which enables retailers to choose a logistics partner on the basis of costs. Nonetheless, omnichannel non-food retail increasingly evolves around stores, which are managed in-house. Stores’ inventories can be used when consumers choose to pick-up their orders in-store. More importantly, shipping from stores...
allows to deliver faster. Although delivery on the day of purchase is uncommon, retailers expect this to change in the short term, to same-day delivery or even delivery within one or two hours after purchase. Fulfilling orders in-store and shipping from there is a strategy that anticipates on this development. These ship-from-store developments drive retailers’ interest for crowdsourcing. Although the crowd’s actual involvement in the last mile is limited to date, the concept is gaining traction thanks to its flexible on-demand capabilities. They provide an answer to omnichannel retailers’ main barrier to deploying stores as shipment point, which is the fact that they depend on logistics service providers’ ability to accommodate this service. This requires pick-up of orders at all stores, potentially multiple times a day. If logistics service providers can offer this, it generally has a cost that omnichannel retailers are not willing to bear. So despite retailers’ preference to allocate their entire last mile volume to one single logistics partner, which increases their power in price negotiations, crowdsourced solutions are considered for the future.

**RQ2 Which last mile options are offered to consumers?**

The findings of chapters 1, 2, 3 and 4 are used to determine the last mile options that are on offer in omnichannel retail. These options are identified by analysing the literature on omnichannel retail logistics and crowd logistics, as well as by interviewing a total of forty-eight experts from retail and logistics in Belgium. This selection of experts includes nineteen decision-makers from omnichannel food and non-food retailers, thirteen senior managers from logistics service providers that capture the majority of Belgium’s parcel volume and sixteen logistics practitioners with an interest to develop crowd logistics activities in their business.

In terms of last mile offer, omnichannel retail revolves around an extensive choice of locations. Two strategies for the last mile are identified, which omnichannel retailers combine: delivery and collection. Again, the distinction between the non-food sector and the food sector is of relevance. Non-food retailers are inclined to offer their customers all options available. This includes delivery at an address of choice (e.g. homes, workplaces), collection in-store (i.e. click-and-collect, click-and-reserve), collection in attended collection points and collection in unattended collection points. Following our sample of non-food retailers, in-store collection accounts for approximately 40% of online orders, while only a small share is allocated to external collection points. The majority is delivered to consumers’ homes.

Food retailers focus on delivery and collection in-store. Three models are applied to facilitate store collection: at a counter in-store, at a counter outside of the store.
and in lockers outside of the store. The third model is emerging as an unattended alternative to counters. Accordingly, this set-up does not need permanently available staff, which is perceived as an important challenge to profitability of e-activities and in-store productivity. In food retail, the majority of orders is picked up in-store, but the share of deliveries is growing. Non-food omnichannel retailers outsource the last mile to logistics service providers. Accordingly, how the last mile is executed is determined by contractual agreements between the logistics service provider and the retailer. The findings show that today's standard option consists of free, next-day delivery to an address of choice. According to the interviews, this standard is set by large marketplaces and to be followed by other players active in the retail space. Hence, free and fast (i.e. within three days, next-day) home delivery has become the norm. Yet, other last mile aspects are considered important as well and relate to delivery information (e.g. track-and-trace), delivery flexibility (e.g. rerouting) and delivery times (e.g. weekend, evening, two-hour timeslots). There are only a few of these marketplaces, but they capture the largest part of sales online: according to The Retail Academy (2018), 3.9% of online shops are responsible for 89% of the online transaction volume. Compared to individual web-shops or predominantly domestic retailers, such marketplaces have a strong negotiation power towards logistics service providers that distribute their parcels, resulting in lower lead times and delivery prices. What's more, to ease hesitation and mistrust of consumers towards online channels, these marketplaces introduced appealing delivery conditions that could compete and even exceed the experience of shopping in physical stores. While consumers have come to expect this, such delivery conditions do not stimulate consumers (because it is free) or even hinder consumers (because it cannot be changed to a fitting day) to plan for order reception. Delivery failures are the result. Accordingly, the standard last mile option brings inefficiencies to logistics service providers and inconveniences to consumers, while reflecting poorly on retailers in turn. Logistics service providers are starting the dialogue with retailers that this standard does not necessarily lead to consumer satisfaction. At the same time, logistics service providers extend their last mile offer to respond to the challenges of the last mile's common mode of operation and by extension the challenges affecting the environment in which they operate. These options relate to location, information and flexibility of delivery, as well as vehicles used for delivery. In terms of delivery locations, logistics service providers are investing heavily in their network of attended and unattended collection points. Such collection points serve multiple functions, e.g. as alternative to home delivery, alternative to home redelivery (i.e. following delivery failure), drop-off location for consumers' returns and drop-off...
location for retailers’ store shipments. Logistics service providers’ investments in collection points focus on network density and proximity to consumers, but also collection point flexibility, e.g. with opening hours extending to evenings and Sundays.

Another way in which logistics service providers aim to improve delivery efficiency and convenience, is by offering consumers mobile applications and dedicated webpages. These tools have three functions and relate to delivery location, delivery information and delivery flexibility. First, they enable consumers to entrust their preferred delivery location in case of absence. Such locations can be diverse, e.g. at a neighbour, at a specific safe place near home or at a particular collection point. Second, these mobile applications and webpages are also used to enhance delivery information, e.g. by pushing delivery status notifications. This information can be real-time and based on drivers’ routing and last scans, or it can be predictive and based on average routing information. Third, they also enhance delivery flexibility by means of dynamic rerouting. This allows consumers to change delivery date, time and/or location at the last minute, i.e. when orders are already in transit.

To respond to environmental challenges, logistics service providers’ vehicles are scrutinised. Although conventional vans still dominate the last mile, alternatives are gaining traction. Today, the most accepted alternatives to conventional vans are powered on gas. Electric vehicles and cargo-bikes become interesting only in combination with small logistics facilities in city centres, or micro-hubs. Other vehicles, such as drones and delivery robots, are not found suitable (yet) for low-value business-to-consumer retailing, nor urban environments.

Omnichannel retailers consider crowdsourcing the last mile under dedicated circumstances: i.e. to speed up deliveries and to facilitate shipment from store. Following the research, crowd logistics is defined as an information connectivity enabled marketplace concept that matches supply and demand for logistics services with an undefined and external crowd that has free capacity with regards to time and/or space, participates on a voluntary basis and is compensated accordingly. Initiatives within the realm of crowd logistics differ based on eighteen characteristics that relate to the concept’s main stakeholders, i.e. receivers, commissioners, logistics service providers, platform providers and crowd. Receivers and commissioners of crowdsourced last mile services can be businesses as well as consumers. Depending on the platform operation, the commissioner and receiver can be the same, e.g. someone requesting the crowd to deliver a purchase to his or her home. When retailers crowdsourcing, they act as commissioners while their customers are at the receiving end. Logistics service providers are potentially, but not necessarily involved in crowd logistics operations. Yet, activating professional third parties is a way to ensure timely service completing, which is key in organising the last mile.
A number of characteristics allow to typify the platform provider that matches commissioners, receivers and crowd: its revenue model, role, strategy, logistics task management, locational dependence, transparency, trust generating mechanism, cooperation, marketing and geographical scale. Various types of platforms can be used by omnichannel retailers to crowdsource the last mile, although beneficial characteristics include inclination towards retail cooperation and a regional and intra-urban scale that enables express deliveries. Five characteristics describe the crowd: its character, transport fulfilment, incentives, motivation and modal choice. In the same vein as platform providers, various types of crowd are fit for omnichannel retail’s last mile. Three types of crowd characters are found: professional drivers, regular crowd workers and casual non-professionals. Within the group of casual non-professionals, a more detailed differentiation can be made. It includes retailers’ employees, retailers’ customers and receivers’ acquaintances (e.g. friends, neighbours).

In terms of last mile offer, crowd logistics gives consumers access to a more extensive range of products and services by being faster, more flexible, more convenient, more personal, traceable in real-time and better priced. In this way, crowdsourcing is found to enhance several aspects that are important to the last mile. While most crowd logistics initiatives focus on transport and delivery of online orders, the crowd also offers in-store picking services and small warehousing services. First, concerning transport and delivery, several models are studied, with variations on transport mode (e.g. public transport, bike, passenger car) (Qi et al., 2016; Serafini et al., 2018) and inclusion of automated lockers that serve as drop-off location for the crowd and pick-up location for receivers (Gatta et al., 2018). Second, concerning crowdsourced picking, the crowd not only picks-up and delivers online orders to end-consumers, but also ventures in-store to search and collect the desired items. Third, concerning crowdsourced warehousing, the crowd opens up their homes to store parcels awaiting collection by neighbours (in case of delivery) and logistics service providers (in case of returns). Akeb et al. (2018) refer to this type of service as “neighbour relays”, that serve as crowdsourced alternative for collection points offered by logistics service providers.

RQ3 Which last mile options do consumers prefer?

Responding to the third research question, consumers’ preferences for omnichannel retailers’ last mile offer are assessed by conducting and analysing a survey among a sample of one-thousand Belgian consumers. The sample is representative for the Belgian population according to age, sex, degree, language, family composition and social class (CIM, 2017). The survey responses are analysed in two studies.
The first study (chapter 5) entails a choice experiment and builds on a review of industry reports, six focus group discussions and eight-thousand choice tasks using the multinomial logit model in Sawtooth Software. The second study (chapter 6) presents descriptive statistics and a two-step cluster analysis using SPSS. Nine aspects of the last mile are identified as important, albeit to a different extent. These aspects relate to location of delivery, price of delivery, term (or speed) of delivery, time of delivery, delivery flexibility, delivery information, delivery vehicle, executing party and sustainability. The industry reports and focus group discussions brought to light that consumers attach most importance to price, speed, location and time of deliveries, as well as to the return conditions. Contrary, consumers are less sensitive to information, vehicle, flexibility, executing party and sustainability related to the last mile. Such aspects can be considered as “nice-to-haves”. Delving deeper in consumers’ attitude towards sustainability, the survey accompanying the choice tasks showed that approximately half of consumers take their environment into account when making a purchase and agree that achieving less vehicle-kilometres for last mile deliveries is important. Yet a high percentage of neutral responses to the last mile sustainability related statement questions is detected. Accordingly, it can be assumed that interest in and/or knowledge about sustainability in last mile delivery among consumers is low. Remarkably, the focus group discussions showed that consumers allocate the responsibility to act sustainably to businesses (i.e. retailers, logistics service providers) and do not feel in charge to sustainability enhancements themselves.

Building upon the last mile aspects that consumers consider most important, the choice experiments stipulate that delivery price weighs in most when consumers select a specific last mile option (53,5%). Return possibility (20,2%) that covers price and location of returns follows next. Delivery term (13,7%) and delivery time and location (i.e. delivery reception, 12,6%) are the least important. Specifically, consumers want their deliveries to be free, or free given a minimal purchase amount (e.g. €25) or loyalty programme, which are gaining ground in Belgium. Consumers avoid high minimal purchase amounts (€75) and high delivery prices (€5,95). They also prefer their deliveries to be fast, e.g. the next day, in two days or within three days. Nonetheless, consumers’ preference for instant (i.e. within two hours) deliveries seems limited. Most unfavourable to consumers is a delivery term that can take at least five days, despite the possibility to freely choose a delivery date within this term. Clearly, consumers do not mind unknown delivery dates. In terms of reception, there is a clear preference for an address of choice (e.g. homes, workplaces), but only small preference differences are detected among the exact delivery times: during the week or the weekend, during regular office hours or after and during a slotted two-hour or unknown timeframe seems to be all the same.
For returns, consumers are reluctant to pay as well. They strongly prefer to return unwanted or faulty orders free of charge, or free by employing a loyalty programme. Returning goods in a collection point is valued most. Consumers avoid paying for their returns, in particular when the return location is a locker. In sum, 81.4% of consumers prefer free, next day delivery to an address of choice, on regular office hours during the week and with a free return possibility in local collection points. This is in line with findings from national and international reports (MetaPack, 2016; Comeos, 2018). However, the research discovered that consumers are in fact making trade-offs when it comes to the last mile, which contradicts common beliefs. Specifically, because consumers appear to be largely indifferent towards delivery term and delivery reception conditions, they are willing to wait longer for their orders to arrive or collect their orders themselves, in collection points or omnichannel retailers’ stores, when delivery and return are free. Accordingly, the importance of delivery price to consumers is confirmed, while also demonstrating that location, time and term conditions are less sensitive.

As consumers do not have distinct preferences regarding the party executing the last mile, interest for a crowdsourced last mile seems to be low overall. 19.2% of consumers’ interest can be captured by various crowdsourcing concepts. Most preference goes out to neighbour relays, i.e. in which a crowd of neighbours serves as collection points (27.1%), and delivery services by a crowd consisting of retailers’ employees (25.5%). Compared to these concepts, consumers are somewhat less interested in delivery by a crowd of non-professional drivers (21%), despite the fact that this concept is most important in terms of initiatives generated and research conducted. Only a minority of consumers is interested in receiving online orders from retailers’ customers (13.8%). Overall, a large part of consumers takes a neutral stand towards crowdsourced last mile services (on average 36.7% of consumers).

Consumers interested in a crowdsourced last mile shop more frequently online and are active users of home delivery services. Additionally, such consumers have a distinct preference for picking-up their orders at a neighbour in case of delivery failure, while consumers generally give preference to pick-up of missed orders at collection points. Accordingly, consumers interested in crowd logistics are more community-oriented. They also have a more positive attitude towards last mile sustainability-enhancements and their interest in other last mile innovations, particularly innovations that enhance last mile’s flexibility, is more pronounced.

**RQ4 How do the last mile options in omnichannel retail impact on environmental sustainability?**

The environmental sustainability of the last mile options in omnichannel retail
is subject to the fourth research question. In the thesis, this matter is studied by means of case-study based external transport cost calculations. The first case-study (chapter 7) is executed in collaboration with an omnichannel footwear retailer in Belgium. This research determines the external costs for CO$_2$ emissions from the retailer’s distribution centre to consumers’ homes, and back in case of returns. Transport distances of all involved parties are considered (i.e. the omnichannel retailer, their logistics partner and their customer base), while also accounting for transport mode, vehicle type and trip chains. The second case-study (chapter 8) is executed in collaboration with an operational crowd logistics platform in Belgium. Next to CO$_2$ emissions, this research focuses on external transport costs for PM, SO$_2$ and NO$_X$ emissions, as well as costs originating from accidents, noise and congestion. These costs are calculated for the transport between retailers’ stores (e.g. supermarkets, florists) and consumers’ homes. This analysis compares transport distances of logistics service providers with transport distances of crowd, while accounting for transport mode, vehicle type and several situational factors (i.e. time of day, traffic type, road time, congestion level).

The first case-study shows that a significant part of consumers are still single channel shoppers: 60,1% of customers in the sample while 39,8% of customers combine multiple channel types. Among the omnichannel shoppers, most common is to combine an in-store purchase with pre-purchase activities in another store or online. The case-study calculations indicate that the last mile of online consumers, who order online and receive their purchases at home or at collection points, generates the lowest environmental impact (€0,02 per purchase, excluding potential return). Collection points are more favourable compared to delivery at home, but only when focussing on professional logistics transport. Because most consumers seem to carry out their collection trips by car (instead of on foot or by bike), the advantage changes in favour of home delivery. Of importance here as well is the fact that the retailer’s customer base in the case-study presents a responsible attitude: virtually none of their home deliveries fail.

Importantly, the case-study proves that e-shoppers are more inclined to travel for pre-purchase activities than in-store shoppers, i.e. for product research and product testing. As a consequence of such trips, the environmental impact multiplies. In this case-study context, CO$_2$ costs generated by online shoppers that travel for pre-purchase trips (i.e. so-called webroomers) are more than eight times higher than the costs generated by online-only shoppers (€0,22 per purchase, excluding potential return). These findings confirm the importance of considering consumers’ omnichannel behaviour when comparing the last mile of online retail and retail in-store.

Next to online consumers, the lowest environmental impact is generated by
traditional consumers (€0.11 per purchase, excluding potential return) that execute all pre-purchase and purchase activities during one store visit and click-and-collect shoppers (€0.10 per purchase, excluding potential return) that shop online but pick-up their orders in-store. These findings advocate for the store’s valuable role as one-stop-shop, limiting fragmentation in purchase behaviour and as such enhancing environmental sustainability as well. The case-study confirms that individual consumer trips are less efficient and thus more harmful to the environment as compared to professional logistics trips. However, this largely depends on the executing logistics service provider. In the first case-study, the retailer’s logistics partner is the largest logistics service provider in Belgium’s parcel market, thus profiting from its volume and size to be efficient. This is not the case when crowdsourcing the last mile, which the second case-study suggests is unfavourable from an environmental sustainability perspective. In comparison to the crowd’s environmental impact (€2.75 per delivery), logistics service providers (€0.32 per delivery) perform considerably better. This difference in external cost is a direct consequence of the number of kilometres that is driven per parcel. For logistics service providers, this number is very small as they consolidate and deliver parcels on a route that is organised as efficiently as possible. Contrary, the crowd handles parcels in a more individual and ad hoc way, resulting in higher vehicle-kilometres per parcel.

Improvements in the crowd’s environmental impact can be achieved by decreasing trip distance, increasing the number of parcels per trip and increasing the share of efficient trips in which the crowd makes use of existing trips instead of dedicated trips. Analysis shows that decreasing trip distance is the least favourable way to reduce crowd logistics’ impact. In this case-study context, making the crowd’s trips five times shorter allows to approach, but not improve, the environmental impact of logistics service providers. Moreover, with an average distance of 16.5 kilometre for crowd deliveries from point A to point B, a more interesting opportunity is shifting from cars (90.1% of trips) and vans (9.9% of trips) to biking and walking. Next, increasing the number of parcels per trip allows to achieve the same level of external costs per parcel as caused by logistics service providers. However, this requires a radical increase from the current one parcel per trip, to ten parcels per trip. Finally, increasing the share of non-dedicated trips from the current 15% has the largest potential. The external costs can be reduced to similar levels as logistics service providers, if the number of dedicated trips would be reduced to zero and the number of trips with a detour longer than fifteen minutes would represent only 6% of the crowd’s trips. It shows that the crowd’s envisioned sustainability benefits can materialise under certain conditions, but not in any case. To achieve environmental sustainability, crowd logistics’ platform provider has a critical role.
The platform needs to facilitate capacity optimisation and reward crowd that leverages existing trips.

Discussion

The previous section listed the findings of this PhD research into enhancing the understanding of omnichannel retail’s impact on the last mile and on the last mile’s environmental sustainability. This section outlines how these findings contribute to last mile research and what they practically imply for the stakeholders in this field. To conclude, the most important limitations are described, together with future research opportunities that this PhD thesis gives rise to.

Research contributions

“Electronic space interweaves and is intertwined with the spaces and places of our physical worlds; practices, processes and products cannot be isolated from one another whether online or offline; printed and digitally mediated formats are co-connected, relational and reveal mutual influence” (Crewe, 2013). Crewe (2013) makes this concluding statement after investigating the impact of digital technologies on the fashion sector. It holds strongly for the retail space as well, in which consumers do not choose between either online or physical channels in their purchase journeys but increasingly combine both (i.e. omnichannel behaviour). A growing number of retailers is omnichannel as well, maximally facilitating consumers’ omnichannel behaviour (Lazaris et al., 2014; Hübner, Holzapfel and Kuhn, 2016). Accordingly, research initiatives that study online and offline retail from an integrated point of view are called for, in this way surpassing bipolar narratives that dominated early e-commerce literature (Crewe, 2013).

The more recent body of literature on e-commerce and last mile sustainability considers consumers’ online purchase behaviour in part: e.g. absence during delivery, product returns and collection trips for failed deliveries (Wiese, Toporowski and Zielke, 2012; Brown and Guiffrida, 2014; Mangiaracina et al., 2015; Van Loon et al., 2015; Hischier, 2018). Some studies account for “browsing-only” shopping trips, in which consumers travel to stores for the sole purpose of product research (Edwards and McKinnon, 2009; Edwards, McKinnon and Cullinane, 2010, 2011; Carling et al., 2015). Yet these studies largely rely on estimations and assumptions of consumer behaviour, instead of profound investigations of contemporary purchase journeys that are highly personal and tailored. Accordingly, the absence and necessity of consumer perspectives has been acknowledged in literature.
Edwards, McKinnon and Cullinane (2010) advocate for an extension of logistics’ traditional focus on the transport of goods in dedicated freight vehicles to include the various forms of personal travel associated with the last mile. This is echoed by Wehner (2018), who suggests an expansion of freight transport’s system boundaries to include consumer transport during the last mile. Consumer behaviour is key in this regard (Collins, 2015), which includes modal choice, activity combination on trips and rebound effects of e-shopping (Pålsson, Pettersson and Winslott Hiselius, 2017). Building on telecommuting research, Winslott Hiselius et al. (2012) reason that telecommunications and travel are complementary and increase together. Yet as Collins (2015) highlights, consumer behaviour is subject to various constraints that are imposed, e.g. consumers’ availabilities and vehicle access as well as retailers’ last mile offer. As such, both offer and behaviour need to be considered in last mile’s environmental impact assessments (Collins, 2015). Mangiaracina et al. (2015) conclude that the impacts of omnichannel shopping experiences on the environment have not been investigated in depth. Thus, the findings of this PhD thesis contribute to filling this gap in research and practice and add empirical evidence to the environmental sustainability of the last mile in today’s omnichannel retail environment.

Part of the research builds on data from a Belgian omnichannel retailer, its last mile logistics partner and revealed preferences of a sample consisting of 707 customers (chapter 7). Using real data is necessary to make accurate conclusions with regards to the environmental impacts associated with the case. The findings of the case-study apply to a given context and hold for 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). These contextual factors are considered critical (Weber et al., 2009; Edwards, McKinnon and Cullinane, 2011; Bernon, Cullen and Gorst, 2016; Park and Kim, 2018; Rosengren et al., 2018) and outline the findings’ generalisability. Yet, they contribute beyond the case-study context as well, by confirming and demonstrating the decisive impact of consumer behaviour on last mile sustainability. The research suggests that delivery to collection points is the most sustainable last mile option, but only when consumers’ collection trips are executed on foot, by bike or en route of a multi-purpose trip. When consumers travel dedicately by car, home delivery scores better (yet only when someone is present).

In this way, the findings of chapter 7 extend the literature review as presented in chapter 5, which builds the case for home delivery being the least sustainable last mile option. Yet this review only considers professional logistics transport (thus
excluding consumer travel), illustrating the progressive understanding of the topic in research in general and to me as a researcher in particular. The case-study also highlights the relevant complexities associated with purchase behaviour, providing evidence that e-consumers engage more in research and/or test trips related to the purchase, as compared to consumers purchasing in physical stores. Such additional trips deteriorate the environmental impact per purchase considerably. Overall, the findings of the case-study suggest that omnichannel consumer behaviour is unfavourable from a sustainability point of view. It is generally acknowledged that consumers consider shopping a social, recreational or even hedonistic activity to be enjoyed in physical stores (Edwards, McKinnon and Cullinane, 2010; Hagberg, Jonsson and Egels-Zandén, 2017). As omnichannel retail facilitates the combination of offline and online retail channels, it drives both professional and consumer trips (e.g. as illustrated by “ship-from-store shoppers” and “showroomers”) and increases vehicle-kilometres per purchase in turn. Unless a significant take-up of sustainable transport modes occurs, omnichannel retail seems to boost customer convenience at the expense of transport sustainability.

In today’s retail space, last mile sustainability results of the trade-off between logistics efficiency and customer convenience. So, consumer preferences and choice behaviour is a crucial part of the puzzle. The assumption lives strongly, both in academic research (Gevaers, Van De Voorde and Vanelslander, 2009) as well as in industry reports (MetaPack, 2016; Comeos, 2018), that consumers demand free and fast delivery at home, without making trade-offs among last mile conditions. Although retailers have largely implemented this last mile option as a standard, challenging supply chain efficiency and last mile sustainability, this research provides evidence in favour of a more sustainable approach (chapter 5). Analysing eight-thousand choice tasks of a representative sample of Belgian consumers shows that consumers prefer this delivery option of free and fast home delivery indeed, but price for delivery (and by extension for return) is most important. Accordingly, when conditions of free delivery and return are met, consumers are willing to make trade-offs by collecting their orders in collection points or stores, or by waiting longer for their orders to arrive. Given the complexities associated with consumers’ collection trips (chapter 7), local crowdsourced collection points are potentially interesting. Yet lowering delivery speed could be the most promising way forward in boosting last mile sustainability: it enhances consolidation and efficiency in terms of vehicle routing and loading (Savelsbergh and Van Woensel, 2016).

Concerning generalisability of the findings, the research in chapter 5 is among the first to investigate consumers’ trade-offs related to the last mile. In designing the choice experiment on which it builds, the study benefits from the extensive study of last mile options and offer in the omnichannel retail space, as presented
in chapters 1 and 2. Starting point of the research is omnichannel retailers’ strategic choice to insource, outsource and/or crowdsourcethe last mile and the multitude of last mile configurations that are possible. Chapter 1 points to retailers’ store network as key difference with pure e-retailers and multichannel retailers. These stores require nearby distribution centres, function as service-added collection points and enable fast home delivery with more ecological vehicles. Chapter 1 contributes as well by disclosing the difference in last mile strategy between the food and non-food sector: while omnichannel food retailers are inclined to organise the last mile in-house, omnichannel non-food retailers prefer to outsource to a specialised logistics service provider. In the non-food sector, omnichannel retailers are focused on providing free, next-day deliveries to several locations, including homes, stores and collection points. In the food-sector, only store pick-up and home delivery are common. Chapter 2 finds that logistics service providers are extending omnichannel retailers’ last mile offer in terms of delivery locations, delivery information, delivery flexibility and delivery vehicles. Although the conditions of the last mile are determined in contractual agreements with these retailers, logistics service providers attempt in this way to improve last mile efficiency and satisfaction among consumers. Following our research on consumers’ trade-offs related to the last mile, other studies investigated the topic as well. Similarly, Nguyen et al. (2019) find that delivery price is the most important attribute in shaping consumer preferences in the Netherlands. Much more than speed, time slot, date and time of delivery is the cost of obtaining a product crucial. For the Brazilian, Chinese and Bolivian context, Janjevic, Winkenbach, Da Silva and Barreto (2019) indicate that time window, lead time, cost and safety are the most relevant factors in determining consumers’ delivery preferences. As Okholm et al. (2013) already showed, preferences of e-consumers often do not differ significantly between countries. In fact, the few country-specific preferences observed are found to be caused by tradition and culture (Okholm et al., 2013). As such, existing and new research validate the findings of chapter 5 and support their applicability broader than the Belgian context. Chapter 1 shows that crowdsourcing in the last mile is uncommon among both food and non-food retailers. Yet, in line with international trends it is considered for future application, e.g. for facilitating fast deliveries and ship-from-store orders. Over the past years, the topic of crowd logistics has received increasing attention from researchers. Also the number of initiatives has grown. Sharing available and idle capacity is key to overcome the increase in goods transport fragmentation with smaller but much more frequent shipments (Kin, Ambra, et al., 2018). Despite initially introduced as a sustainable alternative to traditional last mile services by logistics service providers, the debate about crowd logistics’ actual environmental
benefits remains in full swing. While many envision sustainability benefits (Chen et al., 2016; Allen et al., 2017; Kafle, Zou and Lin, 2017), others question its true potential (Qi et al., 2016; Lin, Zhou and Du, 2017). As mentioned alongside the findings of the first case-study (chapter 7), also the second case-study of (chapter 8) requires real data to make accurate conclusions about the environmental impact. Even more so in the case of crowd logistics, which is subject to a great deal of modelling work and simulation studies. Comparing such studies to the findings of chapter 8 urges to acknowledge the variety of crowd logistics initiatives (and the associated impacts) on the one hand, but also to question whether they build on realistic assumptions on the other hand.

The findings of chapter 8 are based on user-data from an operational crowd logistics platform in Belgium and cover over two-thousand trips, carried out between June 2016 and July 2017. The database includes origin-destination data, date and time references, information on parcel size, price paid for transport and performance ratings. Additionally, the main platform stakeholders are involved as well: 31% of the crowd, 22% of commissioners and 14% of receivers were reached with brief surveys sent by e-mail. While the findings are among the first to disclose the environmental effects of an operational crowd logistics platform, they also extend chapter 7, that demonstrates the importance of logistics service providers’ size and efficiency in the sustainability of home deliveries. When large and efficient, their environmental impact easily outperforms consumers driving individually to stores (i.e. by car). Yet, the crowd survey brought to light that only 15% of crowdsourced deliveries are made on existing trips, which tackles the main motivation behind its believed sustainability potential. More than half of the trips are driven dedicatedly, while 32,5% of the trips consist of detours on existing trips. What’s more, the platform data show that all crowdsourced trips are motorised: 90,1% by passenger car and 9,9% by van. These numbers argue against a crowdsourced shift to sustainable modes and provide a second argument against crowd logistics’ believed sustainability potential. Therefore, this thesis provides evidence that traditional logistics service providers score considerably better in terms of environmental impact per parcel when compared to the crowd.

However, as conceptualised in chapters 3 and 4, a variety of crowd types and crowdsourced services exists within the realm of crowd logistics. Accordingly, the thesis benefits from an extensive investigation of the concept. Next to deliveries as investigated in the case-study (chapter 8), the service that is believed to have most business potential in the future (Carbone, Rouquet and Roussat, 2017), the crowd offers small warehousing services (i.e. neighbourhood or neighbour relays) and in-store picking as well. In case of neighbour relays, the crowd opens up their homes to store parcels awaiting collection by neighbours (deliveries) and logistics
In case of picking, the crowd ventures in-store to search and collect the desired items and deliver them to the requested address. Different services go along with different types of crowd. Three crowd characters are found: professional drivers, regular crowd workers and casual non-professionals. Within the latter group, a more detailed differentiation can be made, consisting of retailers’ employees, retailers’ customers and receivers’ acquaintances (e.g. friends, neighbours). While professional drivers and regular crowd workers can be situated on the business-side of the motivational axis, casual non-professionals are more inclined to be motivated by community values. This motivation is assumed to have an impact on the platform usage and ultimately on the subsequent sustainability outcomes. Encouraging and facilitating a more sustainable use of the crowd logistics platform is largely reserved for platform providers. They can adjust the platform operation in a way that steers sustainable transport modes, or launch an incentivisation scheme which encourages to deliver more parcels per trip or reduce the number of dedicated trips. As the analysis of chapter 8 indicates, these are fruitful ways to improve the environmental impact. In this way, crowdsourced deliveries have the potential to match or even outperform traditional parcel delivery systems. In the future, the expected growth in crowdsourcing models for the last mile can result in more unconsolidated and ad hoc deliveries, thus increasing the environmental impact. Alternatively, it can also result in a critical crowd mass, allowing a better match between parcel destinations and existing crowd trips.

Yet whether or not crowd logistics is sustainable, implementation of last mile innovations is increasingly driven by consumers (Joerss et al., 2016). Accordingly, identifying consumers’ attitude towards such crowdsourced applications is vital. Literature starts to consider the consumer perspective (Punel, Ermagun and Statthopoulos, 2018; Gatta et al., 2019), but its focus lies mainly on crowdsourced deliveries on the one hand and the crowd’s perspective on the other hand. Hence, the findings outlined in this thesis contribute by assessing consumers’ preferences for three service types and four crowd types. Based on descriptive and two-step cluster analysis of a survey among a representative sample of one-thousand Belgian consumers, the findings identify a small share of consumers whose interest can be captured (chapter 6). Nevertheless, most consumers appear reluctant. This corresponds to the findings from chapter 5, that consumers are rather indifferent towards to the party executing the last mile. Yet, in relation to other findings in this thesis (i.e. related to last mile offer and last mile sustainability), there proves to be potential for neighbourhood relays (i.e. avoiding delivery failure and collection trips by car) and crowd delivery by retail employees and non-professionals (i.e. facilitating fast delivery and ship-from-store orders).

In answering the objective of this PhD, to understand the impact of omnichannel
retail on the last mile, and on the last mile’s environmental sustainability, Figure 28 schematically summarises the findings. It presents a framework that highlights the complexities that have to be taken into account when analysing the environmental sustainability of retail’s last mile: it visualises the main stakeholders, as well as the crucial interfaces among them: retailers, logistics service providers and consumers. The context’s spatial characteristics are important too, e.g. area density and form, transport and logistics infrastructure (Wygonik and Goodchild, 2016; Pålsson, Pettersson and Winslott Hiselius, 2017; Lim, Jin and Srai, 2018). As elaborated on extensively in this thesis, both the last mile options offered to consumers as well as consumers’ choices therein, determine last mile sustainability. Retailers that outsource the last mile to third parties make choices as well, among the last mile options offered to them. Hence, retailers’ offer to consumers is determined in part by their cooperating parties. Yet, the logistics service provider in Figure 28 could also be the retailer itself (i.e. insourcing) or a crowd logistics platform (i.e. crowdsourcing). While consumers’ last mile choices are made in connection with retailers, last mile experiences occur between consumers and logistics service providers. Within the constraints of offer and choice, how the last mile is organised determines last mile sustainability as well. This organisation depends largely on logistics service providers, but also involves consumers. The professional interface between retailers and logistics service providers is enclosed within the concept of “retail logistics”, while consumers’ “omnichannel behaviour” potentially affects all stakeholders and interfaces within the spatial context.

Figure 28. Environmental sustainability of the last mile in the omnichannel retail environment.
While neither home delivery nor conventional in-store shopping has an absolute environmental advantage (Edwards, McKinnon and Cullinane, 2010), Figure 29 builds on Figure 28 to provide a detailed overview of the factors that are important to determine the environmental impact of consumers' purchase journeys. Most factors are investigated in this thesis. In terms of last mile offer and last mile choice, chapters 5 and 7 report on price, term, location, time and timeslot conditions of deliveries. Retailers decide about purchase packaging and consolidation of multi-order purchases as well, which are mentioned only briefly in this thesis (Van...
Part 6

Loon et al., 2014; Pålsson, Pettersson and Winslott Hiselius, 2017). In terms of last mile organisation, crucial factors to logistics service providers’ organisation are featured in chapter 2, while their impacts are captured in chapters 7 and 8: trip distance, load factor, drop density, transport mode, vehicle type, delivery communication (e.g. order tracking) and delivery quality (e.g. product damages). Likewise, consumers share in the last mile organisation by being present at the time of delivery or offering an unattended delivery alternative (e.g. garden). In all alternatives to home delivery, consumers’ collection trips are decisive too (as extensively described in chapter 7): trip distance, transport mode, vehicle type and activities chained to the collection trip. Yet, this thesis allocates most attention to consumers’ omnichannel behaviour, presented as the main gap in research and practice, and covers consumers’ research, test and return trips and the associated trip distance, transport mode, vehicle type and activities chained to these trips. Consumers’ purchase and return behaviour is found key, taking stock of effects such as purchase quantity increases due to lower-priced items online, purchase fragmentation due to an abundance of retail channels and intentional purchase returns. The net transport effect due to changes in supply chain configuration, retail structure and consumer behaviour leaves ample room for investigation and is discussed as well in the thesis’ limitations and future research avenues.

Practical implications

The findings presented in this PhD thesis give rise to practical implications for the stakeholders in this field. These implications are formulated as recommendations for improving omnichannel retail’s last mile. Last mile research related to e-commerce sustainability often focusses solely on what logistics service providers can do to reduce environmental impacts. Yet, transport is a derived demand (Rodrigue, 2006), which means that retailers and consumers should not be overlooked. Accordingly, all stakeholders have a part to play in enhancing environmental sustainability. The approach applied in this research consists of identifying consumer behaviour and consumers’ purchase journeys to assess which journey’s impact is the lowest. Yet, it neglects the obvious point that we behave more sustainably when we consume less. In accordance, the least polluting trip is the one that does not take place (unless it is walked or biked). Bearing this argument in mind, Table 22 sheds light on self-regulatory, behavioural and technological opportunities for a sustainable last mile in the omnichannel retail environment.

“Retailers act as intermediaries between consumers and producers and have the role of promoting sustainability behaviour among supply chain members”, state Adivar et al. (2019). Accordingly, they are gatekeepers for environmental development in retail supply chains (Kotzab et al., 2011). From an omnichannel retail point of view,
Environmental sustainability of the last mile in omnichannel retail

Wiese, Zielke and Toporowski (2015) showcase that consumers underestimate the impact they can have on environmental effects. Similarly, research in this thesis uncovered that consumers do not feel responsible for enhancing retail supply chain sustainability but instead expect retailers and logistics service providers to act sustainably. This PhD thesis provides ample evidence in favour of including all stakeholders to the debate, consumers first and foremost. Retailers’ position is key in raising awareness about the environmental impacts associated with different last mile options, alongside an offer that includes more sustainable options, e.g. “green delivery”. Following the concept of “nudging”, incredible opportunity lies in stimulating the uptake and adoption of such last mile options to support behavioural change. Following the suggestion by Browne et al. (2005), consumer transport should be considered as part of retailers’ supply chain. Hence, not only the delivery and collection offer is key, but also locations and accessibility of stores are

Table 22. Opportunities for a more sustainable last mile in the omnichannel retail environment.

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<th>Behaviour</th>
<th>Technology</th>
<th>Self-regulation</th>
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<tbody>
<tr>
<td>Retailers</td>
<td>• create awareness on last mile sustainability</td>
<td>• enhance online product information</td>
<td>• adopt sustainability indicators when outsourcing</td>
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<td></td>
<td>• communicate internal and external delivery cost</td>
<td>• offer routing adapted delivery times</td>
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<td></td>
<td>• stimulate longer delivery terms</td>
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<td></td>
<td>• stimulate delivery consolidation</td>
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<td></td>
<td>• stimulate local collection point use</td>
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<td></td>
<td>• discourage excess returns</td>
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<td></td>
<td>• stimulate stores as “one-shop-shops”</td>
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<td></td>
<td>• enhance packaging</td>
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<td>Logistics service</td>
<td>• improve routing efficiency</td>
<td>• adopt alternative vehicle technologies</td>
<td>• anticipate sustainability objectives</td>
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<td>providers</td>
<td>• improve loading efficiency</td>
<td>• develop communication tools</td>
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<td></td>
<td>• develop collection points</td>
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<td></td>
<td>• avoid re-delivery</td>
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<tr>
<td>Consumers</td>
<td>• consume consciously</td>
<td>• adopt platforms to optimise trips</td>
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<td></td>
<td>• optimise purchase activities per trip</td>
<td>• adopt platforms to optimise store visits</td>
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<td></td>
<td>• increase use of walking and biking</td>
<td>• adopt platforms to employ crowdsourced collection points</td>
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<td></td>
<td>• increase activity chaining to trips</td>
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<td>• use collection points</td>
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<td>• avoid short delivery terms</td>
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<td>• avoid delivery separation</td>
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<td>• avoid delivery failure</td>
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<td>• avoid excess returns</td>
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to be considered from a last mile sustainability perspective. It impacts consumers’ purchase behaviour, collection trips, trip distance, transport mode and the opportunity to chain activities on the trip, among others. Economically, consumers are in charge and increasingly in position to penalise or reward sustainability decisions that businesses make. Consumers that make more sustainable choices in terms of rationalising purchase behaviour, confining transport distances (i.e. covered and induced) and favouring sustainable transport modes, enhance in this way the environmental sustainability of the last mile in omnichannel retail.

As elaborated on in the introduction of this thesis, environmental sustainability and economic efficiency are concepts that are intertwined in the last mile, thus encouraging retailers and logistics service providers to alleviate their impact. When delivery terms stretch, delivery consolidation increases and consumers are present during delivery, logistics’ efficiency improves. In this way, it could provide leverage to invest in more sustainable last mile operations (e.g. more sustainable vehicles). Evidently, policy matters too in our efforts to enhance retail supply chains’ environmental sustainability. Although authorities’ role has not been investigated specifically in this PhD research, they have a responsibility to support stakeholders in enhancing their actions and behaviour. In addition, several suggestions can be made for policy-makers, including stimulants to increase consolidation as well as use of eco-friendlier vehicles and a tailored CO\(_2\) tax on all purchases that includes a reflection on logistics impact. Although this is a big leap from the current “free delivery” situation, in which the delivery costs are added to product prices or covered by marketing funds, enhancing last mile sustainability necessitates transparency and fair communication about its true internal and external cost.

The results of this thesis indicate that there is no “silver bullet” solution or “one-size-fits-all” approach. All stakeholders, i.e. consumers, retailers and logistics service providers, are interconnected and the largest environmental savings can be achieved when actions are supported and underpinned by all.

**Limitations and avenues for future research**

While considering the findings presented in this PhD thesis, it is important to take into account its limitations as well. Specific limitations relate to methodological approaches adopted in this research. They constrain the research’s generalisability and should be investigated further:

- First and foremost, part of this research builds on case-study data. In interpreting the results, it is thus essential to consider the case-study context, e.g. in terms of spatial and temporal situation, stakeholder types and product types. This argument is particularly relevant for findings on consumer preferences and environmental impact, which are expected to differ in contexts with

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different characteristics. Revealed preference data as included in this research are potentially affected by two types of bias: due to respondents’ self-selection (Heckman, 1979; Roztocki, 2001) and due to respondents’ ability to recall events (Haab, 2012). Because respondents were not incentivised to participate in the study, the self-selection bias is assumed to be small. Given the level of detail required in the study (e.g. requiring respondents to submit postal codes), it can be assumed as well that respondents unable to recall events, abandoned the survey before completion. This resulted in low response percentages but potentially decreases the negative effect of the recall bias.

• Second, it should be born in mind that only a selection of external transport cost categories is considered. The ones selected are considered most important and have accurate and scientifically validated figures available for calculation. Yet, other external cost categories are potentially impacted by developments in omnichannel retail as well and could be of interest to this research topic, e.g. visual intrusion and spatial impacts.

• Third, environmental assessments in this research have focused on delivery distances linked to several shipment and destination locations that are relevant for omnichannel retail’s last mile. This excludes other last mile aspects that potentially impact on sustainability as well, such as dynamic delivery prices, longer delivery terms, diverging delivery times, flexible delivery rerouting, enhanced delivery information and alternative delivery vehicles. Some of these aspects have been investigated in research, others provide leeway to explore further.

From a more comprehensive point of view, three limitations should be outlined relating to the conceptual approach applied in this research:

• First, this research focuses on retail’s last mile, given its importance to consumer satisfaction, transport costs and environmental impact. Although this approach is backed by years of research, it does exclude several other supply chain issues. Kotzab et al. (2011) list eight categories for environmental retail supply chains, including packaging.

• Second, the research considers reverse logistics related to order returns, or “the first mile”, only to a limited extend. Yet, these findings and the findings in literature on which it builds (Mangiaracina et al., 2015; Pålsson, Pettersson and Winslott Hiselius, 2017) demonstrate the significant external transport costs it generates. What should also be taken into account are the potential impacts of the first mile on the findings presented in this thesis. Possibly, online shoppers return more compared to in-store shoppers, which favours traditional retailing at the expense of e-commerce. Yet reverse logistics has consolidation potential.
with product deliveries along the last mile, potentially filling up empty return flows to distribution centres and limiting its negative effect. As a growth in e-purchases potentially increases returns as well, future research is urged to investigate the first mile further.

• Third, the research does not account for possible impacts arising from changes in supply chain configuration and retail structure (Cullinane, 2009), nor the net effect of online and omnichannel retail on purchase behaviour and transport (Marshall, 2018). As online retail facilitates to purchase products from anywhere in the world, it potentially induces products to travel further, thus increasing transport kilometres overall. In fact, global marketplaces that are responsible for a significant share of online orders rely on distribution centres to serve geographical areas that multiply those of local retailers (i.e. such as the ones investigated in this PhD research). Moreover, if consumers’ online shopping baskets are smaller online, then substituting the total number of items that would otherwise be bought in physical stores requires more trips. What’s more, online purchases might as well complement purchases in-store and increase the total purchases made overall. In sum, such indirect impacts have not been investigated in this research and thus present an important gap to be addressed in the future.

To conclude, ample research opportunities lie in addressing the limitations presented in this PhD research. Yet, same as consumers’ habits and behaviour, the topic of omnichannel retail’s last mile is sure to remain in transformation in the coming years. This transformation is mainly driven by technological developments that impact on every phase in consumers’ purchase journeys. While some developments are promising from a sustainability point of view, their impact is not assessed yet. Future research needs to focus on technologies, including:

• Autonomous vehicles
• Digital home assistants
• Smart locks
• Remote retailing technologies, e.g. virtual reality, augment reality, touch technology

In line with the findings of this research, assessments of these technologies should follow a holistic approach, not losing sight of omnichannel retail’s complexities. To this end, the framework presented in Figure 28 and Figure 29 is created to assess the last mile’s environmental sustainability and provides a basis for future investigations in this research domain.
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