POLITECNICO DI TORINO

Master of Science in Engineering and Management

Thesis Title

Online Market And Environmental Sustainability: Compatibility And Remedies. Carbon Footprint Between Purchase In Person And HOME Delivery (Case Study)

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Acknowledgment

I wish to express my deepest gratitude and sincere appreciation to my supervisors Prof. Giulio Mangano and Prof. Giovani Zenezini for their continued interest, valuable advice, guidance and encouragement during the research process and for their immense help during the preparation of this thesis.

Dear mama with whom would I start if it wasn't you ain't a woman alive that can take my mama's place cause when I was low you were there for me and never left me alone because you cared for me, I can always depend on my mama and when it seems that I'm hopeless you say the words that that can get me back in focus, to keep me happy there is no limits to the things you did , and I appreciate how you raised me and all the extra love that you gave me ,there are no words that's can express how I feel and there's no way I can pay back but my plan is to show that I understand (you are appreciated)

Many thanks to my family for the love and support that they showed me, also thanks to my father without him I am nothing, thanks to my brothers and sisters for their love and support.

To all the lighting candles in my life my friends, my colleges, my beloved ones and to anyone who supported me in this life I'm really grateful to have such a glamorous people like you in my life.

ABSTRACT

Variability in consumer practices and choices is typically not addressed in comparisons of environmental impacts of traditional shopping and e-commerce. Here, we developed an analytical model to quantify the variability in the Carbon footprints of product distribution and purchase of nine products category via two prevalent retail channels in the city of Torino. We found that shopping online most likely decreases the Carbon footprints when substituting traditional shopping, while products purchased through traditional retail often have higher Carbon footprints compared to those purchased via traditional retail. The number of items purchased, and the last-mile travel distance are the dominant contributors to the variability in the Carbon footprints of the two retail channels. We further showed the differences in the Carbon footprints for a different nine categories and how the consumer choices change these emissions. Finally, a sensitivity analysis showed how major savings on Carbon footprints can be achieved by changing some of the model parameters.

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Introduction

Greenhouse gases trap heat and boost global temperatures. Almost all of the rise in greenhouse emissions in the atmosphere over the last 150 years has been caused by human activities. The combustion of fossil fuels for power, heat, and transportation is the primary source of greenhouse gas emissions from human activities.
Greenhouse gas emissions have a wide range of environmental and health consequences. They lead to respiratory disease caused by smog and air pollution, as well as contributing to climate change by trapping heat. Other consequences of climate change exacerbated by greenhouse emissions include extreme weather, food supply shortages, and increased wildfires. The weather patterns we've become accustomed to will shift; some species will vanish; others will move or expand Carbon dioxide is the most common greenhouse gas, accounting for about three-quarters of all emissions. It can last for thousands of years in the atmosphere. Carbon dioxide levels at Hawaii's Mauna Loa Atmospheric Baseline Observatory reached 411 parts per million in 2018, the highest monthly average ever reported. Carbon dioxide is emitted primarily by the combustion of organic materials such as coal, oil, gas, wood, and solid waste.

The objective of this research is to investigate the carbon dioxide emissions that take place in Turin city due to purchasing items online or in stores, their importance, and find the most effective methods to minimize it in a manner that is friendly to the environment and costly efficient.

Methods to minimize carbon dioxide are used extensively in Europe and the United States of America, with legislation to enforce its use. In Turin little attention has been given to carbon dioxide emissions in general, and the use of mentioned methods in particular.

In this project the evaluation of carbon dioxide emissions terminology was conducted via a literature review and is presented in Chapter 2. Methodology and calculation the carbon dioxide emissions that take place in Turin city due to purchasing items online or in stores in Chapter 3, followed by the data collection in Chapter 4, then the results and their discussion in Chapter 5. Conclusions and recommendations are presented in Chapter 6.

1.1 Greenhouse Gases and Their Impact on Global Warming

Greenhouse gases include CO2, nitrous oxide (N2O), water vapor, methane, and other gases. CO2 and other greenhouse gases wrap around Infrared radiation like a shield, blocking it from escaping into space. The obvious consequence of greenhouse gases is a gradual heating of the Earth's atmosphere and soil, resulting in global warming.

The Greenhouse effect is one of the most important factors in keeping the Earth warm because it prevents any of the planet's heat from escaping into space. . The Earth's average global temperature would be much colder without the greenhouse effect, and life on Earth as we know it would be unlikely. According to NASA, the Environmental Protection Agency (EPA), and other scientific and regulatory bodies, if global warming continues unabated, it would result in significant climate change, a rise in sea levels, increased ocean acidification, life-threatening weather events, and other extreme natural and societal impacts [1].

In 2018, greenhouse gas emissions in the EU fell by 21% relative to 1990 levels, resulting in an absolute reduction of 1018 million tons of CO2-equivalents, placing the EU on track to meet its 2020 goal of cutting GHG emissions by 20% by 2020 and 40% by 2030, as shown in Figure 1 below .

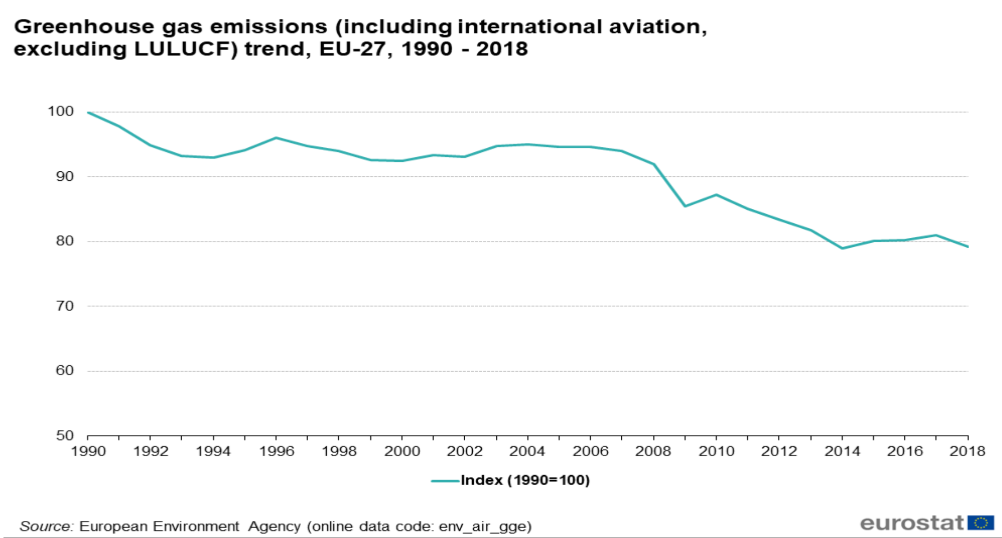

Figure 1 Greenhouse gas emissions for Eu

In 2018, Germany had the highest greenhouse gas emissions among EU Member States (23 percent of total EU emissions, or 889 million tones CO_2-equivalents), led by France and Italy.

Carbon combustion and fugitive emissions from fuels (without transport) accounted for 53 percent of EU greenhouse gas emissions in 2018, according to a breakdown of EU greenhouse gas emissions by major source sectors. This source sector was even more dominant in 1990, with a share of 62 percent. Fuel combustion for transportation (including international aviation) was the second largest source sector in 2018, accounting for 25% of total emissions; it has dramatically increased its contribution since 1990. (15 percent). Agriculture was responsible for 10% of the EU's total greenhouse gas emissions. Industrial processes and product usage accounted for another 9% of the total. Waste management accounted for 3% of overall [2][3].

1.2 Greenhouse Gases reduction challenge for EU countries

By enacting the first European Climate Regulation, the EU aims to commit to becoming climate neutral by 2050. The Commission's priorities are consistent with the Paris Climate Agreement, which went into effect on November 4, 2016. The Paris Climate Agreement's main goal is to limit global warming to well below 2°C over pre-industrial levels and to keep working to keep global warming to 1.5°C above pre-industrial levels, this require improvements in energy efficiency and in the energy mix, technological changes and innovation, less energy consumption. In addition, the energy should rely relatively less on carbon intensive fuels and more on renewables. As a result, these technical developments will make it possible to increase economic growth while emitting fewer emissions [3].

1.3 Transport-related emissions

By comparing 1990 to 2018, the only fuel combustion sector that indicates an increase in GHG emissions is transportation, which includes international aviation. Total GHG emissions rose by 32%, or 231 million tons of CO_2-equivalent, between 1990 and 2018. Before the economic downturn, the volume of transportation increased, as determined by the amount transported multiplied by the distance traveled. However, fuel efficiency has not changed enough to compensate for the increased amount of transportation. In order to reduce these amounts of emissions, fuel efficiency has to be improved and significant favorable shift in the fuel mix towards renewables is to be achieved [3].

1.4 Retailing and their Environmental impacts

Today's definition of retail includes both conventional in-store retail and electronic commerce, or e-commerce. The selling or purchasing of products or services over computer-mediated networks is referred to as e-commerce. The goods and services are ordered over certain networks, but payment and final delivery of the product or service can take place on or off-line. New innovations continue to have an effect on the e-commerce industry, resulting in new types of e-commerce such as mobile commerce (commerce facilitated by mobile devices) and social commerce (the use of social networks to drive commerce).

Different studies on the environmental impact of retailing show that consumer trips contribute significantly to the environmental footprint. Depending on the mode of transport, the distance, and the number of items in the shopping basket, the consumer trip can consume more energy than the total transport energy from factory to shop. If a van home delivery service completely replaces the conventional shopping trip (consumer car travel), the vehicle km can indeed be reduced. However, complete substitution is unlikely to happen. In the case of consumer goods, and especially groceries, products are often bought as part of a larger shopping basket. Nevertheless, a reduction in consumer travel by car is essential if the environmental benefits of e-commerce are to be realized. To determine the true environmental effects of e-commerce, the influence of online shopping on consumer trips must be considered completely. Changes in consumer travel due to online shopping might include changes in shopping frequency, transport mode and changes in the distance between the shop and the consumer [4].

1.4.1 Torino city

Torino is the fourth largest Italian city in terms of population and the third biggest economic and industrial hub after Milano and Roma. It has changed and evolved in recent years and is no longer merely industrial-oriented: it has become a renowned center of excellence in research, technology and innovation, as well as internationally recognized at an academic level. The city has successfully moved towards a services-oriented economy and it also hosts many companies listed in the Italian stock exchange. The corporate environment is also enhanced by several multinational companies that have decided to consolidate their presence in Italy. Torino, for instance, has a wide array of publishing houses making the city one of the top publishing capitals in Italy. The International Airport Sandro Pertini of Torino is the main airport of the region, located only 16 km away from the city center. Porta Susa and Porta Nuova are the two railway stations serving high-speed trains.

Piemonte region shows a particularly high number of out of town centers, with a density of 464 sqm / 1,000 inhabitants (higher than the national average of 322 sqm / 1,000 inhabitants) and a total of 2 million sqm. The Italian high-street market is experiencing a particularly favorable period, thanks to the willingness of both domestic and international brands to expand into markets other than Milano and Roma. Torino boasts a long and consolidated tradition of retailers that dominates both the city and the metropolitan area. The metropolitan area of Torino recorded approximately €470 million in investments over the last 5 years, including 12 single assets, without considering a substantial number of mixed portfolios (6 for a total of approximately €900 million) that includes buildings located in the area [5].

All the mentioned above makes Torino ranked the highest Italian level of PM10 air pollution, among the worst in Europe, the air is moderately polluted, greater than the maximum limit established for one year by WHO. A long-term exposure constitutes a health risk. According to epidemiologists, children’s health in Turin is severely affected by air pollution, primarily originated from private motorized traffic. Based on this data, serious interventions must be taken to improve air quality. These span national and regional regulations to local actions and may involve either single or multiple governmental sectors. They should include those that influence air quality over a long period of time, e.g. the introduction of a new public transportation system, as well as those with short-term goals, e.g. the temporary closure of a road to traffic. Interventions that improve air quality may be implemented for a range of reasons, including meeting air quality standards, reducing congestion, improving traffic flow, or addressing public health concerns

2 Literature

There has been controversy among researchers over the last ten years about whether traditional shopping has a lower environmental effect than e-commerce. Logistics practices are thought to have the greatest effect on the environmental performance of retail supply chains, and transportation is thought to have the greatest impact [6].

There has been a major increase in online shopping since the introduction of the Internet in the 1990s. The online retail industry is rising at the same time as online shopping. Several players are investing in either pure online retailing or click and mortar retailing, which still has a physical presence and provides consumers with a face-to-face experience. In 2016, the e-commerce market in Italy had increased by 18 percent over the previous year, and this growth rate was larger than that of other large European markets, confirming that ecommerce in Italy has high growth margins[7].

The study of Cohorts for Air Pollution Effects (ESCAPE), which involved 360,000 residents across 13 EU countries, found that the health dangers from pollution might be even greater than previously thought, Out of the cities surveyed, Turin residents were found to have the greatest exposure to fine particles of pollution, known as PM2.5, which contribute to heart and lung disease and can lead to lung cancer, Two surveys conducted for the report for Turin, Italy's car manufacturing capital, recorded 30.1 and 30.0 micrograms per cubic meter of the particles - above the EU's recommended 25 micrograms per cubic meter and four times more than those recorded in Stockholm, which is the cleanest city. When combined with the death rates of participants during the study, Turin's results were alarming, the report found.

Although there has been a lot of studies on the operational, marketing, branding, and purchasing behavior aspects of both retailing systems, there have been very few studies on their environmental impacts. [8]. Currently, a few research studies have already focused on the environmental impacts of the logistic system, such as the release of pollutants, intensive energy and resource consumption, and carbon emissions, Therefore, finding an appropriate assessment model for carbon emissions from intracity express delivery has become a strategic imperative for any organization, considering the complexity and connectivity of cities [9].

The urban environment is deteriorating in many cities, and they are all facing challenges of unsustainable development. Hence an energy-saving green express delivery system will eventually have to be established and is part of the development plan of the express delivery industry. And control of carbon emissions from intracity express delivery will not only help address the climate-change issue but will also satisfy regulatory requirements.

Around 63 papers were studied to better understand the environmental impacts off online shopping and last mile delivery, it`s been confirmed that emissions are high and continuously increasing [9]–[13].

These emissions in general depends on two major factors, the consumers behaviors, and the supply chain operations. There was no clear pattern on how the consumers behaviors can increase or decrease the impacts from online shopping this research gap needs to be better analyzed.

2.1 The Consumers behaviors

Impact of online shopping on the environment is not clear cut. Rather the issue is complex and dynamic, involving human behaviors as well as hard business decisions. If the only considerations taken into account are the direct and static ones, i.e. one van replaces 20 shopping journeys, then on balance, yes, it appears that online shopping could be environmentally responsible. However, when consumer behavior and the subtle interactions between shopping and other activities as well as the dynamics of household travel patterns are taken into consideration, the whole issue becomes much more complex. Combining the passenger travel complexities together with those on the freight side and also adding into the pot the problem of where to set the boundaries in terms of looking at the travel and environmental impacts make the whole agenda fraught with difficulties.

What is clear, however, is that there is an over-riding need for further study, particularly in light of the projections for the future of online shopping[14].

There does not appear to be an environmental advantage by default to purchasing items of clothing online compared with purchasing those same items in-store at the nearest city. Rather, it all depends on the behavior of the individual consumer and the choices they make. The variability in the total potential impacts for the traditional way of purchasing clothes is much higher than that in the case of online purchasing [15].
The carbon intensity of the different forms of retail distribution depends on their particular circumstances. Neither has an absolute environmental advantage. Some forms of conventional shopping behavior emit less CO2 than some home delivery operations. However, in the case of non-food purchases, home delivery is likely to produce less CO2, and personal travel is especially significant. If a shopper takes the bus during rush hour and makes several purchases, the emissions per item are lower than when a home delivery van delivers just one item to a customer's home[16].

Consumers, who must aggregate their online transactions into one basket, bear responsibility for reducing externalities from e-commerce, also retailers and last-mile carriers, who must consolidate as many customers as possible into a single distribution tour [17].

64% of users visit physical stores less than before, they still visit physical stores to supplement online purchases. The results therefore suggest that home delivery of groceries reduces personal travel but does not (yet) remove grocery travels altogether. Unsurprisingly, use of services for home delivery of food and groceries impacts travels associated with purchasing food and groceries more than other travel. The results show that respondents whose grocery travels have changed because of home delivery services are more sustainable in their travel mode choices than before: respondents travel less with car (both regular and electric), and more as pedestrians or with public transport. This indicates that home delivery of food and groceries does have a potential for facilitating more sustainable personal transport [18].

2.2 Operations on the supply chain:

operations and innovation on the supply chain plays an important role on reducing the environmental impact of the e-commerce, the researches that have been analyzed tries to introduce these modifications and innovations and see how they can change the environmental impacts of the e-commerce.
Most of researches shows that better improvements can be introduced whether by changing some of the operation parameters or by introducing new innovations that can make a difference as we will discuss below.

Delivery window is one of the parameters that plays an important role on reducing the environmental impacts, as the results of [19] shows that in the night conditions, less fuel would be consumed than in the daily conditions, i.e., that the CO_2 emission would be lower, for the same volume of requirements.

Another interesting results were the one reached by [20] as it shows that while one might assume extending delivery time windows would reduce both costs and emissions, results indicate that such relaxations result in little or no profit. Given high personnel costs, one would have also assumed that reducing the driving time would be beneficial. Instead, it appears that, especially in urban areas, reducing delivery time potentially contributes more significantly towards cost and emission reductions than reducing the actual driving time.

Another important parameter is the optimization methods (routes , vehicle assignation) much of the literature analysis uses algorithms to simulate the optimization of routes in urban freight distribution to achieve savings in journey times, in distances travelled, in waiting times, in energy consumption and, as a result, in CO_2 emissions. The general idea is that the use of optimized routes would not only entail a positive environmental impact, but also entail greater operational efficiency (economic impact) and greater operational sustainability (social impact) [21].
Matching vehicle type with delivery areas also can reduce co2 emissions as been proved by [22]

but using such method will be sensitive to the size and diversity of the vehicle fleet and the variability of road conditions across the delivery area.

The coming parameter is about collaboration the study [23] proved that a strong collaboration among carriers reduces the total travelled distances drastically about 35% of reduction of total km, which is directly translated into strong environmental gains.

Sometimes Monopoly plays as an effective parameter as been illustrated by [20] the benefits of enforcing a regional carrier monopoly in rural regions are considerable. Decreases in emissions, costs, required vehicles, and distance per parcel of up to 80% were observed, while the average route duration increased from 4h40 to almost 8 h, thereby highlighting the capability of operating far more efficient routes when under increasing density conditions.

innovations on the other hand have demonstrated their great potential to achieve environmental gains as many researches have emphasized, electric vehicles and bikes dominates the major part of these innovations as many predicts that they will be the future of the transportation on the coming future [21], [24]–[31] From the results of these studies, it is evidenced the existence of a trend towards more sustainable alternatives for the last mile of urban deliveries, with a shift on the vehicles' source of energy from fossil fuels to electric energy and the reduction of vehicle' sizes, specifically in the adoption of bicycles, tricycles and LDV. It was verified that using electric tricycles as an alternative for last mile postal distribution was able to promote the economic, environmental, and social aspects, maintaining the level of service.

Great benefits also were demonstrated by using pick points and smart lockers both for the operator and the municipality. Specifically, the average travel time of the freight vehicles reduced by 82.4% with analogous reduction in traffic delays. The total vehicle km reduced by 90.9% meaning that almost 80% of the fleet of vehicles is not necessary anymore. [7], [32]–[35].

A new trend of innovation was trying to introduce the robots and autonomous vehicles on executing the last mile delivery and see how the network would benefit from that [36][37], as these new autonomous vehicle types replace ICE delivery vans, the results show that they have a large potential to minimize energy consumption and CO2 emissions. In certain cases, self-driving delivery vehicles are more powerful than existing E-vans on the market. In terms of energy and

emissions efficiency there is no vehicle type that dominates across the board.
Another kind of innovation was the use of Crowd shipping [21], [38], [39]. While crowd shipping may provide some benefits in terms of reduced emissions and congestion by replacing dedicated freight trips, the effects of crowd shipping are unknown and depend on a variety of factors such as the mode of transportation used, supply and demand match, duration of detours, and potential induced demand..

From the above analysis its evidence that there is no much researches have been carried out to assess the environmental impacts of e-commerce in Italy, only few researches were found on this topic [7], [28], [39], [40] this research gab have made it convenient to carry such research. Another important research gab is the uncertainty about the consumers behaviors effects on the environmental impacts as has been discussed earlier that the impact of online shopping on the environment is not clear cut.

3 Methodology

Since the aim of this study is to assess the effect of the purchasing process on the environment, a simplified analytical model is proposed to evaluate the impacts of buying nine different products both online and offline, the buying process for the purposes of this study is then composed by the following three main steps Searching, Purchasing, and Returning.

For every product category the environmental impact is the sum of the environmental impacts related to the three main phases (search, purchase and return):

$$EI = S + P + R$$

EI is measured in g/CO2. For each phase the EI is calculated for both "online behavior" and "traditional behavior". As will be illustrated below

3.1 Purchase phase

For the "traditional behavior" the Purchasing phase EI is calculated as below

$$P_{traditional} = \frac{2d}{basket\ size * trip\ chaining\ rate} * emission\ factor$$

d is the distance traveled by customers to reach the shop.

The Distance, basket size and trip chaining are data taken from a survey's answers that been made on the next chapter, while the emission factors of the transport mode are taken from the literature.

$$P_{online} = \frac{D}{basket\ size * number\ of\ stops} * emission\ factor$$

In this case the distance D is the distance traveled by the last mile delivery vehicle. it is been calculated using the Daganzo's Model as will be explained below.

3.1.1 DISTANCE CALCULATION USING DAGANZO'S MODEL

To roughly estimate the distance traveled by home delivery vehicles, the analytical model reported in the paper: "The Distance Traveled to Visit N Points with a Maximum of C Stops per Vehicle: An Analytic Model and an Application" [41]. Turin city have been used as the reference context. It will be divided into rectangular zones in such a way to use the formula that gives the distance traveled per stop in a rectangle with sides L and l, with l <L.

$$d^* \cong \phi(\delta l^2)/\sqrt{\delta}$$

Delta is the density of points, so the number of points for area unit, which can be assumed constant for all areas. This formula only gives the distance traveled within the zone. Therefore, the line-haul distance (the distance to reach the boundary of the zone) have been added to it, as suggested by the model:

$$\begin{aligned} \tilde{d} &\cong (2/C)[\rho - (l'/2)] + d^*, && \text{if } \rho \geq l'/2, \\ &= d^*, && \text{otherwise,} \end{aligned}$$

Since the position of the depots are known and fixed, the long-haul distances will be estimated using google maps, while the distribution distance within the zone will be estimated with Daganzo's formula. In this way a more accurate estimation will be obtained. So, the input of this model are the position of depots and the number of the orders.

A specific logistic service provider will be considered as a reference (in the case study DHL will be considered the service provider, which has two depots, one in the north and one in the south of Torino), while for estimating the number of orders national statistics and data regarding e-commerce delivery and market shares of different LSP will be used [42], [43].

Once the number of daily orders in the city of Turin have been calculated, using My Maps the rectangular areas will be drawn on the map assuming that each area is served by a van. The number of rectangles in which Turin will be divided must be such as to obtain a reasonable number of deliveries per vehicle. Then by applying the formulas seen above, the distance traveled for each area will be calculated.

Figure 2 show a subdivision example. The rectangle's dimension is only indicative. The blue line is the real line-haul distance between the depot in the north (A) and the boundary of the zone (B).

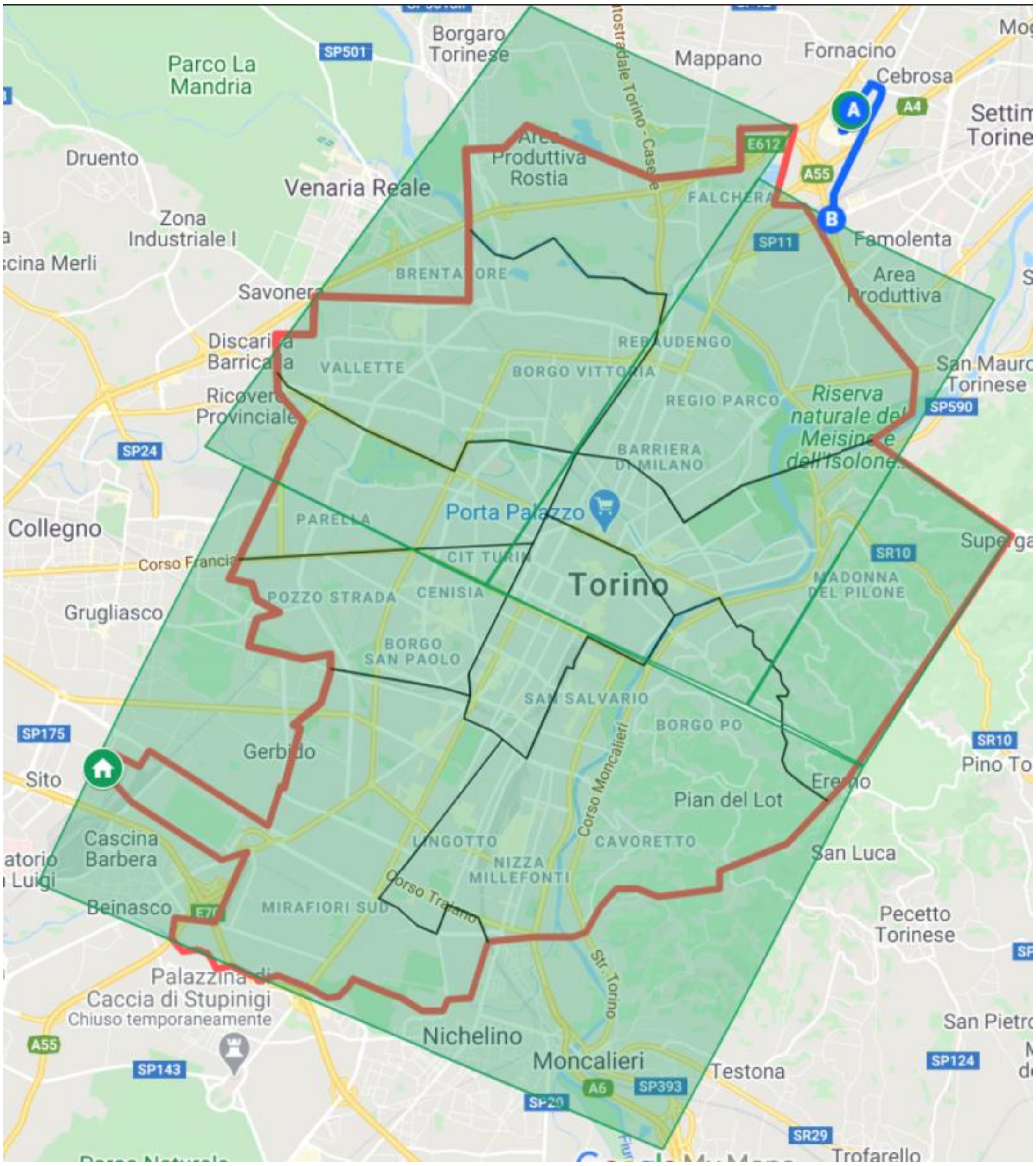

Figure 2 Daganzo Subdivision example

3.2 Search phase

For searching in store it's been assumed that the environmental impact will be equal to the purchasing phase for traditional behavior so accordingly the formula will be:

$$S_{traditional} = P_{traditional}\ (assumption)$$

And for online purchase will be:

$$S_{online} = time\ for\ searching\ on\ internet * emission\ factor$$

The time for searching on internet can be assumed, the emission factor is available on the literature.

3.3 Return phase

As for the search phase also for the return phase in store it's been assumed that the environmental impact will be equal to the purchasing phase for traditional behavior so accordingly the formula will be:

$$R_{traditional} = P_{traditional} = S_{traditional}\ (assumption)$$

And also for online returns:

$$R_{online} = P_{online}(assumption)$$

The return rate for the various product category are also available on the literature.

All the reasoning made so far applies if it's considered the purchase of a single product as a functional unit. So it will be obtained the environmental impact related to the purchase of one product However, since, from the survey, also the frequency of purchase of the products is known, the environmental impact of each category in a certain period of time (month, year) can be calculated.

4 Data Collection

logistics data were collected by means of a real-life data obtained from maps and data from the last mile local courier (DHL, Torino). As a result, we were able to learn more about the retailer's omnichannel success (e.g., online sales, last-mile options, and return policy) as well as logistics operations (i.e., fulfilment, internal transport, last mile transport). We set our system boundaries, accordingly, beginning at the retailer's centralized and integrated fulfillment center as the point of divergence and ending at the distribution center in the event of returns. We gathered consumers information through an online survey, which was followed by the survey being shared on different social media sites. The survey was created in Google Docs and distributed to 31,250 people. The survey was sent through an invitation link to the Google doc webpage on 25 January 2021.

Surveys are essential to understand and chart consumers' shopping journeys because secondary data sources (e.g., household surveys) only offer minimal information on consumer behavior.

To collect data, survey researchers have used a variety of methods and modes, including mail, phone, and e-mail. Web surveys have grown in popularity over the last decade as a new way to perform surveys. [44]. Web surveys have many advantages over conventional survey methods, including faster transmission, lower distribution costs, more design options, and less data entry time. Web surveys, on the other hand, often face unique obstacles, such as missing participants who do not have Internet access and getting low response rates, which can lead to biased outcomes [45]. In a survey, researchers gather data from specific groups of people using different data collection methods such as paper, phone, e-mail, WWW, or cell phone. As a result, survey researchers (surveyors), survey participants (surveyed), and survey tools (or called survey modes, e.g., mail, telephone, and WWW) are usually involved in the process of conducting a survey. using these three main elements the method of conducting a web survey can be visualized in Figure 3.

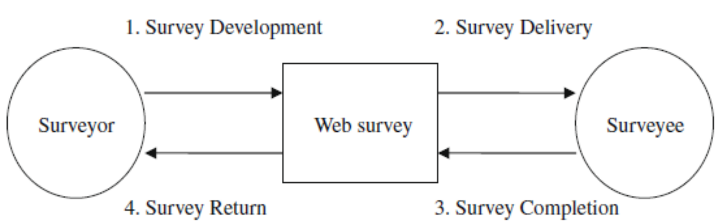

Figure 3 The web survey process

A web survey goes through four basic stages, as shown in Figure 3. The first step is to create a web survey. It refers to the process by which surveyors design and develop a web survey before uploading it to the survey website, similar to the process by which surveyors design and develop a mail survey before printing out the necessary hard copies. The distribution of the web survey is the next move. It refers to the process of surveyors developing a sampling system, contacting potential participants, and delivering the web survey to each surveyee's hands, similar to the process of mailing and distributing mail surveys to each potential respondent. The completion of the web survey is the third step. It refers to the method of web surveyees receiving the survey announcement, logging into the survey website, completing and submitting the survey, and logging out of the website, similar to how a mail survey is completed. The return of the web survey is the fourth phase. It refers to the method by which surveyors download collected web survey data from the website to research computers in specific formats for data analysis, which is like the method by which completed mail surveys are returned.

In general, a questionnaire will contain a number of sections that can collectively

lead a firm to a better understanding of the market, of customer needs, and of the way with which customers perceive competing products. Without going into the details, a good questionnaire design will then pay attention to the following:

The size: questioners should not be too large or too small instead a question should cover all relevant aspects and must lead to sufficiently large non-biased samples.

The structure: must be clear, divided in sections, easy and “fun” to reply to. Easy questions should be at first for kick starting the response, also repetition and jumps should be avoided, and it should follow the respondent’s logic not the analyst’s.

The questions: must be formulated in a clear and non-ambiguous way, Find the right tradeoff between using technical terms, explanatory notes, or accepting some degree of ambiguity, and must be “neutral”.

The responses: must be clearly appropriate to the statistical methods to be used, and should be easy to fill in.

The survey is divided into five sections: an overview, questions about various socio-demographics, questions about purchase frequency and related study practices, questions about related In-store buying habits, and questions about online purchasing habits. In the introduction, we briefly describe the nature and intent of our research and include an estimation of how long it will take to complete the survey (i.e., approximately ten minutes). questions about age, gender, household situation, education, income, and vehicle access are included on the Socio-demographic part. The final three sections discuss each step of the omnichannel route to purchase. We ask for the distance by using the total distance traveled during the purchase and question relevant travel information for each offline operation (if any, in the case of researching and testing). Time, mode of transportation, and trip chaining are among the requested travel information. We presumed equivalent distance per trip for each activity included in the chained trip. We assumed an average return rate of 8.89% for in-store transactions and 30% for online purchases for returned orders. [46].

In total, 263 surveys were completed, resulting in a response rate of 0.84%. Low response rates are common in scientific studies, especially when surveys are conducted online [47]. The length of the survey, respondent communications, compensation, and salience are all variables that have an effect on response rates, according to the literature [47]. Although most respondents completed our survey in less than ten minutes (on average eight minutes), some sections of the survey were difficult to complete (e.g., distance questions). Furthermore, customers only got the invitation once and were not compensated in any way. Nonetheless, it has been shown that the nonresponse rate is insufficient in predicting response bias on its own [48].
Emissions factors for the different transport modes were obtained from literature [49]–[51] as showed in Table 1.

Method of transport	gCO2/km (only urban road)	average passengers	gCO2/passenger/km
Metro			46.39
Tram			59.04
Bus	1267.35	30	42.245
Passenger car	279.35	1.3	215.12
car sharing	137.74	1.3	105.95
Ciclomotors	63.07	1	63.07
Motorcycle	109.48	1	109.48
Electric scooters	4.79	1	4.79
Bicycle	0	1	0
On foot	0	1	0

Table 1 Transport emission factors

Also, the emissions factors regarding the search phase of the online purchase were obtained from the literature [15], [52] for the different electronic devices used to carry out the search as showed in Table 2.

Device	Kwh for 30 minutes	gco2 emitted for kwh	gco2 for searching time
Smartphone	.006	435.76	2.61456
Tablet	.012	435.76	5.22912
Pc	.048	435.76	20.92

Table 2 Search emission factors

5 Implementations and Results

The Data from the survey were analyzed and the important data to carry out the analytical model were extruded , the average basket size , average traveled distance for traditional purchasing and the average trip chaining for each product category as shown on the coming tables

AVERAGE IN STORE BASKET SIZE	
Electronics	2.11
large home electric appliances	2.13
Small home electric appliances	2.12
Books	2.35
Groceries	10.93
Clothes and accessories	3.95
Toys and video games	2.48
Personal care and medicines	3.12
Household products	4.04

Table 3 AVERAGE IN STORE BASKET SIZE

AVERAGE ONLINE BASKET SIZE	
Electronics	2.14
large home electric appliances	2.05
Small home electric appliances	2.14
Books	2.49
Groceries	4.62
Clothes and accessories	3.45
Toys and video games	2.09
Personal care and medicines	2.86
Household products	2.75

Table 4 AVERAGE ONLINE BASKET SIZE

AVERAGE TRIP CHAINING RATE	
Electronics	3.20
large home electric appliances	2.92
Small home electric appliances	2.97
Books	2.57
Groceries	3.18
Clothes and accessories	2.74
Toys and video games	2.58
Personal care and medicines	2.83
Household products	3.09

Table 5 AVERAGE TRIP CHAINING RATE

AVERAGE STORE DISTANCE	[KM]
Electronics	5.15
large home electric appliances	6.17
Small home electric appliances	4.65
Books	4.13
Groceries	4.25
Clothes and accessories	4.52
Toys and video games	4.47
Personal care and medicines	2.29
Household products	2.15

Table 6 AVERAGE STORE DISTANCE

Also, the weights for Purchase mode, transport mode, search mode and online returns mode have been observed from the survey Data as shown on the coming tables

PURCHASE MODE WEIGHTS		
	In store	online
Electronics	0.39	0.61
large home electric appliances	0.68	0.32
Small home electric appliances	0.59	0.41
Books	0.43	0.57
Groceries	0.89	0.11
Clothes and accessories	0.62	0.38
Toys and video games	0.51	0.49
Personal care and medicines	0.8	0.2
Household products	0.82	0.18

Table 7 PURCHASE MODE WEIGHTS

TRANSPORT MODE WEIGHTS							
	Car	Car sharing	Motorcycle	Public transport	Bicycle	Scooter	On foot
Electronics	0.62	0.02	0.03	0.24	0.03	0.00	0.06
large home electric appliances	0.81	0.01	0.02	0.15	0.02	0.00	0.00
Small home electric appliances	0.62	0.01	0.03	0.23	0.03	0.00	0.08
Books	0.34	0.02	0.03	0.27	0.09	0.00	0.27
Groceries	0.42	0.01	0.02	0.11	0.06	0.00	0.38
Clothes and accessories	0.44	0.02	0.02	0.24	0.05	0.01	0.22
Toys and video games	0.57	0.03	0.04	0.22	0.04	0.01	0.09
Personal care and medicines	0.33	0.01	0.03	0.10	0.04	0.01	0.47
Household products	0.40	0.01	0.01	0.13	0.03	0.01	0.40

Table 8 TRANSPORT MODE WEIGHTS

SEARCH MODE WEIGHTS				
	Without	Friend or Parent	online	In store
Electronics	0.02	0.21	0.72	0.04
large home electric appliances	0.17	0.09	0.57	0.18
Small home electric appliances	0.11	0.08	0.62	0.19
Books	0.14	0.18	0.53	0.15
Groceries	0.47	0.14	0.10	0.29
Clothes and accessories	0.24	0.04	0.45	0.27
Toys and video games	0.46	0.06	0.41	0.07
Personal care and medicines	0.30	0.12	0.33	0.26
Household products	0.37	0.16	0.16	0.31

Table 9 SEARCH MODE WEIGHTS

ONLINE RETURN MODE WEIGHTS		
	In store	online
Electronics	0.14	0.86
large home electric appliances	0.33	0.67
Small home electric appliances	0.18	0.82
Books	0.2	0.8
Groceries	0.5	0.5
Clothes and accessories	0.25	0.75
Toys and video games	0.13	0.87
Personal care and medicines	0.35	0.65
Household products	0.28	0.72

Table 10 ONLINE RETURN MODE WEIGHTS

5.1 Implementation of Daganzo's Model

First step to implement the model was finding an appropriate number of stops inside the rectangular zone to do so data from the last mile local courier (DHL, Torino) , a time constraint of eight hours per day and a speed constraint of thirty kilometer per hour were used to estimate the number of stops for each tour the following result were obtained

DATA	VALUE
Parcels from province of Turin (2 months)	4000000
Turin's province inhabitants	2230946
Turin's inhabitants	851240
Parcels from Turin (2 months)	1526240
Parcels from Turin (daily)	25437
Share of national e-commerce parcels	0.75
National e-commerce parcels	19078
Share of national deferred e-commerce parcels	0.16
National deferred e-commerce parcels	3052
Share of national express e-commerce parcels	0.84
National express e-commerce parcels	16026
Market share of DHL in national express e-commerce parcels	0.02
DHL national express parcels	321
Share of international e-commerce parcels	0.25
International e-commerce parcels	6359
Share of international deferred e-commerce parcels	0.78
International deferred e-commerce parcels	4960
Market share of DHL in international deferred e-commerce parcels	0.06
DHL international deferred parcels	298
Share of international express e-commerce parcels	0.22
International express e-commerce parcels	1399
Market share of DHL in international express e-commerce parcels	0.28
DHL international express parcels	392
DHL daily parcels in Torino	1010

Table 11 DHL Daily Pracels Estimation for Torino

It was found that the DHL on average deliver around 1010 daily and by applying the time and speed constraints an average number of 72 stops were estimated for each zone, accordingly the city were divided into 14 zones (7 on the north and 7 on the south) as shown on Figure 4.

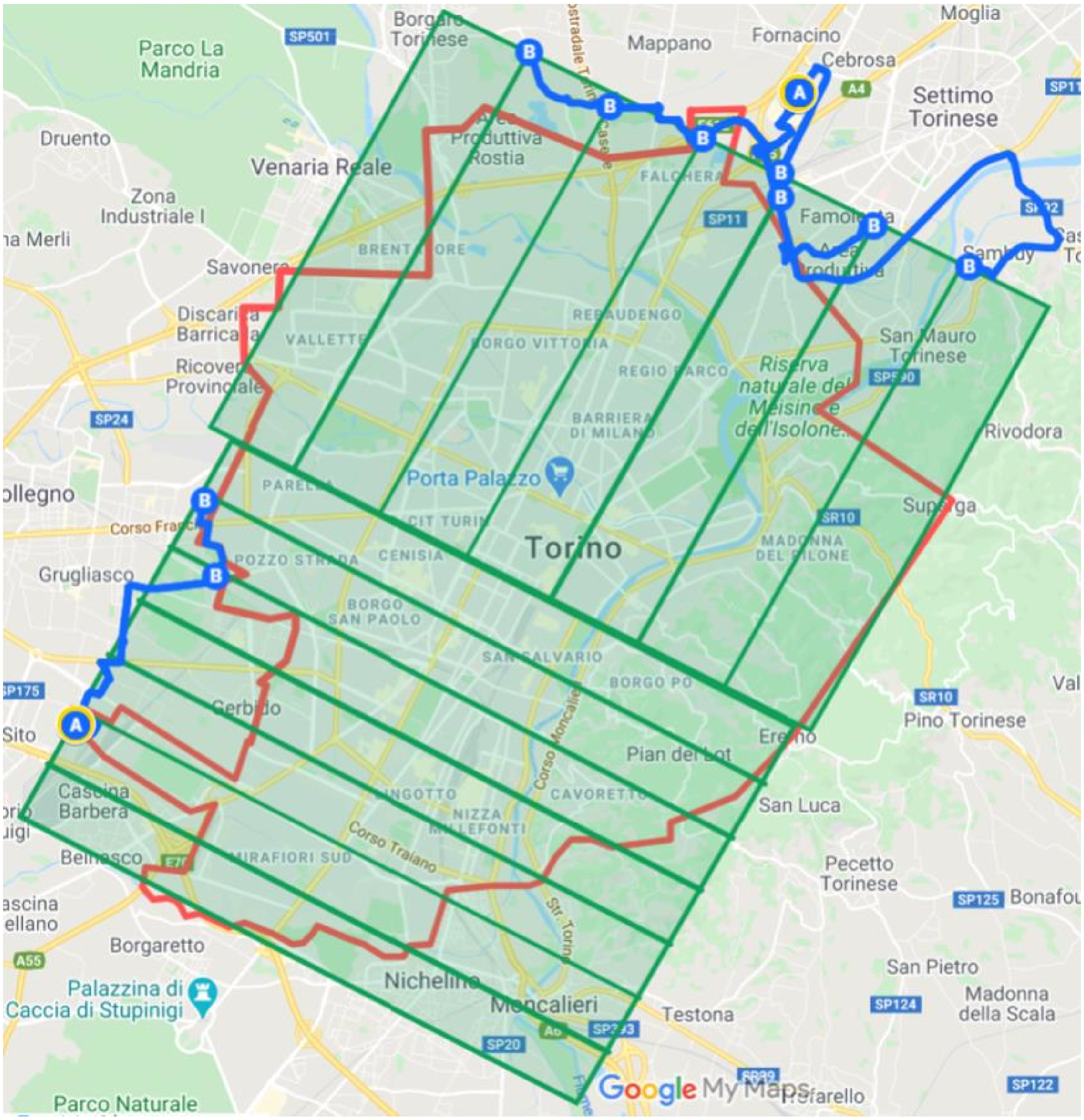

Figure 4 Torino city after Daganzo Subdivision

The second step was using the formula provided by Daganzo to calculate the average distance traveled on each zone on the below tables are presented the results for both depots.

North depot			
Number of points	N	505	
total area [km2]	A	100.00	
density of points [point/km2]	δ	5.05	
long side [km]	L	8.48	
short side [km]	l	1.69	
average vehicle speed [km/h]	v	30	
working time [h]	w	7	
time for stops [min]	s	5	
number of vehicles	H	7	
number of stops per vehicle	C	72	
δ*l^2	x	14.34	
phi of x	ϕ(x)	0.90	
distance per point	d	0.401	
tour total distance	D	28.891	
tour total time	T	6.97	
	long haul distance	total distance	total distance per point
region 1	7	42.84	0.59
region 2	5	38.84	0.54
region 3	3	35.24	0.48
region 4	4	36.84	0.51
region 5	4	36.84	0.51
region 6	6	40.84	0.57
region 7	13	54.84	0.76

Table 12 Average distance traveled on each zone for north Torino depot

South depot			
Number of points	N	505	
total area [km2]	A	84.7	
density of points [point/km2]	δ	5.96	
long side [km]	L	11	
short side [km]	l	1.10	
average vehicle speed [km/h]	v	30	
working time [h]	w	7	
time for stops [min]	s	5	
number of vehicles	H	7	
number of stops per vehicle	C	72	
δ*l^2	x	7.21	
phi of x	ϕ(x)	0.98	
distance per point	d	0.403	
tour total distance	D	29.065	
tour total time	T	6.98	
	long haul distance	total distance	total distance per point
region 1	8	45.07	0.62
region 2	6	41.07	0.57
region 3	5	39.07	0.54
region 4	4	37.07	0.51
region 5	3	35.07	0.49
region 6	0	29.07	0.40
region 7	4	37.07	0.51

Table 13 Average distance traveled on each zone for north Torino depot

An average total distance per point were calculated in the total area and the result was .544 km/point. Also the average distance per point inside the zone were found to be .4 Km/point.
it was then necessary to calculate the emissions for each point, to do so the Arvidsson formula [53] below were used to calculate the fuel consumption for the previous model.

$$\text{Urban fuel consumption} = \sum_{ij}^{n} 0.057767 \times d_{ij}(w + l_{ij})^{0.6672}$$

Then by using emissions factor from the literature the fuel consumption were converted into Co2 emissions, for each delivery it has been found that on average a 207.55 gCo2 is emitted.

At this point all the input data needed to calculate the Environmental impacts were obtained, now all is left is just calculating the EI for the three phases for both online and traditional purchasing , finally these impacts were calculated for all the products category and below is the results demonstrated on the tables for each product category.

electronics					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
96.92	228.26	9.94	228.26	29.07	20.32
148.14		16.90		24.91	
189.95 g co2/purchase					

Table 14 Baseline scenario results for Electronics category

large home electric appliances					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
101.20	364.07	9.94	364.07	30.36	32.40
279.95		70.19		31.96	
382.11 g co2/purchase					

Table 15 Baseline scenario results for large home electric appliances category

Small home electric appliances					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
96.93	220.31	9.94	220.31	29.08	19.61
169.72		48.32		22.79	
240.83 g co2/purchase					

Table 16 Baseline scenario results for small home electric appliances category

Books					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
83.29	122.69	9.94	122.69	24.99	10.92
100.23		23.56		17.33	
141.12 g co2/purchase					

Table 17 Baseline scenario results for books category

Groceries					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
44.95	11.57	9.94	11.57	13.48	1.03
15.24		4.35		1.71	
21.30 g co2/purchase					

Table 18 Baseline scenario results for groceries category

Clothes and accessories					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
60.24	91.73	9.94	91.73	18.07	8.16
79.76		29.16		10.99	
119.91 g co2/purchase					

Table 19 Baseline scenario results for clothes and accessories category

Toys and video games					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
99.39	194.18	9.94	194.18	29.82	17.28
147.73		17.86		22.63	
188.22 g co2/purchase					

Table 20 Baseline scenario results for toys and video games category

Personal care and medicines					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
72.46	41.51	9.94	41.51	21.74	3.69
47.70		13.84		6.04	
67.58 g co2/purchase					

Table 21 Baseline scenario results for personal care and medicines category

Household products					
Purchase		Search		Return	
Online	In store	Online	In store	Online	In store
75.47	33.14	9.94	33.14	22.64	2.95
40.76		11.89		5.50	
58.15 g co2/purchase					

Table 22 Baseline scenario results for household products category

These results will then be used as a base scenario, other scenarios will then be developed by changing some of the model parameters to carry the sensitivity analysis and to find savings and improvements opportunities on the current practices. Below is demonstrated each scenario and the outcome from it, in total five scenarios were developed as will be showed.

5.2 Sensitivity analysis

Five scenarios were developed in order to test the previous result and to find solutions to decrease the amount of CO2 emitted during purchasing an item, the first scenario was to electrify the transports mode and assess the potential savings that can be obtained, similar to the first scenario the second scenario was developed by electrifying the vehicles used on the delivery process, while the third scenario was developed by increasing the demand on the online purchasing and assess the potential increase on the CO2, the last two scenarios were built based on the road traffic two different situations were considered (congestion and decongestion) and the potential savings and increase on emissions were assessed below is explained each scenario in details .

5.2.1 Electronification of consumer's transport mode scenario

On this scenario have been developed assuming that all the transports modes will be using electricity instead of the traditional fossil fuels mode, in order to do so new emissions factors were obtained from the literature and by using the Italian electric mix emission factor (435.76 g CO2/KWH) as shown by the below table.

Transport mode	kwh / km	g co2 / kwh	g co2 / km
Bus	1.000	435.760	435.760
Car sharing	0.110		47.934
Ciclomotors	0.033		14.380
passenger car	0.160		69.722

Table 23 Emissions factors for Electric transport mode

All the steps for the base scenario is then applied again to obtain the final result which was an impressive result as in average a 48% of savings of CO2 emissions per item purchased were obtained as shown on the below table

Product Category	Average emissions for a single product purchase [g CO2]	Average emissions for a single product purchase (BASELINE)	DELTA CO2 EMISSIONS g co2/purchase	PERCENTUAL VARIATION
Electronics	114.32	189.95	75.63	-40%
large home electric appliances	137.72	382.11	244.39	-64%
Small home electric appliances	111.23	240.83	129.60	-54%
Books	90.76	141.12	50.36	-36%
Groceries	10.93	21.30	10.38	-49%
Clothes and accessories	60.49	119.91	59.42	-50%
Toys and video games	103.12	188.22	85.10	-45%
Personal care and medicines	34.80	67.58	32.78	-49%
Household products	29.83	58.15	28.32	-49%
Average	77.02	156.58	79.55	-48%

Table 24 Results of the electrification of transports mode scenario

5.2.2 Electric delivery van scenario

This scenario have been developed by assuming that the courier (DHL in our case) uses an electric van to carry out the last mile delivery instead of sing the traditional fossil fuel van that have been used on the base scenario, a new emission factor for the van were obtained from the literature, as we see in this case since the van is electric the Arvidsson model that were used on the base scenario cannot be used to obtain the precise emission per delivery, so instead we assumed that the emission will be equal to the van emission factor multiplied by the distance per delivery that were obtained from Dganzo`s model as shown on the below table an average of 68.92 g of co2 will be emitted for a single delivery.

electric consumption [wh/km]	electric consumption [kwh/km]	consumption per delivery [kwh]	g CO2 / kwh	gCO2 per delivery
290.56	0.29056	0.158158683	435.76	68.92

Table 25 Emission factor of an electric van

Then the results were obtained by following the same steps of the base scenario, as the first scenario the second scenario also shows some savings on the emitted co2 per purchase but this time the savings on average is just 18% as shown on the below table .

Product Category	Average emissions for a single product purchase [g CO2]	Average emissions for a single product purchase (BASELINE)	DELTA CO2 EMISSIONS g co2/purchase	PERCENTUAL VARIATION
Electronics	140.28	189.95	49.68	-26%
large home electric appliances	356.13	382.11	25.98	-7%
Small home electric appliances	207.76	240.83	33.08	-14%
Books	101.80	141.12	39.32	-28%
Groceries	17.51	21.30	3.80	-18%
Clothes and accessories	101.18	119.91	18.73	-16%
Toys and video games	147.20	188.22	41.02	-22%
Personal care and medicines	56.01	67.58	11.57	-17%
Household products	47.12	58.15	11.03	-19%
Average	130.55	156.58	26.02	-18%

Table 26 Results of the Electric van scenario

5.2.3 E-commerce growth scenario

This scenario was developed assuming an increase on the e-commerce purchasing by 20% for the city of Torino according to this increase It was found that the DHL on average will deliver around 1212 daily and by applying the same time and speed constraints an average number of 67 stops were estimated for each zone, accordingly the city were divided into 18 zones (9 on the north and 9 on the south) , on this scenario since there is an increase on the number of orders it was necessary to increase the number of vehicles to maintain the level of service, after applying the model it was found that the average distance per order have increased also the average emission per delivery have increased so based on all the above it was reasonable to have an increase on the average emission for single product purchase for all the different product categories with respect to the baseline as shown on the below table.

Product Category	Average emissions for a single product purchase [g CO2]	Average emissions for a single product purchase (BASELINE)	DELTA CO2 EMISSIONS g co2/purchase	PERCENTUAL VARIATION
Electronics	198.17	189.95	-8.22	4%
large home electric appliances	386.40	382.11	-4.30	1%
Small home electric appliances	246.30	240.83	-5.47	2%
Books	147.63	141.12	-6.50	5%
Groceries	21.93	21.30	-0.63	3%
Clothes and accessories	123.01	119.91	-3.10	3%
Toys and video games	195.00	188.22	-6.78	4%
Personal care and medicines	69.49	67.58	-1.91	3%
Household products	59.98	58.15	-1.82	3%
Average	160.88	156.58	-4.30	3%

Table 27 Results of the E-commerce growth scenario

5.2.4 Traffic congestion scenario

This scenario was built assuming a traffic congestion on the city, the initial number of orders was taken as in the base scenario but in this case the speed of the van will be lower than the case of the base line and also the time per stop will be higher, resulting on the truck not delivering all the orders that it supposed to deliver in the given time frame, in this case the average total distance per delivery is higher than the baseline as been calculated by Daganzo's model , which resulted in a higher CO_2 emission per delivery on the Arvidsson model, all these factors resulted in an increase of 2% in the average emission for single product purchase with respect to the baseline as showed on the below table.

Product Category	Average emissions for a single product purchase [g CO2]	Average emissions for a single product purchase (BASELINE)	DELTA CO2 EMISSIONS g co2/purchase	PERCENTUAL VARIATION
Electronics	196.28	189.95	-6.33	3%
large home electric appliances	385.42	382.11	-3.31	1%
Small home electric appliances	245.05	240.83	-4.21	2%
Books	146.13	141.12	-5.01	4%
Groceries	21.79	21.30	-0.48	2%
Clothes and accessories	122.29	119.91	-2.39	2%
Toys and video games	193.44	188.22	-5.22	3%
Personal care and medicines	69.05	67.58	-1.47	2%
Household products	59.56	58.15	-1.41	2%
Average	159.89	156.58	-3.31	2%

Table 28 Results of the Traffic congestion scenario

5.2.5 Traffic decongestion scenario

This scenario is the contrary of the previous scenario in this case scenario was built assuming a traffic decongestion on the city, the initial number of orders per tour was taken higher than in the base scenario also in this case the speed of the van will be higher than the case of the base line and the time per stop will be lower, resulting on the truck delivering orders higher than the orders delivered in the baseline scenario, so less vehicles were needed to maintain the same level of service as per the baseline only (10 vehicles will be used instead of 14) in this case the average total distance per delivery is lower than the baseline as been calculated by Daganzo's model , which resulted in a lower CO2 emission per delivery on the Arvidsson model, all these factors resulted in a decrease of 4% in the average emission for single product purchase with respect to the baseline as showed on the next table

Product Category	Average emissions for a single product purchase [g CO2]	Average emissions for a single product purchase (BASELINE)	DELTA CO2 EMISSIONS g co2/purchase	PERCENTUAL VARIATION
Electronics	179.19	189.95	10.76	-6%
large home electric appliances	376.48	382.11	5.63	-1%
Small home electric appliances	233.67	240.83	7.16	-3%
Books	132.61	141.12	8.52	-6%
Groceries	20.48	21.30	0.82	-4%
Clothes and accessories	115.85	119.91	4.06	-3%
Toys and video games	179.33	188.22	8.88	-5%
Personal care and medicines	65.07	67.58	2.51	-4%
Household products	55.76	58.15	2.39	-4%
Average	150.94	156.58	5.64	-4%

Table 29 Results of Traffic decongestion scenario

6 Conclusions

The goal of this thesis was to assess the environmental impacts of both traditional shopping and e-commerce and to assess the impact of the consumer behaviors on it for the city of Torino (Italy) for different product categories in total 9 categories were taken into consideration, the consumer travel behavior has been regularly omitted by the previous research for the reason of failed deliveries, product returns and trip chaining. This research takes into account these factors, as well as the fact that online ordering does not fully eradicate customer shopping trips.

Our findings show that the essence of a customer's travel behavior, e-fulfillment method selection, and basket size are all important factors in deciding sustainability of shopping, Encouraging customers to order more goods per delivery (and therefore reduce the amount of trips/delivery) provides a major opportunity to reduce the environmental impacts of retailing.

our results show the difference between the emissions for online and traditional shopping for the 9 different product categories these results could be used to encourage the consumers to change some of their shopping behaviors in order to improve the current situation regarding the environmental impacts of retailing.

finally our sensitivity analysis shows some solutions to reduce the environmental impacts of retailing as been proved by the different scenarios as we can reach a savings up to 48% on the case of electrification of the transports modes that consumers use, also the sensitivity analysis shows some situations where the emissions increase as the case of E-commerce growth and the traffic congestion these situations can be mitigated by the governance by forcing some policies and by improving the roads infrastructure and traffic.

6.1 Limitations and future studies

Despite that the results are robust and consistent with the scientific literature, the study conducted in this thesis also presents a series of limitations mainly to the assumptions underlying the analysis model as will be illustrated by the following points:

- The distance traveled by the vehicles used for home deliveries, which represent one of the main discriminators of the environmental impact, was not detected empirically but was estimated through analytical calculations. There subdivision of the urban area into rectangular areas of equal size, used by the analytical model is not 100% realistic; this method of estimation in fact assumes that the final customers are equally distributed among the various city areas (density is constant) and also neglects the actual conformation of the road network.
- The formula used to calculate the fuel consumption of vehicles does not take into account the size and weight of each package because, for simplicity, it was decided to assume that the mass unloaded from the van is the same for each delivery.
- The analytical model developed does not take into account all possible behaviors assumable by consumers and all purchase and delivery options available on the market, as adopting an analytical / quantitative approach is very complex and it's hard to build a model that considers all possible existing combinations, given the enormous variability.
- The final results of the study cannot be generalized, but their significance is limited only to the specific geographical context of the case study, i.e. the city of Turin, and the demographic characteristics of the sample from which the starting data. It is possible, indeed very likely, that the application of the same analysis model to a case study located in a different geographical area or that consider a sample of the population with different characteristics, generate different results.

For the future studies it will be convenient to build a model that takes into consideration all the E-fulfillment channels including the new innovations that are emerging these days to try to understand better how the different consumers behavior can affect the environment, it will also be convenient to build more scenarios by changing other parameters than the ones that have been used to find more solutions to mitigate the current situation, its also reasonable to carry out the study to another Italian city in order to see the difference that the demographic characteristics can make in order to improve the environmental aspects in the whole country.

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