TRAVEL BEHAVIOR OF E-CONSUMERS: DO TRAVEL HABITS VARY AMONG LAST-MILE PRACTICES?

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Abstract

E-commerce can no longer be considered out of the daily lives of many consumers. In recent years, both the frequency of purchases and the amount spent have skyrocketed. This study also observed a significant shift from lower purchase frequency (every 3 to 6 months and every 6 to 12 months) to higher (monthly and weekly) ones. This growing tendency has been further supported by the coronavirus outbreak, as over 50% of Belgian online shoppers cited the impact of the health crisis as a factor in their decision to shop online. This shift from bricks to clicks raises the question of the effects on consumers' travel behavior. Most research focuses on the overall impact of online shopping on personal mobility. However, little is known about how to characterize personal shopping mobility when considering the various last-mile options and weight categories of online purchases. This paper does not only map the travel behavior and last-mile practices of the Belgian e-commerce users but also gives crucial information related to customer travel behavior in order to assess the environmental impact of e-commerce from a consumer side. This research is based on self-reported travel data collected through an online-survey among the Belgian e-consumers (N = 2105). Results indicate that respondents' last-mile choices are not greatly affected by the weight category of an order. Yet, significant difference between the different modes used, travel distances and number of stops across the four last-mile options can be observed. Furthermore, regional variations were also noted in consumer travel patterns.

Keywords: Online shopping, Consumer behavior, Travel patterns, Last-mile practices

1. Introduction

E-commerce is a rapidly worldwide expanding, changing industry, which increased even more as a result of the pandemic (United Nations, 2021). And it is predicted that by 2024, online sales would account for about 22 percent of all retail sales worldwide (International trade administration, 2021). This growing trend can also be observed all around Europe, including Belgium where over the past years, both the frequency of purchases and the amount spent have skyrocketed (BIPT, 2021; Statbel, 2020). For nearly 50 percent of the Belgian online shoppers, the impact of the health crisis was a motive for shopping online (Federale overheidsdienst mobiliteit en vervoer, 2021). These previously stated figures imply that e-commerce is a promising sector with a bright future ahead.

The evolution from bricks to clicks has, however, also created significant logistic challenges, especially in the so-called last-mile (Macioszek, 2018; Goodman, 2005). In addition, concerns about the sustainable impact of online shopping both on the logistic as on the consumer side are also raised (Ignat & Chankov, 2020; Mangiaracina et al., 2015; Edwards et al., 2010). According to a systematic quantitative review of environmental impact studies that compare the carbon footprint of online and in-store purchases, online purchases typically result in a reduced carbon footprint than retail purchases do, but only for people who rely heavily on their cars for transport (Buldeo Rai et al., 2023). Yet, the

authors Buldeo Rai et al. (2023) highlight that the majority of research fail to account for changes in consumer behavior and the consumption landscape which could have an impact on the outcome. Moreover, when assessing the environmental impact of e-commerce, factors related to customer behavior and transport mode choices are just as important (Cullinane, 2009; Hiselius et al., 2015; Hischier, 2018). Literature shows that e-commerce not only affects customer buying behavior, but it also transforms its travel behavior (Le et al., 2022; Hiselius et al., 2015; Cullinane , 2009). This illustrates how technological developments, such as e-commerce, tend to influence people's behavior and practices in the various organizations, economies, and societies (Bjerkan, Bjørgen, & Hjelkrem, 2020). The majority of studies concentrate on the overall effect of internet shopping on personal mobility. However, little is known about how personal shopping mobility can be characterized when differentiating the different last-mile practices, such as home delivery, delivery in a collection point, delivery in a parcel locker, and delivery to a brick-and-mortar store. Therefore, this paper seeks to understand the impact of the different last-mile practices and weight categories of parcels on consumers travel behavior. To the best of the author's knowledge, it is the first study done that specifically explores the transport behavior of the different last-mile practices.

The rest of this article is structured as follows. In section 2 research on personal travel behavior and the interaction of e-commerce is investigated. Section 3 discussed how the data via an online administered survey was collected. The structure of the sample based on socio-demographic characteristics is also described. Section 4 of the paper details the results of the survey in terms of the travel behavior related to the different last mile practices and weight categories of parcels. And lastly, in section 5 the study's conclusions are presented.

2. Research on personal travel behavior of e-commerce users

Scientific sources describe that, in theory, there are four different behavioral effects on transport that can emerge from online shopping, i.e., substitution, complementarity, modification and neutral effect. Researchers Solomon (1986) and Mokhtarian (1990) first discussed these behavioral effects in the early days of the uprise of telecommunication products and services, such as mobile phones, teleshopping & internet and provided the following descriptions of them. (1) The substitution effect occurs when all aspects of shopping are done online, which lessens the amount of actual shopping trips and (2) the complementary effect refer to the exact opposite, namely that online shopping leads to more trips. (3) The term "modification effect" reflects the way the use of ICT has altered certain aspects of travel, including modes of transportation, time, and destinations. And lastly, (4) the neutral effect describes the fact that the use of ICT does not affect the travel behavior (Solomon, 1986; Mokhtarian, 1990). An increasing number of studies suggests that online shopping can replace in-person shopping trips (Weltevreden & Van Rietbergen, 2007; Motte-baumvol et al., 2017; Suel, Daina, & Polak, 2018). Since

home deliveries are prevalent in Belgium (Federale overheidsdienst mobiliteit en vervoer, 2021), one could assume that the substitution effect is indeed occurring. This could be refuted if failed deliveries which potentially cause pick-up trips and other non-shopping trips are also considered. Moreover, it should be understood that shopping can be seen as way to socialize with people, which could offset the substitute effect of online shopping. (Mokhtarian, 2004; Hiselius et al., 2015). On the other hand, there are studies that found online shopping to have a complementary effect on traditional in-store shopping, this is especially the case when pre-purchase activities are considered (Hjorthol, 2009; Lee et al., 2017; Xi et al., 2018). According to research by Buldeo Rai (2019), retailers have developed new business models by blending online and offline channels as e-commerce has expanded and opened up new market opportunities. In light of this, consumers have also changed their behavior by combining in-store and online purchases using different sales channels for a single purchase which increased the trip frequency. The study findings, based on a case study in Davis, California, conducted by Lee et al. (2017), also demonstrated that the households that purchase online undertake more trips to physical stores. Several studies revealed that travel time saved for shopping might be used for other types of travel, indicating that there may even be a combination of substitution and complementary effects on travel (Le, Carrel, & Shah, 2022). Furthermore, Shah et al. (2021) find that the impact of e-commerce on travel behavior is also closely related to the socio-demographic profile of consumers. More so, Maat & Konings (2018) find that the type of the product (i.e., clothes, books, and groceries) purchased online, although with limited impact, also lead to different travel behavior patterns. This perhaps demonstrate that e-commerce has broaden consumers shopping possibilities such as the option to purchase some products online, with or without a pre-purchasing experience in-store, the option to still buy products in-store, with or without a pre-purchasing experience online and the option of a monthly weekly subscription on products. And this fragmented shopping behavior impacts the travel behavior as well.

In general, above-mentioned literature demonstrates that prior studies have not reached a consensus regarding the dominating impact of e-commerce. Additionally, it demonstrates how complex it is to assess, how e-commerce may affect consumers' personal trips. On top of that, most studies to date have focused on trip frequency but neglected other travel outcomes (Le, Carrel, & Shah, 2022). In order to fully analyze the effect on travel behavior, it is also necessary to include travel distance, transportation mode, trip chaining, characteristics of the consumer and residential localities (Zhou & Wang, 2014; Farag et al., 2006; Hiselius et al., 2015). Furthermore, findings from a study by Bjerkan et al. (2020) reveal that last-mile practices, rather than e-commerce itself, appear to have an impact on personal travel behavior. Despite the fact that there have been many studies on the topic, most of them focus primarily on how traveling for in-store buying is affected by online purchasing and frequently ignore consumer attitudes concerning the different last-mile options, failed deliveries and make assumptions about the transport mode choices. There is a limited state of the art of the transport impact of the different last-mile practices. Therefore, the aim of this paper is to describe the e-consumer transport

mode choices, travelled distance, number of stops (trip chaining) and trip motive for delivery and collection of online purchases considering the different last mile options, failed deliveries and environmental factors such as the residential locations of consumers.

3. Methods and data

In order to map the travel behavior and last-mile practices of the Belgian e-commerce users, an online-survey was employed as the data collection method. The survey's target demographic was the adult population of Belgium. This quantitative approach provides access to sizable, widely scattered populations, in this case the Belgian residents (Lefever et al., 2007). Moreover, online surveys also have a number of additional benefits, including the ability to support with multimedia, adapt the question structure, transfer the data from prior responses, and skip questions that aren't applicable for the respondent (Tuten, 2010). The literature indicates that the sample of respondents in online surveys is restricted to those with internet access, which might lead to sampling issues (Wright, 2005; Van Selm & Jankowski , 2006; Fricker, 2017). Since this study looks at the travel patterns of online customers, it can be assumed that the whole research population has access to the internet. For this reason, this should have little effect on the study's representativeness.
E-commerce use does not differ considerably between the three Belgian regions (i.e., Brussels region, Flanders, and Wallonia) (Statbel, 2020), but the modal split does (MORA , 2022; Brussel Mobiliteit, 2021; Wallonie IWEPS, 2020; Federale overheidsdienst Mobiliteit en vervoer, 2022). The findings of the Federale overheidsdienst Mobiliteit en vervoer (2022) study unequivocally show that the modal split differ between the three regions. Compared to the Flemish, inhabitants of Wallonia use cars more frequently (59% for Flanders and 73% for Wallonia), mainly at the detriment of the use of bicycles (18% for Flanders and 2% for Wallonia). This can be linked to the differences in degree of urbanization and population density in those two regions (Statbel, 2022). Meanwhile, the residents of Brussels, travel substantially differently as the area is mainly urban; they use an alternative to the car more than half of the time, mainly by using public transport, i.e., train, metro, tram, and bus (24%) or walking (24%).

This research is based on an online-survey among the Belgian e-consumers over all the different e-commerce sectors. The online survey was conducted by a survey agency over an *Qualtrics survey* link between June 4th, 2022, and June 24th, 2022. Respondents were recruited with an aim of achieving a sample representative for the adult Belgian population in terms of residential location. Since the questionnaire was planned to be distributed to the entire Belgian population, it was drawn up in both Dutch and French. Furthermore, respondents must have had previous experience making online purchases of tangible products, in other words, purchases requiring a delivery. The last-mile practices and travel behavior of the e-commerce users are explored through the self-reported travel data provided by the respondents. All respondents have reported which mode of transportation, trip distance, trip

motive and number of stops (trip chaining) was employed for the used last-mile practice. In case of a home delivery, potential pick-up trips due to failed deliveries were also included. This data was asked on the level of their habitual travel behavior, considering the different weight categories of online purchases and different last-mile options. This allowed respondents who employed various last-mile options to report the travel data for each practice.

Respondents were rewarded by the survey agency if they completed the questionnaire completely and were selected after the data-cleaning process. Prior to analysis, preparation processing was applied to the dataset, also called the data-cleaning process. In fact, this preliminary phase can be considered as the initial exploration of the dataset. Moreover, this is a critical stage in scientific research as it should ensure optimal data quality (Chu et al., 2016; Osborne, 2014). The data-cleaning process consisted out of five criteria (minimum and maximum completion time, existence of the zip code, straight lining behavior, consistency in responses by comparing some responses with each other and attentiveness in the responses based on specific questions that were inserted to check the quality of the responses). After applying the data-cleaning criteria, 2105 (N) respondents remained for further analysis.

3.1 Socio-demographic profile of Belgian e-commerce users

First, comparisons are carried out between the survey sample and data on the Belgian adult population, as well as between frequent and occasional e-commerce users, in order to study the characteristics of the Belgian e-commerce users. Frequent users are defined as those who buy online at least once a month, while occasional users buy online less frequently (Bjerkan et al., 2020). The population data is provided by Statbel, the Belgian statistical office and the data used are based on the adult Belgian population on Jan. 1, 2022. Significant differences, with a 95% confidence interval, between frequent users and occasional users, as well as between the entire sample and the Belgian adult population, are indicated by the numbers in bold.

The general sample consists of 2105 respondents, 1028 frequent users of e-commerce and 1077 non-frequent users (see table 1). It can be observed that 48.9% of respondents buy products online at least monthly, 15% of them do so weekly. Compared to the results from a study in 2017 also conducted in Belgium, where 27% of respondents purchased tangible products at least once a month online (Buldeo Rai et al., 2019), a significant shift ($\chi 2$ = 667,431; df = 6 and $p < 0.001$) can be observed from the lower frequency (every 3 to 6 months and every 6 to 12 months) to the higher frequency (weekly and monthly). These results are in line with academic research and market studies that demonstrate how swiftly e-commerce is developing worldwide, with rising spending and purchase frequency (Statbel, 2022; Comeos, 2020; Ecommerce News Europe, 2021). Additionally, there was a rise in the number of product categories bought online by consumers, with an average of 3.83, which can be an indication of how e-commerce has fragmented customers' purchasing habits.

Table 1: Description of the used sample based on the socio-demographic characteristics

Socio-demographic factor	Frequent user (N = 1028)		Non-frequent user (N = 1077)		Total sample (N = 2105)	
	N	%	N	%	N	%
Gender						
Male	455	44.3%	509	47.3%	964	**45.8%**
Female	571	55.5%	565	52.5%	1136	**54.0%**
Non-binary	1	0.1%	1	0.1%	2	0.1%
Unknown	1	0.1%	2	0.2%	3	0.1%
Age						
18 – 24	112	**10.9%**	70	6.5%	182	8.6%
25 – 31	131	**12.7%**	66	6.1%	197	9.4%
32 – 38	179	**17.4%**	81	7.5%	260	12.4%
39 – 45	160	**15.6%**	97	9.0%	257	12.2%
46 – 53	132	12.8%	145	13.5%	277	13.2%
54 – 60	110	10.7%	161	**14.9%**	271	12.9%
61 – 67	121	11.8%	229	**21.3%**	350	16.6%
68 – 74	72	7%	163	**15.1%**	235	11.2%
75 +	11	1.1%	65	**6.0%**	76	3.6%
Residential location						
Flanders	625	60.8%	568	52.7%	1193	56.7%
Wallonia	288	28.0%	407	37.8%	695	33.0%
Brussels region	115	11.2%	102	9.5%	217	10.3%
Education						
Low (ISCED[1] 0 -2)	44	4.3%	67	**6.2%**	111	5.3%
Middle (ISCED 3 - 4)	402	39.1%	493	**45.8%**	895	42.5%
High (ISCED 5 - 8)	582	**56.6%**	517	48%	1099	52.2%

[1] ISCED: International standard classification of education

Looking at the socio-demographic profile, first, a significant difference ($\chi 2$ = 7.045; df = 1 and p = 0.008) between the sample and the Belgian adult population in terms of gender can be observed. It can be noted that women are over-represented in this sample. However, based on a study conducted by FOD Economie (2021), it does appear that Belgian women ordered online more easily than men in 2020. The evidence is conflicting when examined in the academic literature. According to certain studies, men are more likely to make online purchases (Hwang, 2010; Yang & Lester, 2005; Farag, Dijst, & Lanzendorf, 2003) while other sources were unable to find a significant difference between men and women when it comes to making online purchases (Goethals et al., 2009; Bae & Lee, 2011). The age range of the respondents was 18 to 85, with a mean age of 49.14 and a standard deviation of 16.331. The median age is fifty. The sample mean and population mean do not differ significantly (t = -1.905; df = 2104 and p = 0.057) when compared to the adult Belgian population, where the average age of a Belgian is 49.82 years (Statbel, 2022). Additionally, it can be seen that e-commerce non-regular users tend to be older (t = -13.726; df = 2103 and p 0.001) than frequent users. This is also in accordance with research from FOD Economie (2021) and Comeos (2020), which found that although these differences gradually disappear with time, people between the ages of 18 and 54 still buy online more frequently than older generations. The education level of respondents from this dataset is noticeably greater than that of the adult Belgian population ($\chi 2$= 178.932; df = 2; p0.001). Again, this is consistent

with FOD Economie research from 2021, which indicated that more educated people use e-commerce more frequently. Between respondents with low and middle levels of education, there is no statistically significant variation in the frequency of purchases (t = 1.030; df = 971.196; p = 0.308). Between highly educated and less highly educated (low and middle) people, there is a significant difference (t = 4.029; df = 2093 and p 0.001), indicating that more educated people use the internet more frequently. Academic research also supports the idea that a person's level of education affects their tendency to purchase online (Bădîrcea et al., 2022; Beneke et al., 2010; Liebermann & Stashevsky , 2002). Based on the abovementioned literature and figures, it can be concluded that the obtained sample does correctly reflects the Belgian e-commerce user.

4 Results and discussion

4.1 Last mile practices of Belgium e-commerce users

Figure 1 shows the percentage ratio for the used last mile option by respondents, considering the different weight categories of purchases. Also, respondents had the option to indicate if they had never ordered a specific weight category online. The findings showed that compared to the other three weight categories (*very small* – *small* en *medium*), the *large* and *very large* weight categories had much higher percentages of respondents (20% and 29%, respectively) who had never purchased this weight category online. To prevent a bias in the results, only respondents who had actually purchased products in the various weight categories were taken into account in the analysis that follows.

Overall, it can be seen that home delivery is by far the most commonly used last-mile option in Belgium. And nearly 80% of respondents who choose home delivery have experienced a failed delivery at some point. Yet, it can be noted that in case of a failed delivery, for almost 50% the parcel is still delivered to their home, whether or not to a safe place or to the neighbors/concierge. Thus, this ensures that for almost 50% of respondents, in case of a failed delivery, no additional travel, both for the consumer and the logistics player, is required to receive/deliver the parcel. For only 1.8% of respondents, in case of a failed delivery, an order is again delivered to their home the following day. The popularity of home delivery in this study is in line with a recent survey where about 80% of Belgian consumers preferred home delivery (Federale overheidsdienst mobiliteit en vervoer, 2021). The results show that the used last-mile option does not vary significantly between weight categories, both with and without considering very large orders, where home delivery is often mandatory (With: F = 1.173; df = 4; p = 0.360 - Without: F = 0.624; df = 3; p = 0.613). Typically, consumers choose the same option or a limited number of options. This could indicate that respondents' last-mile choices are not greatly affected by the weight category of an order. Yet, it can be observed that within the "small" and "medium" weight categories, home delivery appears to be losing share to a delivery at a collection delivery point, although the trend does not appear to be significant. Nevertheless, this could be an indication, similarly to the

study by Bjerkan et al. (2020) that pick-up points are used for lighter shipments while home delivery is more frequently employed in segments with heavier goods.

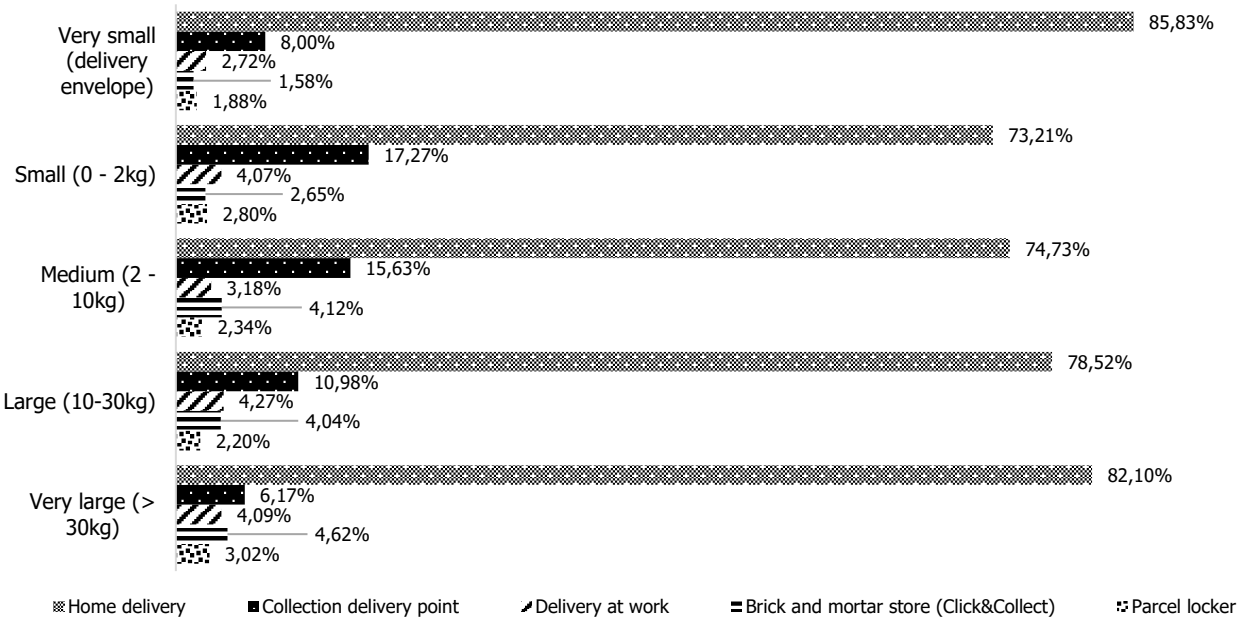

Figure 1: Percentage ratio for choice of pickup or delivery option considering weight category

An overview of consumers' travel patterns considering the different last-mile options can be found in table 2. The car is generally the most popular mode of transportation used by customers to pick up their online orders, and this holds true for all last-mile choices. Nevertheless, deliveries to collection delivery points and parcel lockers show a more frequently use of soft mobility. Hence, a significant difference between the different modes used across the four last-mile options can be observed ($F = 3.890$; $df = 3$; $p = 0.037$). This may indicate that the choice of last-mile option determines the transportation mode. Furthermore, the findings show that consumers travel longer distances to collect a package at a store or their workplace than to a collection delivery point or a parcel locker. Though, these deliveries (work and store) do involve a higher number of stops (trip chaining) during the trip. Additionally, there is a significant difference between the various last mile options in terms of trip chaining ($F = 3.826$; $df = 3$; $p = 0.032$). When picking up in a physical store and in a collection delivery point, it can be observed that, 65% and 71% of respondents, respectively, do not combine this with other purchases in the store or collection delivery point itself. Respondents are more likely to combine their purchase with purchases at another location and or other activities such as picking up the children from school (trip chaining) but a lot less with purchases at the collection delivery point or store where their order is delivered. If the distribution of trip chaining by transportation mode is considered, a significant difference can also be observed. The results reveal that consumers combine trips more often when using car and bicycle than by foot ($F = 3.721$; $df = 4$; $p = 0.025$).

Table 2: Consumer travel patterns for parcel pickup by delivery option

	Delivery at work (N = 170)		Brick-and-mortar store: Click&Collect (N = 261)		Collection delivery point (N = 1467)		Parcel locker (N = 219)	
Mode								
Car	**76%**		**67.0%**		55.8%		58.9%	
Bicycle	15%		14.9%		**12.5%**		**22.8%**	
Public transportation	6%		6.5%		**3.0%**		**5.5%**	
By foot	2%		11.1%		**28.3%**		**11.9%**	
Other	0%		0.4%		0.3%		0.9%	
Afstand	0 – 4km	5%	0 – 1,9 km	13.8%	**0 – 499m**	**12.2%**	**0 – 499m**	**8.7%**
	5 – 9	18%	2 – 4,9	30.3%	**500 – 999**	**21.2%**	**500 – 999**	**21.0%**
	10 – 14	**28%**	**5 – 9,9**	**24.1%**	**1 – 1,4km**	**21.6%**	**1 – 1,4km**	**25.1%**
	15 – 19	**14%**	**10 – 14,9**	**16.1%**	**1,5 – 1,9**	**13.9%**	**1,5 – 1,9**	**18.7%**
	20 – 29	**15%**	**15 – 19,9**	**10.0%**	2 – 2,9	11.0%	2 – 2,9	9.6%
	30 – 39	8%	20 – 29,9	4.2%	3 – 4,9	10.8%	3 – 4,9	11.0%
	40 – 49	5%	30km +	0.8%	5km +	9.1%	5km +	5.9%
	50km+	6%	Unknown	0.8%	Unknown	0.1%	Unknown	0%
Trip chaining								
No extra stop	18%		28.7%		**42.2%**		**33.8%**	
1	**53%**		**42.9%**		**41.6%**		**42.0%**	
2	**25%**		**22.2%**		13.1%		16.9%	
3	4%		4.6%		1.7%		5.5%	
4+	1%		1.4%		0.5%		0.9%	
Unknown	1%		0%		0.9%		0.9%	
Trip motive	Assumption:						Assumption:	
Yes	**0%**		64.8%		70.8%		**100%**	
No	**100%**		35.2%		29.2%		**0%**	

In table 3 the consumer trip patterns by region based on the residential location of consumers are described in order to identify variations across the three regions: Brussels region, Flanders, and Wallonia.

Table 3: Consumer travel patterns by region

	Brussels region	Flanders	Wallonia
Mode			
Car	110	647	495
Bicycle	27	234	38
Public transportation	33	30	21
By foot	107	226	141
Other	0	7	1
Trip chaining			
No extra stop	120	442	236
1 extra stop	117	456	332
2 extra stops	26	206	97
3 extra stops	7	29	19
4 + extra stops	2	6	4
Trip motive			
Yes	184	621	402
No	38	307	167

A significant difference can be observed for the parameter trip chaining ($F = 5.627$; $df = 2$; $p = 0.030$). Consumers living in Wallonia combine their trips to pick up their orders more, on average, with other trips than consumers living in the two other regions. This is also related to the fact that these consumers

use the car more often as a transport mode. However, there is no significant difference in the three regions' use of different mode of transportation ($F = 2{,}667$; $df = 2$; $p = 0.130$). Nevertheless, there is still a pattern that can be noticed namely, in the Brussels Capital Region, parcel pickup is primarily done by car (39.7%) and on foot (38.6%). The most common mode of transportation for Flemish people is a car (56.6%), followed by a bicycle (20.5%). Meanwhile, more than seven out of ten customers who reside in Wallonia pick up their orders by car, followed by 20.3% of people who do so by foot. Additionally, the findings demonstrate that consumers residing outside the Brussels Capital Region are more likely to combine picking up an online order with other purchases or activities at the pickup location ($F = 17{,}647$; $df = 2$; $p = 0.0536$). Because the result of the later test is at the cutoff value of 0.05, it should be interpreted with prudence.

5 Conclusion

This study observed a significant shift from the lower purchase frequency (every 3 to 6 months and every 6 to 12 months) to the higher frequency (weekly and monthly) in comparison with a study conducted by Buldeo Rai et al. (2019) which indicate how swiftly e-commerce is developing with rising spending and purchase frequency. Literature shows that e-commerce does not only affect customer buying behavior, but it also transforms its travel behavior. Moreover, travel behavior in terms of modes of transportation, travel distance, trip motive, and trip chaining are essential when discussing the sustainability implications of online shopping (Hiselius et al., 2015). Yet, literature has not reached a consensus regarding the dominating impact of e-commerce on travel behavior and the sustainability impact of e-commerce, as the majority of research fail to account for the different travel outcomes and consumer behavior. Finding from a study conducted by Bjerkan et al. (2020) reveal that last-mile practices, rather than e-commerce itself, appear to have an impact on personal travel behavior. For that reason, the parameters transportation mode, travel distance, trip chaining, trip motive and the residential localities of consumers were mapped in order to better understand the transport impact of the different last-mile practices. The different weight categories of online purchases were also considered for the last-mile choice. Overall, it can be seen that home delivery is by far the most commonly used last-mile option. And for almost 50 percent of respondents, that encountered failed deliveries, no additional travel, both for the consumer and the logistics player, were required to receive/deliver the parcel. Moreover, typically, consumers choose the same last-mile option across all different weight categories of parcels or a limited number of options. This could indicate that respondents' last-mile choices are not greatly affected by the weight category of an order. If travel behavior is examined in more detail, significant difference between the different modes used across the four last-mile options can be observed. The findings also show that consumers travel longer distances to collect a package at a store or work. However, these deliveries (work and store) do involve a higher number of stops (trip chaining) during the trip, indicating that there might even be a combination of

substitution and modification effects on travel. The results reveal that consumers combine trips more often when using car and bicycle than by foot. Furthermore, consumers living in Wallonia combine their trips to pick up their orders more, on average, with other trips than consumers living in the two other regions. No significant difference in the three regions' use of different mode of transportation was noted. The results of this study generally support the findings of Bjerkan et al. (2020) study, which found that last-mile practices appear to significantly influence the personal travel behavior of e-commerce customers. The findings also highlight the significance of taking into account a variety of travel outcomes, including mode of transportation, trip chaining, as well as last-mile practices and customer residential locations, in order to thoroughly assess how e-commerce affects travel behavior.

Since the self-reported travel data provided by the respondents only included the travel outcomes employed for the used last-mile practice, it is difficult to fully understand the impact of e-commerce on personal travel behavior. Therefore, a study that investigate the impact of e-commerce on personal travel behavior explored through a travel diary will give more insights. Moreover, the data was asked on the level of the habitual travel behavior of consumers, preventing situational factors such as sector related specificities from being captured in the results. Perhaps, it would be interesting to draw different samples from different e-commerce sectors and look for patterns of similarity and difference. Furthermore, a study with longitudinal data could provide also more significant results. Nonetheless, the results indicate that the last mile practices associated with e-commerce appear to impact personal travel behavior and the importance of including the different travel outcomes. A next step could be to combine the combine consumer transportation data with the data from transport companies and e-retailers in order to evaluate the sustainability impact of the last-mile for each last mile option.

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