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Study of customer experience of sustainable mobility services with electric bicycles - the case of the U-Bike project

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Master Thesis

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A mia moglie, alla mia famiglia e in particolare a mio nonno Antonio Paolelli (in memoriam), i cui ricordi della sua presenza in questo mondo sono quotidiani e il suo entusiasmo per la vita mi ispira ogni giorno.

Abstract

Faced with threats of global temperature rise due to greenhouse gas emissions from human activities, the search for solutions in the transport sector has motivated several research fields, industry and governments to find alternatives to fossil fuel vehicles. In this scenario, the electric bike appears as an attractive option.

Based on a program aimed at encouraging the adoption of sustainable mobility habits in academic communities through the rental of electric bicycles, we conducted an exploratory study adopting a qualitative approach with the purpose of making a thorough investigation into the personal perception of the contextual factors that act as barriers or drivers for users. The main goal was to identify behavioral aspects and their impacts on physical and psychological well-being; situational aspects, such as the available infrastructure for bicycle commuting, the influence of the natural environment on frequency, as well as the convergences between them. We also investigate aspects that are inherent to the project and point out improvements.

In total, 16 in-depth interviews were conducted which were recorded, transcribed and then analyzed using NVivo12. The result show that regarding to Situational Aspects, dedicated cycling infrastructure has a major impact on personal perception of safety while commuting and parking, as well as sharing streets with other vehicles influence the routes of bicycle users. Regarding behavioral aspects, bicycle adoption has a positive impact on physical and psychological well-being, especially reducing stress and anxiety through its continued use, improving mood in the workplace. The electric bike has a fundamental role in being able to explore user segments that usually would not adopt the conventional bicycle, surpassing distance, hilliness or effort requirements issues, as well as mitigating the need for showers and lockers. Electric assistance proved to be the main driver to use this travel mode.

KEYWORDS: Urban Mobility, Sustainability, Transformative Service Research, Electric bikes, Cycling.

Resumo

Diante das ameaças do aumento da temperatura global devido às emissões de gases de efeito estufa provenientes de atividades humanas, a busca de soluções no setor de transportes tem motivado vários campos de pesquisa, indústria e governos a encontrar alternativas aos veículos de combustíveis fósseis. Nesse cenário, a bicicleta elétrica aparece como uma opção atraente.

Com base em um programa destinado a encorajar a adoção de hábitos de mobilidade sustentável nas comunidades acadêmicas por meio do aluguel de bicicletas elétricas, realizamos um estudo exploratório adotando a pesquisa qualitativa com o objetivo de fazer uma investigação aprofundada sobre a percepção pessoal dos fatores contextuais que atuam como barreiras ou motrizes para os usuários. O objetivo principal era identificar aspectos comportamentais e seus impactos no bem-estar físico e psicológico; aspectos situacionais, como a infraestrutura disponível para o deslocamento de bicicleta, a influência do ambiente natural na frequência e as vínculos entre esses aspectos. Também investigamos aspectos inerentes ao projeto e apontamos melhorias.

No total, foram realizadas 16 entrevistas em profundidade que foram gravadas, transcritas e depois analisadas com o software NVivo12. O resultado mostra que, em relação aos Aspectos Situacionais, a infraestrutura de ciclismo dedicada tem um grande impacto na percepção pessoal de segurança durante o deslocamento e o estacionamento, além de compartilhar ruas com outros veículos, influenciando as rotas dos usuários de bicicleta. Em relação aos aspectos comportamentais, a adoção da bicicleta tem um impacto positivo no bem-estar físico e psicológico, principalmente reduzindo o estresse e a ansiedade por meio do uso contínuo, melhorando o humor no local de trabalho. A bicicleta elétrica tem um papel fundamental na capacidade de explorar segmentos de usuários que normalmente não adotariam a bicicleta convencional, superando os problemas de distância, inclinação ou esforço, além de atenuar a necessidade de chuveiros e armários. A assistência elétrica provou ser a principal força motriz no uso das bicicletas elétricas.

PALAVRAS-CHAVE: Mobilidade urbana, Sustentabilidade, serviços transformadores, Bicicletas elétricas, Ciclismo.

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List of abbreviations

GHG – Greenhouse gas emissions

CO_2 – Carbon Dioxide

INE – Instituto Nacional de Estatística (Statistics Portugal)

IMT – Instituto da Mobilidade e dos Transportes (Portugal)

IPCC – Intergovernmental Panel on Climate Change

GT – Grounded Theory

1.5 DS – 1.5 Degree Celsius Scenario

NGO – Non-governmental Organization

CDUP-UP – Centro Desporto Da Universidade Do Porto.

ERASMUS – European Region Action Scheme for the Mobility of University Students

CONEBI – Confederation of The European Bicycle Industry

MTOE – Megatoe is one million ton of oil equivalent (toe), approximately 42 million gigajoules of energy by burning crude oil.

WCED – World Commission on Environment and Development

E-Bike – Electric bicycle

GPS – Global Positioning System

EU-28 – 28 member states of European Union

EU – European Union

TSR – Transformative Research Service

1 Introduction

This section frames the dissertation subject, and aims to better understand the landscape of public, private and non-motorized transport in the urban context, and how the bicycle as active transport is positioned in commuting phenomena. It will also address the role of active transport as part of the overall strategy in the greenhouse gas reduction and CO_2 emission guidelines and what their relevance in that context. The current scenario about transportation in urban areas such as Porto, Lisbon and some of the main metropolitan areas of the world, and their experiences in policies to promote active transport will also be discussed.

1.1 Transport Sector, Greenhouse gas emissions and the Environment Threat

The next three decades will be decisive for the global community. Our consumption habits, how we use energy and transform natural resources, the use of technology by industry and the service sector must undergo profound changes to avoid escalating gas emissions and thus increasing temperatures by more than 1.5 degree Celsius (Peet et al., 2019). This is perhaps one of the greatest challenges of our age.

In this context, the transport sector is of great importance and should play an active role in the set of changes that will be needed in the coming decades, with profound transformations in all segments: private transport, public transport and active transport, as this sector accounts for nearly a quarter of all global emissions, 14% of global greenhouse gas (GHG) direct emissions, and it is the third largest global emitter after power sector and other industrial combustion (Peet et al., 2019). Still within the transport sector, light duty vehicles account for about 75% of passenger transport CO_2 emissions, while public transport generates about 7% of emissions in the sector, despite serving one fifth of passenger transport on a global scale. Transport has the fastest growth rate of gas emissions among all other sectors (Peet et al., 2019), having grown by 29% between the years 2000 and 2016.

It is, therefore, fundamental to adopt mitigation and shift actions in the way urban population commutes because there is a probability that the emissions from the transportation sector will double by the year 2050 (Peet et al., 2019).

In the Figure 1, we have the graphical representation of the global percentage of greenhouse gas emissions in the transport sector, and in the Figure 2 the percentage relative to each mode of transportation in the total impact of the respective sector.

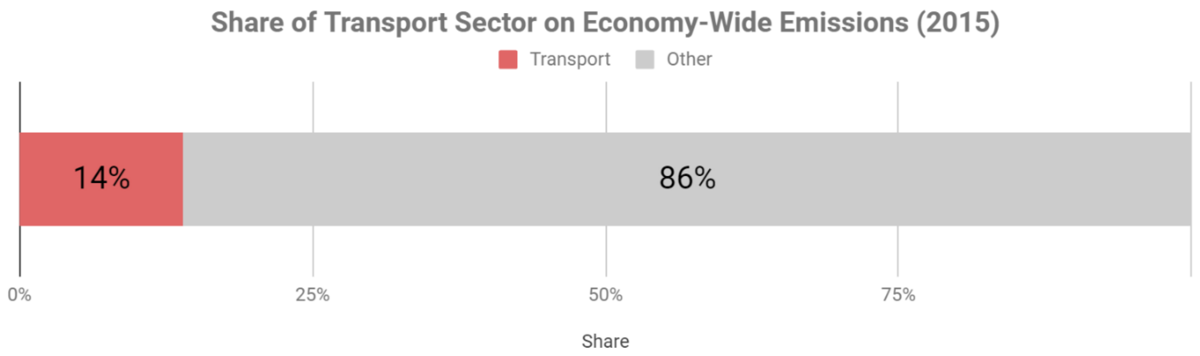

Figure 1 - Share of Transport Sector on Economy-Wide Emission (Source: Peet et al. 2019)

In Portugal, transport is the sector whose activity consumed the largest share of total primary energy (37.2% in 2017), followed by Industry (28.8%), domestic consumption (16.4%), services (12.2% %), Agriculture & Fisheries (2.9%) and Public Works (2.5%).

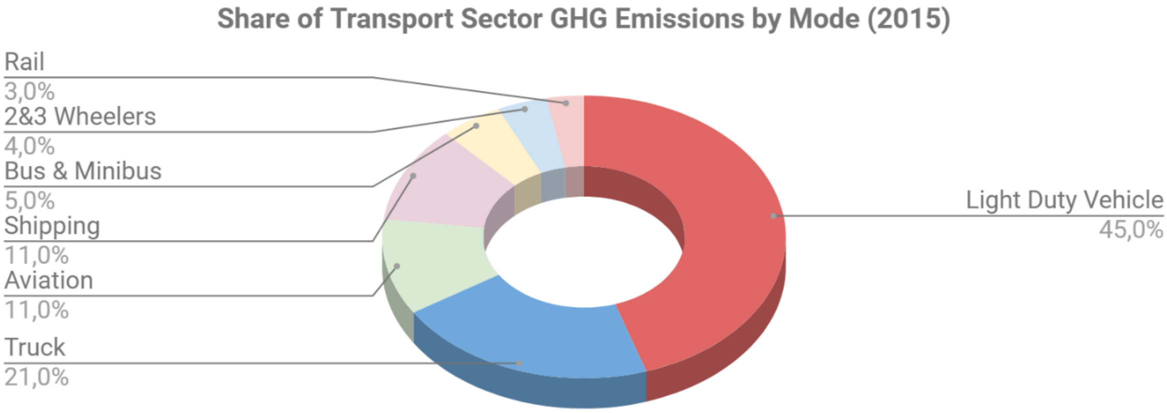

Figure 2 - Share of Transport Sector Greenhouse Gas Emissions by Mode (Source: Peet et al. 2019)

Dependency of petroleum-based fuels is high. In 2016, 75.5% of the final consumption of oil occurred in the transport sector. In 2017, 5.5 million tons of oil equivalent (Mtoe) were consumed, rising 1.2% than in the previous year. Diesel, the main fuel consumed accounted for 79.0%, increased by 2.3% in 2017, and gasoline which decreased by 2.9%, according to Portuguese Environment Agency (2019).

Despite the dependence on oil, efforts to reduce these numbers were satisfactory until 2010, when there was a sharp drop in the use of renewable energy. Even so, in 2017, the transport sector achieved renewable energy consumption of 7.93% of total energy, exceeding the EU-28 average (7.56%). Portuguese Environment Agency's (2019) report provides further data. Still in Portugal, the transport sector accounted for 25% of the total GHG emissions in 2016, while in the EU-28 the same sector accounted for 22% in 2016.

That said, it is clear that 1.5 Degrees Celsius Scenario (1.5DS) should include low-carbon and transports as core solutions for climate threat and to achieve the Paris agreement’s 1.5 DS-goal, reducing the petroleum-based vehicle’s share in transport sector, avoiding disastrous consequences for the environment in the middle of the 21st century.

1.2 Urban mobility Scenario in Portugal and Metropolitan Areas

At the local level, Portugal is also in an adverse position in terms of bicycle commuting rates accounting for only 1% of total trips, behind the European average of 8% (European Commission, 2014) and the world average of 6% (Mason, Fulton, & McDonald, 2015). In population terms, the two largest Portuguese cities show the predominance of the car as a means of transport in relation to the total number of trips: Porto with 67.6% and Lisbon 58.9%, with rates of 1.56 and 1.60 occupants per car respectively, followed by public transport, with 11.1% (Porto) and 15.8% (Lisbon), while non-motorized means of transportation, more specifically bicycle, accounted for only 0.4% in Porto and 0.5% in Lisbon of overall trip rates (Instituto Nacional de Estatística, 2018). This ratios are considered low compared to other metropolitan areas of the world, such as Amsterdam–NEL (27%), Portland-USA (3.5%), Rio de Janeiro-BRA (3.2%), Melbourne-AUS (2%) and Montreal-CAN (1.3%), as reported by Pucher and Buehler (2008).

In Table 1, there are some facts about mobility in the metropolitan area of Porto and Lisbon (Instituto Nacional de Estatística, 2018). In addition to the low share of cycling mode shown in both cities, there are also a 58% percentage in Porto and 61% in Lisbon of people traveling for work, shopping and study purposes. We have some valuable travel information, such as average

Table 1 - Urban mobility indicators of Porto and Lisbon Metropolitan Areas (Source: Instituto Nacional de Estatística 2018)

Urban Mobility Indicators	Metropolitan Area of Porto	Metropolitan Area of Lisbon
Mobile Population Ratios	78.9%	80.4%
How we move		
Travel mode rates		
Automobile	67.6%	58.9%
Ocuppancy Rate	1.56	1.60
Public Transport	11.1%	15.8%
Non-motorized (Walking, Bicycle)	18.9%	23.5%
Bicycle	0.4%	0.5%
How often		
overall trips per day	3.4 millions	5.4 millions
within the metropolitan area	71.0%	65.4%
day trips per person	2.72	2.60
for work reason	30.3%	30.8%
for shopping reason	18.5%	19.8%
for escorting someone	15.7%	15.2%
for studying	9.6%	10.5%
for leasure purposes	10.8%	11.2%
for personal purposes	14.6%	11.9%
for others	0.4%	0.7%
How long		
commuting time per day (minutes)	66.8	72.5
commuting time per trip (minutes)	22.0	24.5
within Municipalities (minutes)	23.6	26.0
for work reasons (minutes)	23.8	29.5
for study reasons (minutes)	22.6	23.6
How far we go		
avarage (km)	10.6	11.0
for work reasons (km)	13.4	14.8

travel distance of 10.6 km in Porto and 11 km in Lisbon, and for work purposes, distance of 13.4 km in Porto and 14.8 km in Lisbon. In other words, achievable and acceptable standards for conventional and electric bicycles, considering that this is an average, therefore, perfectly absorbable by this demand, especially routes between 1.5 km and 10 km, as we will can see in later chapters of this work. There is a great opportunity to convert the high rates of car use as a means of transport for these purposes, being partially absorbed by bicycle commuting.

This scenario reveals the size of the challenge of understanding the pattern of population commuting in the main urban centers, whose goal is to redesign new services and make travel more efficient, sustainable and more attractive.

1.3 Electric Bicycle

Among low-carbon transport options, non-motorized transport and electric vehicles, the electric bicycles are already appearing in some cities around the world as an important zero-emission transport mode. In 2015, over 40 million electric bikes were marketed worldwide, led by China, Netherlands and Germany. Among the many advantages, the E-Bike maintains the speed with less effort required to cycle compared to a conventional bike, being a great attraction for its use, besides the unquestionable differences of emission compared to the car when traveling the same distance. Other advantages, such as increased distance over conventional bikes, increased frequency of use, health and wellness benefits, are also closely linked to e-bikes. There are also safety issues that arise, while more research on this subject will come as the electric bicycle is taking up space in cities around the world, it is still in its infancy. It is necessary to contribute to the specialized literature so that governments, policymakers and industry can better understand this phenomenon, evolve and make this category of transportation more attractive to the public.

1.4 U-Bike Portugal (Project Background) and the University of Porto.

U-Bike Portugal is a national project that is part of the partnership program with the European Commission, carried out by the European Structural and Investment Funds, to foster and promote smart, sustainable and inclusive growth in Portugal between 2014 and 2020, within the “EUROPE 2020 STRATEGY”, in which the country will receive 25 billion euros by 2020 (IMT 2018). Within these resources, the Operational Program for Sustainability and Efficiency in the Use of Resources has approximately 6 million Euros to support the implementation of energy efficiency measures and the rationalization of consumption in transport, infrastructure and the promotion of clean urban transport (including equipment), electric and conventional bicycles, including the U-Bike Portugal Project (IMT, 2018b).

As a target, the project provides for the creation of regular habits of use of bicycles as a means of urban transportation through long-term rents (from 3 months to 1 year period), where a total of 3,234 bicycles will be distributed, 2,096 electric and 1,138 conventional, based on norms of each university institution (IMT, 2018b). The project is expected to achieve about 2.4 million kilometers of bicycle travel among 26 cities, reducing 505 tons of carbon dioxide in the atmosphere (IMT, 2018b).

For the University of Porto, the amount for investment in this project is € 614,436.04 providing 220 electric bicycles and 45 conventional bicycles, totaling 265 (IMT, 2018b). The first bicycle delivery session took place on November 9, 2018 at the Rectory of the University of Porto.

U-Bike in University of Porto, namely as “Academia a Pedalar”, or Cycling Academy, aims to promote cycling mobility for the academic community. Students, professors, scholarship holders, researchers and employees are eligible to join the program that aims to serve the entire academic community and the various campuses throughout the city of Porto (IMT, 2018b).

The distribution of bicycles will meet the following guidelines following the occupational division of the University: 70% for students, 10% for teachers and researchers, 10% for non-teaching staff and 10% for scholarship students (IMT, 2018b), whose selection is given by proving the link with the institution and its respective faculty by order of registration of the requests received (IMT, 2018b), through the online registration form of the program on the CDUP-UP website (CDUP-UP, 2018).

The selection criteria is the following: availability of bicycles at the University of Porto's Pole where the applicant is linked to; commitment by the user to change the way of commuting to the U. Porto, choosing the bicycle as a means of transportation, using it periodically, with a daily average of 10 km in the chosen period of contract (from 3 months to 1 year); Authorize the monitoring of the bicycle via GPS by consent term; Obligation to attend by scheduled appointment in a designated place and with a period of 3 months to maintain the bicycle, which is currently the Gaia Bike Store, located in Vila Nova de Gaia, a city near Porto; in case of loss or theft, the user should contact the project coordinator and attach a copy of the complaint to the law enforcement authorities. (CDUP-UP, 2018)

Through a website, the interested parties can submit their applications where they inform the data of which college they study or work, which place of residence and how many kilometers they intend to do weekly. The service only has the cost of theft and accident insurance and gives 2 options for the bicycle loan: 6 months or 1 year in duration and, in the case of mobility students (ERASMUS), 3 months, costing € 40 per period. The shared use of the bicycle is extremely prohibited (CDUP-UP, 2018).

The Project also provides some accessories that are also included in the service package as user’s manual; a Project’s info brochure; helmets; cell phone pockets attachable to the handlebars; battery charger; reserve tube; toolkit with 11 padlock; night lights and bag for all complementary material. To complete the package, there is also a mobile app, where the user can check the location of the bike, and some features that are not yet available, such as distance traveled, average speed, time spent, accumulated altimetry, the amount of greenhouse gases saved and the calories burned (CDUP-UP, 2018)

Once selected, the candidate must wait for the delivery of the bikes that is made in the CDUP-UP unit. Users are informed of how the electric bicycle works, how to select the power, how to check the level of battery and how to recharge it, how to calibrate tire pressure and how to change it, and some basic bicycle maintenance recommendations (CDUP-UP, 2018).

The project itself gained a lot of adhesion in its launch and in the registration phase. The delayed delivery of bicycles, however, had some negative impact, due to contractual and manufacturing reasons. Another point reported by Project Coordination was the low frequency of use of conventional bicycles in the first 6 months. It was then decided to convert and adapt conventional bicycles into e-bikes with completion and reintegration into the program by the end of 2019. From 265 bikes, all 220 e-bikes were being used. All 45 conventional bikes awaited conversion on September 2019.

All the relevant aspects were included within the project: bicycles, preventive and corrective maintenance, services, delivery and accessories, relevant aspects for the project and its adhesion to become attractive to its users.

1.5 Problem Description

Cycling as a mean of transportation is still under-represented and not perceived as alternatives to motorized transport, then, could play a much bigger role, although has been proved its efficiency in terms of cost and energy efficiency because it requires minimal infrastructure and investment capital for its implementation. The bicycle offers several benefits which include social cohesion, support equity (particularly for the poor), economic gains and quality of life (Peet et al., 2019), and adding to these aspects it offers several benefits as savings in travel time and expense, disease prevention and health promotion (Mason et al., 2015).
According to INE (Statistics Portugal), Portugal's two main metropolitan areas, Porto and Lisbon) have a low bicycle travel rate compared to other European metropolitan areas, even with a representative industry in the European context (IMT, 2018a). In addition, according to Eurobarometer surveys (European Commission 2014), Portugal has 1% of bicycle mode share, far from European 8% average and far below from leaders (such as Netherlands, Sweden or Finland with bicycle commuting shares of 17–36%). It also has a growing motorization rate: the number of light vehicles per increased by 8.8% between 2014 and 2017, reaching a mark of 491.6 of 1,000 inhabitants (IMT, 2018a).

Efforts to adopt sustainable modes of transport within urban centers are part of the global agreement strategies to reduce greenhouse gas emissions, thereby preventing the global average temperature increase from exceeding 1.5 degrees Celsius in the year 2050, most known as 1.5 degrees Celsius scenario – 1.5DS (Peet et al., 2019). The bicycle as a means of urban displacement, both conventional and electric, are an essential part of this global strategy within the transport sector (Mason et al., 2015). The main objective of this strategy is to reduce gas emissions by up to 40%, compared to the current trend scenario, where urban passenger transport is responsible for the emission of 2.3 gigatonnes of CO_2 by 2015, and can reach 4.3 gigatonnes in 2050 (Mason et al., 2015). Cycling can represent between 7% and 11% reduction in the gas emissions and energy use if the share mode of bicycles goes from 6% to 14% in this time interval (Mason et al., 2015).

Service Research has been steadily increasing its participation and concentrating its efforts on societal well-being, at one line named as Transformative Service Research (Anderson, 2010). This emerging line of service research can explore sustainable mobility, a system that is closely tied to economic prosperity and social connectivity in a more just and equitable way, addressing the resources, environment and form with which we explore them, avoiding risks to human and nature entities (Hidas & Black, 2002).

There are many researches on bike commuting, mainly quantitative studies on conventional bicycle. These studies relate very commonly data and socio-economic aspects of a specific place with data on infrastructure offered, the natural environment (e.g.: climate, seasons, hilliness), and some personal perceptions (e.g.: effort, safety, traffic) (Heinen, van Wee, & Maat, 2010). It is important to note that electric bikes can be considered an emerging sustainable urban transport mode, where, being a recent technology, qualitative and quantitative publications are still scarce. Little research has been made with a qualitative approach, exploring through user perception, how such drivers can make the context more attractive to bicycle adoption or even for current bike commuters; or in the strategy of mitigating and softening barriers that make cycling less attractive or restrict its adoption.

The University of Porto, along with other Portuguese universities, launched the U-Bike Project, the national initiative to promote active mobility through cycling, whose goal is to create sustainable mobility habits for the academic community through e-bike rental provided at a low cost.

The purpose of this master thesis is to understand drivers and barriers to electric bike commuting adoption, identifying the positive influences and aspects that make the cycling experience more attractive; and the negative influences, named as barriers, restricting their bicycle use, based on the perception of the most varied characteristics among the users; to understand the patterns between the identified drivers and barriers, proposing improvements, insomuch, that active transport can be more explored and adopted in Portuguese soil, aiming to increase the physical activity, physical and psychological well-being, as well as promoting social inclusion and more sustainable urban mobility.

Within the context of service provided, investigate the user's experience of the U-Bike Service in the city of Porto, its weaknesses and strengths, proposing improvements to the project, which will improve the user experience without detaching from the characteristic of being a service based on sustainability; and to contribute to the literature on bike commuting and e-bike in the European context based on a qualitative approach.

In the next section we present the literature review, where we have made an overview of the major publications on commuting bike phenomena; electric bicycles: the market; situational and behavioral barriers and drivers; socioeconomic aspects of adopting and using this travel mode; and finally the Transformative Services and Sustainability. In the following chapter, we address the methodology used to conduct this research, including sociodemographic data of the interviewees. We also present how the interviews took place and how the data was analyzed. In the last two chapters we address the results within each main category, and in the conclusion, we discuss what was collected and potential improvements to be considered to achieve higher standards for bike commuting.

2 Literature Review

The section reviews the relevant literature to address the research objectives, focusing on studies of urban bicycle travel, drivers and barriers factors to its users, case studies from other metropolitan areas, and their relevance to the challenges of urban transportation in reducing greenhouse gas emissions challenges. The electric bicycle will also be approached as it is the central object of this study as a sustainable means of transport and its main characteristics and differences in relation to conventional bicycle. Another topic that will be addressed is the role of Transformative Service Research as theoretical foundation in investigation of such phenomena. In Appendix A, we provide the table 8 containing the main references used in this chapter divided by main categories of aspects.

2.1 Conventional and Electric Bicycle.

In individual and societal terms, bicycle adds numerous benefits and advantages over other means of transportation (Heinen et al., 2010). The bicycle is often referred to as the fastest way to avoid urban traffic jams, to be the healthiest and cheapest way of transportation (Heinen et al., 2010).

In societal terms, cycling is also beneficial to the environmental sustainability, including direct CO_2 emissions, noise and environmental pollution, low infrastructure implementation costs, and improvements in public health (Fishman, Schepers, & Kamphuis, 2015; Heinen et al., 2010; Peet et al., 2019). In the Netherlands, where bicycle travel accounts for about 27% of overall commuting (Pucher & Buehler, 2008), calculation suggests that the Dutch population would die half a year earlier if they did not use the bicycle, and such increase in life expectancy could only be achieved because cycling rate over 65 years old is high. This is also responsible for prevent about 6,500 deaths by increasing life expectancy about half a year, and such benefit represents about 3% of Overall Dutch GDP (Fishman et al., 2015). It also has a number of barriers, such as the need for greater effort by users, which directly impacts the distances traveled and speed (Heinen et al., 2010; Parkin, Wardman, & Page, 2008), difficulty in transporting larger loads, and weather conditions has a direct impact on frequency and use (Heinen et al., 2010; Nankervis, 1999).

The electric bike (e-bike) has entered the of urban mobility context as a sustainable option and has been associated with benefits to mobility, human health and the environment and these impacts depends on which transport mode that people are replacing for conventional bikes or cars (Fishman & Cherry, 2016; Fishman et al., 2015; Fyhri & Fearnley, 2015; MacArthur, Dill, & Person, 2014; Popovich et al., 2014; Simsekoglu & Klöckner, 2019), increasing physical activity, as well as health benefits, thanks to growth of bike trips, reduction of traffic congestion and the use of energy resources and environmental problems (Berntsen, Malnes, Langåker, & Bere, 2017; Cherry, Yang, Jones, & He, 2016; Dave, 2010; Fyhri & Fearnley, 2015). The electric bicycle has an electric motor and a battery, increasing (or assisting) the pedaling power of the user. In Europe, the e-bike is classified as a Bicycle and must meet certain criteria for this categorization, such as restricting the speed limit at 25 km/h. This bicycle is considerably heavy compared to conventional due to the weight of the battery, the electric motor and the frame itself to support the additional weight (Fyhri & Fearnley, 2015; Simsekoglu & Klöckner, 2019). According to Dave (2010), the electric bicycle is also more energy efficient than any other type of transport, even with walking, with the exception of the conventional bicycle by a small margin, so it can be concluded that the electric bicycle is environmentally superior than any motorized means of transportation. E-Bike also allows user to travel longer distances than conventional bikes. (Fyhri & Fearnley, 2015; MacArthur et al., 2014). However, the relatively high prices of e-bikes are potential barriers to their purchase and adoption, as studies show that e-bikes users tend to have higher education and income compared to average (MacArthur et al., 2014; Popovich et al., 2014). In addition, researches have also reported as negative aspects the weight and battery life, especially on long trips (Popovich et al., 2014), and the difficulty to

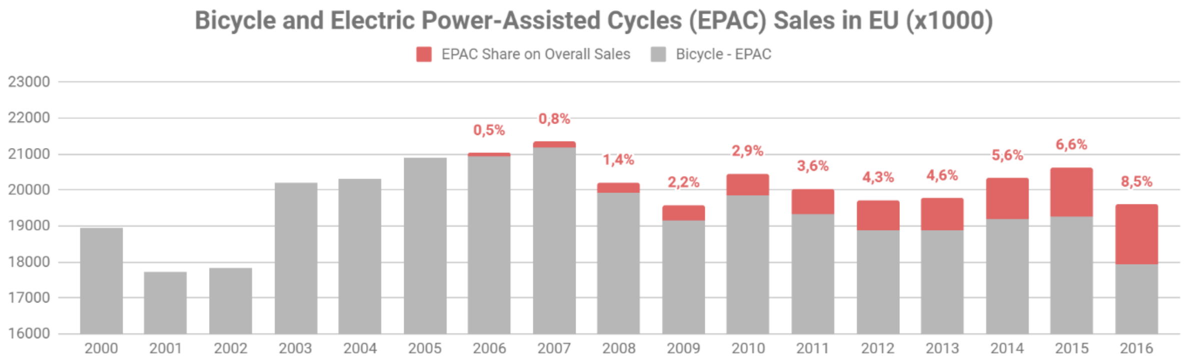

Figure 3 - Bicycle and electric power-assisted cycles (EPAC) sales in EU (Source: Conebi 2017)

pedal when the battery is discharged or switched off (Simsekoglu & Klöckner, 2019).

According to the CONEBI (Confederation of the European Bicycle Industry), in the year of 2016, the electric bicycle segment accounted for 8.5% of the total sales of European market, with 1.667 million units sold, with the first three countries in this ranking being Germany (36.3%), the Netherlands (16.4%) and Belgium (10.1%). Portugal is on the 17th place, with 0.18% of overall sales (CONEBI, 2017). In terms of production, electric bicycles have already reached 10.1% in relation to total bicycle production in 2016, with 1.16 million manufactured bicycles. Germany (30.2%), the Netherlands (17.2%) and Hungary (14.7%) are the top three, and Portugal is the 10th largest producer of e-bikes in Europe and the third largest producer holding 15% of all production of bicycles (including E-bikes) (CONEBI, 2017).

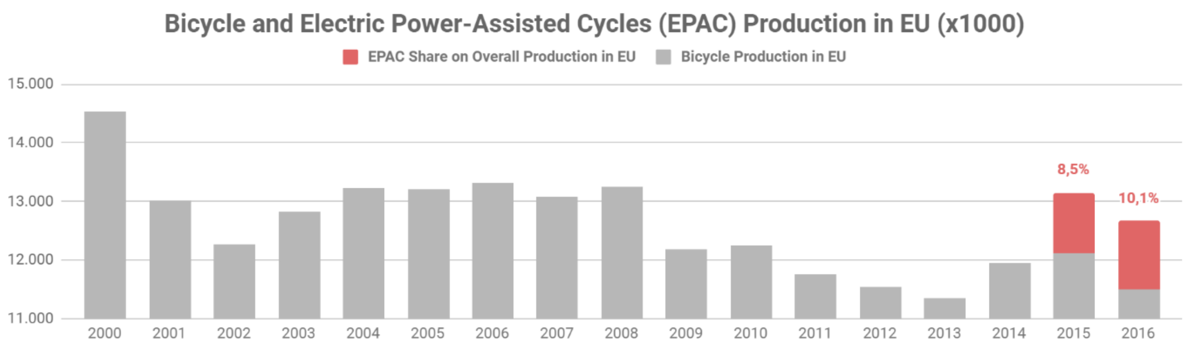

Figure 4 - Bicycle and electric-assisted cycles (EPAC) production in EU (Source: Conebi 2017)

2.2 Drivers and Barriers to Cycling

The bicycle used as a means of transportation, has numerous advantages and disadvantages in its use, which will be listed below. In this work, we will relate the positive and negative influences on its use as barriers and drivers, from the perspective of the user, in relation to cycling commuting within the urban context. It is also related the influences of these aspects with the use of the electric bicycle and how this new vehicle can reduce, increase or mitigate barriers and drivers according to user's perceptions.

2.2.1 Situational Aspects

Distance is one of the determining factors in choosing a bicycle or other means of transport because the distance traveled is proportional to the effort required (Heinen et al., 2010; van Wee, Rietveld, & Meurs, 2006). Non-cyclists (27%) use the travel distance as an excuse for not using the bicycle compared with cyclists (3%) (Dickinson, Kingham, Copsey, & Pearlman Hougie, 2003; Stinson & Bhat, 2004), and studies suggest that women cycle short distances to work than men (6.6 km against 11.6 km, respectively) (Garrard, Rose, & Lo, 2008; Howard & Burns, 2007). In Netherlands, small and medium-sized cities have the highest share modes for cycling (Rietveld & Daniel, 2004), probably indicating an influence and a relationship between distance and the destinations involved are smaller (Heinen et al., 2010). Another study that corroborates this tendency for small distances is from Keijer and Rietveld (2000), where it shows that between 0.5 and 3.5 km the bicycle is more used. Conducted studies relating the use of e-bike show that users cycle 30 km per week in average compared to 18 km of normal cyclists, says a Dutch study (Hendriksen, Knaap, & Rooijen, 2015), suggesting that electric bikes can eliminate the distance barrier for untested users. The same was also seen by Fyhri and Fearnley (2015), when cycling trips per day increased 55% (from 0.9 to 1.4 trip a day) and the distance 118% (from 4.8 to 10.5 km), being greatest for women cycling on e-bikes.

Regarding to infrastructures, results indicate that there is a preference, based on subjective notions of safety, for dedicated cycle paths (Garrard et al., 2008; Hunt & Abraham, 2007; Stinson & Bhat, 2005). Potential users prefer bicycle paths to bicycle lanes and roads without bike dedicated facilities (Hunt & Abraham, 2007; Stinson & Bhat, 2005), which is corroborated by comparative studies by Pucher (2001) suggesting that in countries with more facilities for cyclists have a higher modal shares of cycling and higher levels of bicycle safety. Also, denser road structures or the more fine-grained the road network, more suitable for non-motorized transportation: better for cyclists because distances tend to be smaller (Southworth, 2005), and higher densities tend to higher the bike share mode (Parkin et al., 2008; Pucher & Buehler, 2006), which is also related to lower levels of car use and ownership (Litman, 2007). Other studies show that preferences for certain cycling facilities vary according to socio-economic groups and the degree of user experience. Younger cyclists and women are likely to consider dedicated bike facilities to be more important (Garrard et al., 2008; Stinson & Bhat, 2003a, 2005), and for the experienced, wide curb lanes are more preferable to bike lanes (Taylor & Mahmassani, 2007).

In terms of safety perceived (or subjective safety) by users, Klobucar and Fricker (2008) argue that safety levels are higher when there are dedicated bike facilities are present, while objective safety remains unclear. Objective safety differs from subjective safety (or perceived safety) due to the first is measured in terms of the number of bicycles-related incidents per million inhabitants, and the latter it is related in terms of the perceived safety experience of cyclists and non-cyclists, and these two types can both correspond with and differ from one another (Heinen et al., 2010). Bicycle users have also a negative perception of high traffic intensity roads, according to Dill and Voros (2007) and prefer two-lane roads to four lane (Petritsch, Landis, Huang, & Challa, 2007) for car drivers and other motorized vehicles, due traffic attention must be harder with speed (Heinen et al., 2010). Other aspect related to infrastructure is continuity of bicycle paths and lanes, because the lack of this facility could discourage people from cycling, whereas for the expert cyclists, the presence of continuous dedicated bike facilities are preferable, according to M. a Stinson and Bhat (2003). In other study, M. A. Stinson and Bhat (2005) find that the sudden discontinuity of a bicycle lane or path is perceived as negative by bike users.

Studies state that having more bicycle paths result in a higher cycling (Barnes, Thompson, & Krizek, 2006; Pucher & Buehler, 2006), the same for constructing bicycle paths increased bicycle share by 1-2%, compared to little increase in other locations (Barnes et al., 2006), whereas people tend to say that they would cycle more frequently if they had more bicycle paths, and if they were connected to useful destinations (Dill & Voros, 2007). In the other hand, traffic-controlling systems, which can cause delays and irritations to users throughout the route, due to the fact that stopping and accelerating demands a great amount of effort (Fajans & Curry, 2001), but these and other findings related to traffic lights seems to be unclear due to different research methods, say Heinen, van Wee, and Maat (2010).

Other reasons presented in studies about barriers to bike commuting bicycle trips are facilities at work, such as showers, lockers and safe parking facilities, however, despite being mentioned by cyclists and non-cyclists, these facilities did not appear to be relate in the increase of bicycle travel rate (Heinen et al., 2010). In order of preference, safe parking facilities comes first as conditioners in relation to lockers and showers facilities at work (Dickinson et al., 2003). E-bike users, in respect of showers and lockers, tend to have a different view from conventional bike users. According to Berntsen et al. (2017), who made a commuting comparative between conventional bicycles and e-bikes, less time is spent on bike trips and the intensity of physical effort is reduced by up to 35%, thus almost mitigating the need for shower and locker facilities (at work for a instance). In MacArthur, Dill, and Person (2014) and Popovich et al. (2014), it was also verified that users tended not to need showers and claimed that they do not sweat on trips with an e-bike. So, e-bikes tend to mitigate or reduce the sweat, thus, the need for showers, becoming a driver. According to (Fishman et al., 2015), the bike commuter on an e-bike saves about 21% of the energy spent compared to a conventional bike owner, and 62% less than for walking trips.

Regarding to the Natural Environment (defined as hilliness, weather and climate), hilliness directly influences the amount of effort required in commuting by bike, and negatively impacts bicycle travel rates (Parkin et al., 2008), therefore, the presence of slopes has a negative effect on bike commuting (Parkin et al., 2008; Rietveld & Daniel, 2004). Bradford (UK), with high cumulative altimetry – too much steep slopes on its surface area – has a cycling share of 0.8%, meanwhile in York (UK), with more significant slopes (More than 3%) on only 5% of its surface, in other words, a place considered flat, has a cycling share of 13.1% (Parkin et al., 2008). An observation is necessary to point out: among users of bicycles for recreational purposes, the presence of climbs and altimetry is a positive factor, so it is common to find a high rate of cycling in mountainous regions within the recreational universe (Moudon et al., 2005; Stinson & Bhat, 2005). However, this preference for hilliness is probably not representative as far as the average cyclist is concerned (Heinen et al., 2010). In this context, e-bikes show up as drivers for cycling in hilly locations or on hilly routes, according to MacArthur, Dill, and Person (2014). About 35% of users answered an open-ended question saying they do not deviate from hilly routes to make their courses when using e-bikes.

Weather and climate have a great influence on the user's decision for cycling and its frequency. Rain and the probability of rain, low temperatures and darkness have a negative impact in cycling. By weather we refer to the daily weather conditions, whereas the term climate describes the weather over a 30-year period (Heinen et al., 2010). Landscape and weather conditions will be described in this section and its effects on cycling mode.

The weather (conditions) also impacts on bike commuting as well as its frequency. Liu, Susilo, and Karlström (2015) show that the different climate perceptions vary according to the region analyzed. In Sweden, cyclists from the North, where average winter temperatures are extremely low, are more aware of the variation of temperature than those counterparts in the central and southern Sweden in spring and autumn when temperatures change significantly. However, in the winter, cyclists in the center and south are more susceptible to changes in temperature than those in the north.

For Stinson and Bhat (2004), this can be verified when looking to propensity to commute by bike in winter at the regions of North America: Canada is very low, low in the midwestern and northeastern regions of the United States, moderate in the Mideastern and southwestern United States, and highest on the West Coast. For Stinson and Bhat (2004) it is clear the negative impact of harsh winters (frigid temperatures, snow, and ice) when commuting to work by bicycle, improving the mode shares in middle seasons, as autumn and springs, and becomes higher in summer. Not only sharper decreases in cycling rates are seen in regions with low winter temperatures (Stinson & Bhat, 2004) than regions with milder winter, but it also affects maximum distance cycled: in Sweden, it is also seen a decrease from 20 km in summer to 10 km in winter (Bergström & Magnusson, 2003). The same study indicated that for distances up to 3 km, 25% of people prefer to travel by car in the summer, while in winter the number rises to 40%. Other finding corroborates the pattern of higher cycling shares: In Australia, cycling shares are higher in summer (over 20% of all travelers) and autumn, whereas in the winter (less than 10% of all travelers) and spring people cycle less (Nankervis, 1999). Daylight is another factor that can positively influence the use of the Bicycle; therefore, seasons have an intimate relationship with the daylight hours range. Darkness has a negative impact on Bicycle commuting (Stinson & Bhat, 2004), and its sharpened in women cyclists (Bergström & Magnusson, 2003). Climate is defined as the weather conditions prevailing in an area in general or over a long period. In the USA, the six cities with the lowest rate of bicycle use have more than 100 days of rain per year on average. Although there are very few researches about climate effects on cycling, In the USA, the six lowest rates cities of cycling use have more than 100 days of rain a year on average, but the three of the top six cities also have over 100 days of rain (Carr & Dill, 2003). Pucher and Buehler (2006) argue that temperature does not play a relevant role in cycling relative to other factors, due to the fact that people in Canada, with lower temperatures, have higher share modes than the Americans.

Weather, which is defined as meteorological conditions in a short-term range, can be decisive on daily commuting choices. Precipitation or the chance of rain is, by far, cited as the worst weather aspect and the reason not to commute by bike (Brandenburg, Matzarakis, & Arnberger, 2004; Nankervis, 1999), and mentioned by women, recreational cyclists and commuters as having grater aversion to rainy days (Bergström & Magnusson, 2003; Brandenburg et al., 2004).

In the Figure 5 is shown the amount of rainy days in terms of percentage of days over the year, from 1967 to 2018. Porto has an average of 41% per year in the last ten years (2009-2018), with a peak of up to 211 days (58%) in 2014, comparatively higher than Lisbon, with an average of 30% rainy days over the year, considering the last decade (Pordata.pt, 2019). In the Figure 6,

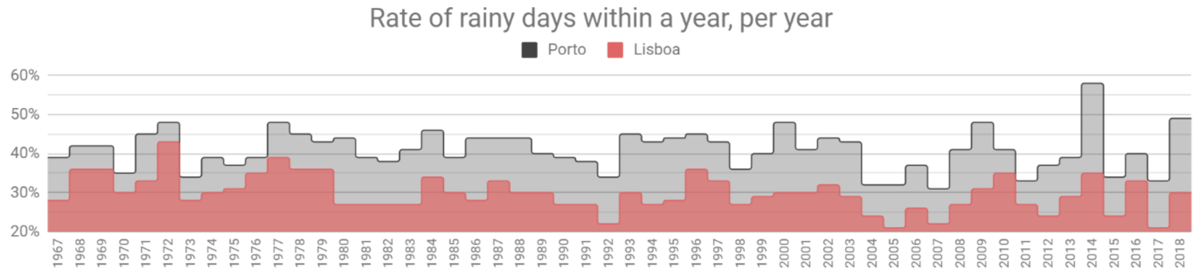

Figure 5 - Rainy days rate within the year, per year (Source: Pordata.pt)

the comparison of the average percentage of days of the year that rains between Porto, Lisbon, Amsterdam and Copenhagen (Weather-and-climate.com, 2019), two national capitals with the world's highest bicycle travel shares.

Temperature is another factor that is closely related to the use of the bicycle. Higher cycling rates are seen when temperature increases (between 8.6°C and 10.3°C) (Parkin, Wardman, and Page 2008 [UK]), but commuters are less affected than other type of cyclists (for leisure and physical purposes), and it could be explained due to commuters have few choices but to cycle (Heinen et al., 2010).

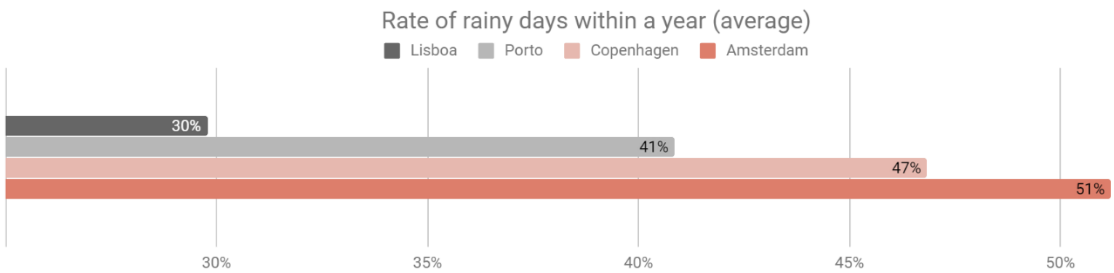

Figure 6 - Average rate of rainy days within a year (Source: Weather-and-climate-com)

2.2.2 Behavioral Aspects

Transport costs have a direct influence on the choice of how people commute (Heinen et al., 2010), therefore, even though cycling are a relatively cheap mean of transportation (Bergström & Magnusson, 2003), other cost's modes also plays a role in commuting decision (Pucher & Buehler, 2006). A study conducted in UK shows that there is a relationship between fuel prices, income, car use and the use of bicycles (Pucher & Buehler, 2006), and other study suggests that offering loans for users to buy bicycles has a positive effect on bicycle use, encouraging 7% of respondents to cycle (Dickinson et al., 2003).

One of the major drivers for cycling is the fact that it is an enjoyment activity for both leisure and commuting reasons, and enables them to appreciate the scenery (Stinson & Bhat, 2004). Cyclists tend to evaluate their journeys to work as being more relaxing and exciting compared to public transport users, drivers and walkers (Gatersleben & Uzzell, 2007). The same is seen in E-bike researches: According to Popovich et al. (2014); Fyhri and Fearnley (2015), e-bikes users reported the sense of enjoyment, and electric assistance had made cycling fun again. Fitness and health concerns, namely as improving or maintaining fitness, relaxing and reducing stress, building physical activity into a busy lifestyle, also are important drivers mentioned for cycling (Gatersleben & Uzzell, 2007; Iwińska, Blicharska, Pierotti, Tainio, & de Nazelle, 2018; K.C., S., & J., 2012). One of the most frequent reasons for purchasing an e-bike was a sense of decline in physical ability and a solution for maintaining the cycling habit for physical activity reasons (T. Jones, Harms, & Heinen, 2016).

A person's habits, and their breaking, can cause a reconsideration in the way people commutes, such as experimenting what it is like to go to work on a bicycle, can convince some people to adopt the bicycle as a means of transportation, points out Rose and Marfurt (2007). The same applies for people who use their free time to cycle or cycled in the childhood, say M. Stinson and Bhat (2004) and Dill and Voros (2007). The way people see cyclists can also play a barrier or driver role in a non-rider’s decision making for whether for cycling or not. A non-user can be positively influenced by the perception of a cyclist being a "brave," "fit", “environmentally friendly”, or negatively as "a fool", "reckless", depending on the context (Skinner and Rosen 2007). Environmental causes are important drivers for cycling, feeling good about doing something positive for the environment, although they claim it's not their prime motivation for cycling. In the other hand, some riders felt they are pejoratively classified by others as “greenie activists”, militant students, elitists and leftists. The label greenie is labeled for who is passionate about environmental issues, tagged as having extreme views (Daley & Rissel, 2011). Cyclists are more likely to believe that cycling contributes in reduction of air pollution (Iwińska et al., 2018). Regarding to e-bikes, early adopters hold pro-environmental attitudes, and they compromise older adults who use e-bikes for leisure trips (Dill & Rose, 2012).

Travel time also plays an important role in bike commuting. The perceived convenience of a trip declines with an increase in the travel time, which is not applicable for other transport modes (Noland & Kunreuther, 1995), which is also supported by the findings of (Wardman, Tight, & Page, 2007) that travel time is considered to be three times more unpleasant than time traveled by other means of transportation. Convenience, flexibility and rapidity is also related as drivers for bike commuting (Heinen et al., 2010; Iwińska et al., 2018). Cycling as a daily mean of transportation could avoid waiting times, delays and uncomfortable trips of public transportation, as well as car traffic, stress when commuting by car. In other words, cyclists evaluate their round-trip as more exciting and relaxing compared to car drivers (Gatersleben & Uzzell, 2007). In e-bikes studies, users have reported that one of the main drivers compared to conventional bikes, is speed: e-bikes travels faster than conventional bikes, though still not as fast as cars. The speed of e-bikes reduces travel time by a certain distance, accelerates faster and maintains top speed with less effort (Popovich et al., 2014), while Berntsen et al. (2017) shows that e-bikes reduce travel time by about 16% on flat terrain, and 29% on hilly terrain with less effort required.

2.2.3 Socioeconomic Aspects

The socio-demographic, personal, housing, gender, income, vehicle ownership (bike and car), age, employment status and other economic factors directly influence the choice of means of transportation.

Most research shows that men commute by bicycle more than women (Dickinson et al., 2003; Heinen et al., 2010). Dickinson et al. (2003) cites the difficulty of combining appointments as picking up the children or shopping as reasons for woman not cycling. It is important to emphasize that in countries with high cycling rates, women have a more active participation, such as Belgium and Netherlands (Dill & Voros, 2007; Garrard et al., 2008; Moudon et al., 2005; Ryley, 2006; Stinson & Bhat, 2005). According to Fyhri and Fearnley (2015), a study has shown that woman tend to cycle more than man with an e-bike.

Bike commuting levels decrease with the age (Heinen et al., 2010), because elderly people needs to much effort they are not capable of, and the declined age also is mentioned as a reason not to cycle, says Heinen, van Wee, and Maat (2010). Research shows that the advancement of age and the presence of chronic diseases as a barrier to cycling tend to be mitigated by the use of e-bike (Fishman & Cherry, 2016; T. Jones et al., 2016; MacArthur et al., 2014).

Some studies show that high incomes have a negative impact on cycling (Pucher & Buehler, 2006), while Parkin, Wardman, and Page 2008 indicates low incomes has a link with low bicycle use rates because the economic deprivation could be a driver for crime, safe storage, bicycle availability and image issues. On the other hand, according to M. A. Stinson and Bhat (2005), there is a positive connection between the yield and the bike commuting: people that earn more tend to cycle more often due to greater attention they may pay for health in the USA (Pucher & Buehler, 2008). On the other hand, having a high income implies that one is able to spend more money on transport in general, including buying a car (Witlox & Tindemans, 2004). According to MacArthur, Dill, and Person (2014); Popovich et al. (2014), income and educational levels tend to be higher for e-bike users compared with the average.

Car ownership have a negative effect on cycling mode share (Parkin et al., 2008; Pucher & Buehler, 2006; Stinson & Bhat, 2004, 2005), as well as bike ownership increases the likelihood of people traveling by bicycle (Heinen et al., 2010). In this respect, some research shows that e-bikes tend to replace cars in daily commutes (Popovich et al. 2014; MacArthur, Dill, and Person (2014); Cherry et al. 2016), however, Fishman and Cherry (2016) claims that more conclusive studies on car ownership and replacement by e-bikes are needed. A person’s employment status is mentioned as a factor that implies on the use or non-use of the bicycle (Heinen et al., 2010). Part-time workers tend to live closer to their work and, a result, they commute at higher rates than fulltime employed people (Boumans & Harms, 2004). Childless people also commutes higher (16%), Students (17.9%), people who works fewer than 40 hours a week, part-time workers without children (8.1%), divorced or widowed (Moudon et al., 2005) are more likely to cycle compared with the average of bike commuters (6.4%), found Ryley (2006). High social status as well as having a young family are likely to cycle less (Moudon et al., 2005; Ryley, 2006). Being physically active increases the likelihood for cycling (Heinen et al., 2010), however, higher levels of education by a person reduces the probability to cycle (Moudon et al., 2005; Parkin et al., 2008; Rietveld & Daniel, 2004).

2.3 Sustainability and Transformative Service Research

In this section, we address the role of sustainability and transformative service research, starting with a brief background on urban mobility.

2.3.1 Urban Mobility Background

The recent problem of urban mobility is directly related to how societies have developed and prioritized urban planning around private transport since the early 20th century, with the expansion of the automotive industry, prioritizing the maximization of car capacity on existing streets, including a large supply of parking spaces. This has led to reduced public transport investment capacity, reduced public space for pedestrians and cyclists, commercial activities, and extensive on-street tram systems are removed to increase capacity for motor vehicles.

Many urban centers around the world then adopted the model of US cities, with policies for using urban space to favor the car over sustainable modes of transport. This policy was, in addition to being supported by groups in positions of power and wealth (direct beneficiaries such as car owners), was also supported by the population, who, seeing large infrastructure investments aimed at road construction, also aspired to car ownership, as well as a job in the automotive industry, the most prominent sector of that time and synonymous with economic and technological development (P. Jones, 2014). Shortly thereafter, it became clear that it was not possible to address uncontrolled car use in urban areas with high and medium densities, as well as apparent evidence such as air pollution, concern about CO_2 emissions, accidents and increased traffic jams. In London in 1973, the popular outcry under the slogan "houses before the roads" caused the Greater London Council administration to promise to end the construction of highways. Chinese cities like Beijing and Shanghai suffer from air pollution. Congestion costs to the EU about 1% of GDP, approximately € 100 billion annually (European Commission, 2015). Such questions were important in redefining the problem and the paradigm, changing the main objective to study in how to switch to cater for growing person movement.

After much evidence of deteriorating urban mobility and sustainability, policies focused on the efficiency of people's commuting between origin and destination, no matter which mode they move. This was supported by the introduction of new means of transportation, with mass transportation carrying more people in less time, imposing restrictions on car use to counter high levels of air pollution (Davies, Jefferson, Longhurst, & Marquez, 2000). While Europe, Japan and China (Beijing and Shanghai) invested in rail-based transport solutions, South America invested in cheaper Bus Rapid Transit systems due to funding constraints (P. Jones, 2014; Peet et al., 2019). Considering the predicted growth of urban centers where most (70–80%) of the world’s population will live (Banister, 2007), the concern and recognition of the importance of cities as centers of commercial, cultural and social activities began to take over policymakers: to provide a better quality of life, health and livability in urban areas (P. Jones, 2014).

Subsequently, commuting shifted from a mean to an end rather to an end activity itself (P. Jones, 2014), raising questions about whether commuting is necessary for part of urban activities, after the emergence and popularization of new forms of internet-based communication and the home-office.

The resurgence of interest in cycling and walking in cities as a sustainable and healthy means of transport, as well as increasing public space and providing space for street activities were other factors that came in line with the need to increase wellbeing within cities' urban mobility. Other perspectives were raised, such as flexible working hours to mitigate traffic peaks, encouragement of home-working, internet shopping and home deliveries as substitutes (P. Jones, 2014).

Policies such as reducing spaces for car traffic and parking, parking fees, reallocation of space for sustainable street activities and transportation such as cycling and walking; greater provision of public transport and encouragement of walking and cycling, with better infrastructure and better communication with the public; Promotion of street and public domain activities. Some cities even demolished infrastructure built for car traffic, such as elevated roads and vertical parking lots built before the 1960s (P. Jones, 2014).

Transport planning is undergoing a crisis and its problems are being underestimated by public planners and governments (Balaker & Staley, 2006; Banister, 2005) and also survived these crises and their condition is practically intact in terms of operation mode. Two principles according to Banister 2005 must be analyzed: First, demand is derived and not a voluntary activity, that is, the value of the end-activity that results in commuting. And the second principle is that people minimize their generalized travel costs combined with travel time. The two principles explain the predominance of transport solutions to urban problems such as increased travel distance and shorter travel time (Banister, 2007), resulting in less attractiveness for means of transportation such as walking, cycling, and public transport. This leads to an increase car dependency by people who lives in cities whose centers are even more decentralized, which is more difficult to revert to a more sustainable mobility system (Banister, 2007).

2.3.2 Sustainability

Sustainability is a concept that deals with the rational relation between consumption and production, or in other words, resource use and productivity, making the cycle between production and consumption uninterrupted. Its concept and definition were created in 1987 by the World Commission on Environment and Development (WCED) of the United Nations The report called “Our Common Future”, and defined Sustainable Development as the "Development that meets the needs of the present without compromising the ability of future generations to meet their own need" (WCDE 1987).

All human activities can be included in this concept and stands on three pillars: environment, society and economy, being the last two confined by the environment limits. Based on this premise and human’s activities, 17 Sustainable Development Goals (SDGs) were identified by the United Nations in 2015 (United Nations 2015), in which the transport sector is included, has imposed challenges on its implementation due to the complexity and inseparability of all social entities: individuals, governments and private entities. The first implementation step is to educate the younger and those generation to come, creating and rising sustainability awareness, consciousness for the preservation of the environment and its needs since primary school until adulthood, which was exposed by Stockholm Declaration at UNESCO, 1972 (UNESCO, 1972). Since then, other international conferences have been held to increase dissemination of the understanding and dissemination of Sustainable Development and its practices around the world, such as in Declaration of the Talloires in 1994, which defined a plan of action for higher education and its role in sustainable development, and as in 2002, the United Nations General Assembly declared the decade of education for sustainable development from 2005 to 2014 (UNESCO, 2005), among others, culminating in the commitments: teach; encourage research; green campuses and support local sustainability efforts; and engage and share information with international networks about sustainable development (United Nations, 2015).

Regarding to sustainability in mobility, which was defined by Hidas and Black (2002) as “a system that supports social connectivity and economic prosperity in a fair and equitable manner, without presenting risks to local or global environmental quality and resource use”, being therefore an indispensable part within the concept of sustainable city. According to Hidas and Black (2002), sustainability in transportation has three fundamentals, despite most of sustainability in transport is related to environmental issues:

- Economic sustainability: create incentives for efficient responses to human requirements
- Environmental sustainability: protect ecosystems, promote more livable settlements and reduce externalities.
- Social sustainability: promotes equity.

Hidas and Black (2002) emphasizes the need to create measurable indicators to assess the sustainability of activities, emphasizing the importance of economic, social and other factors, topics recognized as relevant but not addressed, as well as environmental issues, the main focus of the sustainability topic in mobility. Seven broader sustainability-related objectives, namely: economic efficiency; livable neighborhoods and streets; protection of the environment; equity and social inclusion; safety; contribution to economic growth; and Energy efficiency are proposed and measured from broader approaches.

2.3.3 Transformative Service Research

We spend much of our daily routine in an array of services and systems contexts which are part of our activities and affect our lives and well-being as humans, consumers, employees, families and as a community in sectors such as telecommunication, education, finance and government. Given the connection and usage of such services and their implications in our daily routines, the issues must go beyond simply measurements of service quality, customer satisfaction and loyalty (Anderson et al., 2013). First developed by Anderson (2010), the main goal of Transformative Research Service (TSR), is to investigate the relationship between service and well-being, focusing on creating uplifting changes, improve the lives of individuals, society, consumers, employees, and the ecosystem in a more comprehensive way. One of the characteristics of TSR is to distinguish themselves by showing the indicators of well-being, such as physical health (objective and subjective perceptions), mental health (stress, resilience), financial wellbeing, inclusion, literacy and many others (Anderson et al., 2013). Sangiorgi (2011) says that organizations operate in a constantly changing environment and today the challenge is not to design an answer to a problem, but how to design a way to respond, adapt and innovate continuously, adopting tools, skills and organizational capacity for ongoing change in organizations, since the design debate has recognized the nature of services as complex and relational entities that cannot be fully planned.

Services are no longer conceived as an end in themselves, they are currently undergoing change and are increasingly being considered as a driver for societal transformations, supporting the emergence of a more collaborative, sustainable and creative society and economy (Sangiorgi, 2011), having service innovation as a facilitator to address social challenges and as catalysts for social and economic change (European Commission, 2009) in areas such as health, well-being, clean energy, built environment and knowledge society (Ezell, Ogilvie, & Rae 2008, apud Sangiorgi 2011 p.30).

Even services that are typically unrelated to well-being impact positively and negatively well-being, such as using online payment services and retail interactions, in ways firms may not have intended. The potential vulnerability of consumers is also directly linked to their well-being (Baker, Gentry, & Rittenburg, 2005) when, for example, there is a difference in expertise compared to service providers. Service co-creation between service providers and consumers in this case may be a way to alleviate this disadvantage (Prahalad & Ramaswamy, 2004). These interactions performed by service providers and consumers are always emotionally charged and influence emotionally and physical well-being, thus, organizations have a share of responsibility for welfare (Anderson, et al. 2011 apud Anderson et al. 2013).

Consumers can be affected at individual levels and collectively, such as families, social networks, neighborhoods, communities, cities and nations, when dealing with service entities. The natural environment cannot be left out of this interaction ecosystem, because when the service entity impacts nature in some way, it can impact on the well-being of people, therefore. There are also situations where the service provider may find themselves in a situation of choosing to focus on the welfare of one community over another, when the latter thinks that such a service may affect their welfare (Mehren, 2002). We can also explain in terms of the transportation sector, when a lane on the road is used for the construction of a bicycle path, and residents and business owners in the area feel harmed by the reduced number of parking spaces for vehicles.

TSR's main goal is concern for the well-being of consumers and employees, both individually and collectively, while affected by services, so measurements such as profitability, market share and customer satisfaction do not fit into the issues addressed by TSR.

According to Anderson et al. (2013), TSR has addressed its research in some areas. Within Financial Services, the TSR issues such as literacy related to consumer welfare. In health services, the discussion is on the importance of focusing on the collective levels of consumer entities and the need to holistically view the socio-cultural context. The social services sector examines the influence of the macro environment and public policies, including employee welfare and impact on consumers. It also points to directions for future research in the area, and how utilities such as water, sewage, energy and transportation can benefit from TSR to promote sustainability for cities by rethinking the delivery and consumption of products and services from these sectors.

Trying to solve this paradigm, sustainable mobility provides an alternative that is responsible for investigating the relationships between land use, transportation, and complexity of urban centers, and what strategies can be adopted by businesses, nonprofits and governments to more effectively promote sustainable transport, wellbeing and equity in society.

3 Methodology

For this research, we conducted a qualitative study based on semi-structured interviews using Grounded Theory (GT) tenets with Project U-bike users. Audio recorded interviews was made with 16 users, fully transcribed not to miss any detail as well as the most important information. NVivo was used to process and to assist the coding process, thus, to categorize to frame the project. Some literature review was done in the beginning and as data analysis was been made, to fully understand the concepts and to better classify nodes and details collected during interviews.

First, we analyze the research methodologies to understand and choose the best approach to be made for our research. A brief summary of the analysis and the final motivation to pursue with qualitative methods is explained further. A description of the qualitative methods is emphasized, especially with respect to GT, which is one the main approach adopted by this work. Sample design is then framed, and the most important topics, which supported data collection and coding techniques, are detailed.

The interviews were conducted using a guideline with a first part of brief questions on socio-demographic data. The second, longer part contained open-ended questions for users to tell their service experience, understand barriers and drivers, and wherever possible, delving deeper into topics where relevancy was needed. Each interview was recorded in audio and then literally transcribed. The collected data was coded and analyzed with a Computer-Assisted Qualitative Data Analysis Software (Nvivo®) in order to map the U-bike users' activities, experiences, barriers and drivers for cycling. The relationships between this aspects and concepts emerge from the interviews, and then we compare them with previous studies (Gioia, Corley, & Hamilton, 2012).

This methodology is considered the most suitable one, once it allows exploring, understanding and learning about experiences and behaviors from the openness given (Charmaz, 2006), thus allowing to answer to the research questions.

3.1 Research methodologies and qualitative approach

There are two major types of categories for the data collection and analysis, among several used in research. First, the quantitative, which is basically based on the quantification of the data, in this case, numerically. The quantitative research process is mostly used for testable hypotheses and theories. Quantitative research methods include, e.g., surveys, simulation and experiments, and looks measurable and quantifiable terms in order to achieve undeniable truths (Neuman, 2013).

In contrast, qualitative research is the method that, through a deeper approach on textual data, is more convenient to understand the reasons, motivations and perceptions of the sample space to be studied (Neuman, 2013). Qualitative and quantitative methods, in many approaches, must be done together so that the interpretation of the data is based on a better interpretation of perception and experience from the point of view of the analyzed sample, bringing a better understanding about their meanings and giving more robustness to the actions that should be planned and taken (Creswell, 2014).

The major advantage of using qualitative research is to gain a deeper understanding of a given subject by acquiring detailed information about the reasons and motivations of a group or social community, in written form or pictures. Qualitative research has an essentially interpretive basis because, through the collection of data, which can be provided through interviews, observation, records and documents, it investigates aspects such as interactions, feelings, behaviors, experiences, motivations and the social context in which it is found the research group (Neuman, 2013).

3.2 Sample Design

The choice of the sample, in a qualitative research, is a critical variable of the study as a whole, since it determines the success, the practicality, the efficiency and the ethics of it, therefore, the sample must have representativity, both in numbers, as in its shares, so that the results, after being collected, can be applied and generalized without prejudice to the population from which the sample came. (Marshall, 1996). Marshall also points out three types of approach on how to select a sampling technique in a qualitative study:

- Convenience Sampling: It is considered the least rigorous, least costly technique in terms of money and effort and focuses on selecting accessible subjects. May result in poor quality outcomes.
- Judgment sampling: This is the most common sampling technique, where the researcher selects the most productive sample to answer the research question. This sampling technique may be disadvantageous to study a broad range of subjects, or subjects who have specific experiences, as it is based on the researcher's practical knowledge and available literature but may fail when deviations are not addressed in the research framework.
- Theoretical Sampling: Requires building interpretative theories from the emerging data and selecting a new sample to examine and elaborate on this theory, being the main technique used in GT, but it is widely used in qualitative investigations whose interpretation is required.

In our research, we used theoretical sampling, since the sample group reflects the different users of the same service, the U-bike Project. And throughout the interviews, aspect can be included in the guideline framework, and can be explored or not, depending on the relevance and the perception of such aspect of each interviewee.

At the first meeting with the U-Bike project manager at the University of Porto at CDUP, some information was gathered to know the basic aspects of the project. Also showed the total users and their occupational profiles, as follows below in the Table 2:

Table 2 - Number of U-bike users per occupation

Occupation	Amount	%
Student	84	48.3%
Professor	34	19.5%
Employees	51	29.3%
Researchers	5	2.9%
Total	174	100.0%

In total, 16 interviews were conducted between March 27 and May 14, 2019 and accounted for over 10 hours and 24 minutes of audio recordings.

From the 16 interviewed, four are women, 12 men. Among the occupations of the users, six are senior technicians, five are teachers, four are students (from graduation master and doctorate degree courses) and one is a researcher. 11 of the 16 interviewees own a car and seven have children.

Table 3 - Sociodemographic data and travel indicators about U-Bike interviewees

Sociodemografic Data

Data	Female	Male	Total
Total	**4**	**12**	**16**
Occupation			
Professor	1	4	**5**
Student		4	**4**
Researcher		1	**1**
Senior Technician	3	3	**6**
Age Range			
18-25		3	**3**
26-30		2	**2**
31-35			
36-40		2	**2**
41-45	1	1	**2**
46-50	2	2	**4**
51-55		1	**1**
55-60			
60+	1	1	**2**
Vehicle Owner	**3**	**8**	**11**
Professor	1	4	**5**
Researcher		1	**1**
Senior Technician	2	3	**5**
Have Children	**2**	**5**	**7**
Professor	1	3	**4**
Senior Technician	1	2	**3**
Have to Escort Someone	**2**	**2**	**4**
Professor	1	2	**3**
Senior Technician	1		**1**
		Average (min)	
Avarage Time Lenght (min)	**34**	**40**	**39**

Travel Mode Indicators

	Average	Unit
Trip distance range	from 2 to 13	km
Average distance traveled weekly	53.1	km
Average trip distance	6.7	km
Weekly use frequency	4.7	(times /week)
Average time spent per trip	20.3	Min

Travel Mode *(Before and After ingressing in U-Bike)*	**Users** Before	After
Car	12	5
Walking	7	1
Mass Transportation	8	3
Bus	4	3
Subway	5	1
Motorcycle	3	1
Bicycle	2	0
U-Bike	N/A	**16**

Previous experiences with cycling	**Users**
Leisure cycling	11
Utility cycling	2
Childhood & Adolescence	8
Mountain Biking	5
Health and Cronical Diseases	1

Have to escort someone	**Users**
	5

Other travel mode indicators are presented from the interviews: distances traveled ranged from 2 to 13 km on each trip, averaging 6.7 km. The average cycling frequency was 4.7 times a week, and the average cycling time was 20.3 minutes per trip. Twelve users used to drive their cars, and after joining the U-Bike project, only five continued to use it for their weekly activities, the same number of people who had to escort relatives on appointments. Eleven users had ridden the bike in previous experiences, followed by eight who used it in childhood and adolescence. Other socioeconomic and travel indicators can be seen in table 3.

3.3 Data Collection

After the initial meeting with the coordination of the U-Bike Project, which were explained the purpose of the research and the thesis, as well as its needs, the Project coordinator sent an e-mail to all users who had already received and were using the bicycles from U-Bike. The email invited the users to spontaneously collaborate with the research, explaining in general terms the scope, how the interview would be given and a brief introduction about the interviewer was made. We should point out that at the time we held the meeting, the bicycles made available by the U-Bike Project were almost all electric and the few conventional bicycles still left in the hands of the users had not been fully adhered to, because according to the project coordinator, these had low adherence, since the frequency of commuting was close to zero. The few conventional bikes were being collected, converted into electric and reinserted into the program.

Interviews were conducted among 16 users: students, researchers, teachers and senior technicians who work or study at the various campuses of the University of Porto. Interviews were scheduled according to the availability of time and location of each U-bike participant, after the coordination advised us that a user had contacted and was available to be interviewed.

The interviews then began with a brief presentation of the research, the objectives, and some topics that would be covered superficially. The informed consent was then read and signed for the audio recording to begin. The audio recording was made under prior agreement with the interviewees and signed in an informed consent form integrated with the interview guideline, which can be seen in Appendix B. The interviews were conducted using a guideline with a first part of brief questions on socio-demographic data. The second and longer part contained open-ended questions for users to tell their service experience, understand barriers and drivers, and wherever possible, delving deeper into topics where relevancy was needed. Each interview was recorded in audio and then literally transcribed.

3.4 Interviewing and Data Analysis

To conduct data analysis and coding of qualitative data extracted from interviews, NVivo12 software was used to manage data and organize the transcription of the interviewees' text; management of ideas and their rapid categorization and access; making queries to make associations and relationships between contexts and categories, such as marital status or having children, can affect cycling; produce reports easily and automatically (Bazeley & Jackson, 2013).

After transcription, initial coding, a process that categorizes into segments with small designations, begins (Charmaz, 2006), containing larger categories and subcategories to facilitate the analytical process, helping to organize the data, making it easy and quick to retrieve data, making the view on multiple categories more systemic and revealing interdependencies, identifying common themes, thus developing theories within the research. The definition of such categories and subcategories required a brief literature review to assist in this initial coding.

There is no such structure of barriers and driver categories in the literature that we can adapt to the commuting bike phenomenon. Therefore, we need to adapt such a structure to this context. As this work will use a qualitative methodology for the evaluation of the determining factors as drivers and barriers for cycling, we will also use as a basis for our framework the one used in previous bike commuting researches like in the broad study mixing qualitative and quantitative aspects of Heinen, van Wee, and Maat (2010), which created 5 categories for evaluation: Built environment, natural environment, socioeconomic aspects, psychological factors and the last one, aspects related to cost, effort, time and safety. After being thoroughly analyzed, the categories were reformulated, refined, recoded through a continuous interaction process to better represent the collected data and their outcomes in a process called Axial Coding (Charmaz 2006).

The barrier and driver structure we designed for this work was based on the four-category WRAP Barriers framework (Jesson et al., 2014). In 2008, WRAP published a document aimed at structuring, analyzing and interpreting barriers to recycling at home. The result would be to develop approach and communication strategies.

That said, we adapted from the four categories used for home recycling in WRAP framework. two categories were created to compose the main four categories. They are:

- **Socioeconomic data:** It will address the factors collected in the early part of the survey where you will have more direct questions about the socioeconomic data of the respondents. This item will contain information such as motor vehicle ownership, children, age, marital status, occupation, educational background, previous bicycle experience, means of transportation used before and after the U-Bike project, among others.
- **U-Bike Services:** It will address all barriers and drivers of the U-Bike service. This aspect is important to evaluate in isolation from the other factors already mentioned, independent subcategories related to the service itself, such as: service pack accessories, bicycle maintenance service, service attendance, electric bicycle assistance, the application, among other categories.
- **Situational Aspects:** Aspects related to the user's perception of the environment in which the user is inserted, such as the infrastructure (or built environment) offered to the cyclist and his/her commute; Natural environment (which are relevant aspects when dealing with non-motorized transport modes), such as weather conditions, climate and hilliness; Distance; and Governmental Policies.
- **Behavioral Aspects:** It will address factors related to users' perceptions about personal aspects and attitudes in which the bike commuter is inserted. As an example, we have factors like Bike Culture; Effort; Practice; Safety; Social status; Time of travel; Car traffic and fear of accidents.

Throughout the coding phases it was necessary to subcategorize the main categories. Within the main subcategories, the aspects were cataloged as “Drivers to cycling” and “Barriers to cycling”, listed below:

- **Barriers to cycling:** This is the subcategory responsible for having all aspects that negatively influence, demotivate, disable, impacts negatively the cycling in some way.
- **Drivers to cycling:** This is the subcategory responsible for having all aspects that positively influence, motivate, enable, impacts positively the cycling in some way.

It is important to remember that this framework is conditional: the four main barrier categories are very often mutually interdependent and so should be approached in an integrated, context-specific way (Jesson et al., 2014).

As already mentioned, other "layers" of subcategories emerged from the main categories after successive interactions of data analysis and coding processes. Importantly, the same sentence in the interview can be categorized as both barrier and driver, in three different subcategories. For example: “I notice that there is a town hall effort to build more bike paths, that's good! But I still think it's too slow.” In coding, it will be possible to find such a phrase as “*driver - governmental policies - driver*” and as “*governmental policies - barrier*”; as it can be found in the section "*situational aspects - built environment - road, streets, bike paths, bike lanes - barrier* ".

The process of analysis and querying began after all coding, allowing associations between different categories and subcategories to be made through matrix coding queries to find interrelationships between each node created and coded during transcriptions and categorizations. NVivo12 crosses the existing information on each node and can establish dependency links and thus devise theories to solidify the study. The results of the data analysis are presented in the next section.

4 Results

The results section explores all the results obtained during the interviews, with the respective data already coded and analyzed. The main categories are presented as well as their subcategories. The results are presented with the quotes taken from the interviews, highlighting this aspect and what influence it has, as a barrier or driver, on the cycling experience and at U-Bike Service. The tables presented during the analysis always represent the number of participants who referred to the respective category, remembering that the total number of participants is 16, so the values ranged from 0 to 16.

This results section is focused on the different barriers and drivers to cycling, including those

Nodes

Name	Files	References
Behavioral	16	273
Cultural and Personal Aspects	14	73
Bicycle culture (lack of)	9	30
Cost	8	18
Environmental causes	7	11
Pratice (lack of)	5	7
Social Status	3	7
Psychological and Physical Well being	16	147
Accident and fear of traffic	15	56
Effort	16	35
Enjoyment	13	16
Increased well being	11	28
Safety and fear of theft	7	12
Time and Schedule	14	53
Situational	16	201
Built environment	16	139
Distance & Governmental Policies	9	21
Natural environment	15	41
Sociodemographic Data	16	266
U-Bike Service	16	222
Accessories	10	31
Bicycle	16	98
General Aspects	16	73

Figure 7 - NVivo screenshot with the four main categories and a subcategory layer

from the U-Bike service. In the Figure 7, the four main categories of nodes and its subcategories are shown. The reference column displays how many times a phrase has been related to a specific category or node. The total is counted in its parent category or its main category. The same goes for the files or respondent's column.

4.1 Situational Aspects: Barriers and Drivers to Cycling

Regarding the situational aspects, reported here as the built environment, natural environment, distance and government policies, factors related to the user's perception of the environment in which the user is inserted, are shown in Table 4 and described below.

Table 4 - Situational aspects and subcategories displayed in barriers and drivers' columns

			Barriers		Drivers	
	Files	Ref	Files	References	Files	References
Situational Aspects	**16**	**201**				
Built Environment	**16**	**139**				
Roads, Streets, Bike Panes and Paths			16	64	6	7
Parking facilities			12	22	13	22
Air Pollution			6	10		
Facilities at work (Lack of)			5	14		
Natural Environment	**15**	**41**				
Rain			14	31		
Hilliness			6	6		
High Temperatures			1	2		
Low Temperatures			1	1		
Wind			1	1		
Distance & Gov Policies	**9**	**21**				
Distance			1	3		
Governmental Policies			7	15	3	3

4.1.1 Built Environment

This section describes the results for four categories: roads, streets, bike lanes and bike paths; parking facilities; air pollution; and facilities at work. Built Environment or the infrastructure related to cycling, namely roads, streets, traffic signs and bike lanes and paths were mentioned by all 16 respondents as the major situational barrier within the built environment context which has a dauting aspect. Users reported that paths, lanes and bicycle infrastructure are not enough and do not meet the needs of bicycle users which commute to work. The few existing bike paths suit only for leisure and tourism purposes, as they are concentrated along the beach, as well as the lack of connectivity between the few cycle paths. Stone paving is also a problem for cyclists who complain about the discomfort of pedaling on this type of pavement, and when it rains, the risk of slipping, falling, an accident or to be hit by heavier vehicles is high because the braking is greatly impaired by the floor being extremely slippery (also discussed in natural situational barriers). Users also reported pavement with irregularities (holes, manhole covers and irregularities on the floor), narrow streets with little space, and prefer to cycle out of rush hours due to, as there is no infrastructure dedicated to bicycles. The heavy traffic and high speed of cars are considered factors that increase the risk and insecurity in commuting. U-Bike users report that, due of the lack of dedicated bicycle structures, such as bicycle lanes and cycle paths, they travel longer and avoid streets with heavy traffic or streets that have “higher-than-average” vehicle speeds, choosing routes "through the inner streets" of the city, that is, adopting longer but safer routes according to their perception. The facilities dedicated to bicycles have a direct influence on the subjective safety of cyclists (or perceived safety). In the interviews were also mentioned as good influences the existence, although small, of the infrastructure for bike commuting by six of the interviewees. For example, the Vila Nova de Gaia’s marginal cycle paths are better used for displacement and *Rua da Constituição* (when they are not occupied by cars). In general, cyclists feel safer and more relaxed on dedicated facility for a bicycle, such as bike path.

> *"The streets in Porto are terrible. The only good route in Porto is on Boavista Avenue, where you have the car tracks and a bicycle-only path. Otherwise, we have here on campus: there is a space which is indicated as being for bicycles, It is a roadside, which has holes, sewage caps, has those grills ... that is, it is not a path for bicycles, it is a small roadside with a few little traffic signs to pretend it is a cycle path. The infrastructure is not good!"*

Male, 22 years old, master's degree student, about Infrastructure

> *“on the bike path I feel safer, I am in a space that is practically mine, I do not have to pay much attention to the traffic, I am more relaxed”*

Female, 46 years old, senior technician, about Infrastructure

Another aspect is the parking facilities, reported as barriers to bicycle use by 12 out of 16 respondents. Difficulty in finding safe places, or having to lock in places that, in the perception of users, make them insecure about thefts, such as poles or dumpsters, which do not seem to be suitable places for the respondents. The last efforts to expand the bicycle rack in Porto University's schools were recognized, although they are still insufficient for the growing demand. In contrast, 13 out of 16 respondents said that parking facilities have positive influences, praising the infrastructure and security that the university offers in colleges, with the recent installation of more bike stands facilities; users also realized and praised after they began to move around the city or go shopping, the existence of bike stands in some shops; it was also mentioned that with the U-Bike project, some people returned to circulate through the Porto downtown, as there are covered parking lots for bicycles.

> *“The bicycle, in this aspect, gave me much more opportunities to visit more often the Porto downtown, for example. I'm going anytime and anywhere ... many indoor parking lots have bike stands. They stay safe. Here in college there are many sites that have been installed, in the city, there are many other sites that have been installed, next to the beaches, in that aspect not much reason of complaint, it is working well.”*

Male, 48 years old, Professor, about parking facilities

> *"Sometimes I go to downtown to have dinner with my friends, before I come back home (after class), to a restaurant, and I have to park it somewhere. sometimes it is a bit difficult to find suitable sites to attach. It is not right to park in the middle of the sidewalk, in anywhere, in passing areas and I have already been called to the attention by the police officer because of this. "*

Male, 30 years old, Researcher, about parking facilities

Users reported in the interviews that the air pollution caused by the gas from internal combustion motor vehicles is a negative influence in the daily life of those who use the bicycle for commuting. Six of the interviewees said that exhaust gases from bus and automobile fleet (considered old according to their personal perceptions) cause them discomfort when commuting; the presence of bicycle lanes would reduce this sensation; users avoids certain routes not to catch emission gases in the face; thinks of adopting a mask to soften the inhaled gases. There were no reports of positive influences, namely drivers, related to air conditions by the participants.

> *"I think it is the only unsafe thing is…to catch all that pollution in my face, and that is why I am thinking to get some stuff…they could have offered me, perhaps, a bandana that filtered the air a little, which is a bit boring and I even feel really healthy for the bike, but ... heat, particles, gases ..."*

Male, 61 years old, professor, about air pollution

Facilities at work, namely as showers and lockers were related as barriers due to the lack of infrastructure. In this respect, although the citations from five users who related to the topic were as a negative influence, they were not directly correlated with the U-Bike Project itself. Users reported that the absence of lockers and showers, related to previous experiences, when they used or tried to travel on conventional bicycles. They may need a shower when temperatures rise in summer or spring, they think it is difficult to have pieces of clothing at work and need to change them and professional activity demotivated bicycle use.

> *"...and I got sweaty, because I always cycle through a valley... so I arrived with dirty clothes, I had to change them. It's complicated, bringing clothes, having clothes here (at work), there, everywhere ... "*

Male, 47 years old, Professor, about changing clothes at work

4.1.2 Natural Environment

This section describes how landscape and weather conditions affect bicycle mode share.

Rain was reported by 14 out of 16 interviewees as a barrier to pedaling more and more often. The users claim that in addition to the discomfort of getting wet and arriving at their appointments with wet clothing, there is the risk of cycling on wet floors, and this incurs the difficulty in braking and the higher possibility of falling due the slippery floor, mainly because the city of Porto has many streets with the paving stone floor type, extremely dangerous when wet, as reported by cyclists of U-Bike Project. Some have claimed that they do not cycle with the rainy weather because of the electronic equipment they have to carry and the risk of damaging it.

> *"The rain dampens me because the route is long, it is about 10 km, if it was 1 km, I can wait for an interval to come, without rain, but 10 km is almost impossible to reach college without being all wet. And it's also dangerous, I've had a motorcycle accident and when there's rain, I do not cycle. It's to drive (car)! The floor is slippery, and here in Porto some streets that I use for cycle are paving stones. Paving Stones, bike and raining combination is not the best for sure. It's a safety issue indeed. "*

Male, 48 years old, Professor, about rain

Hilliness was reported by six of the users interviewed as a factor that impacts negatively the bicycle commuting due to the increase in travel time that occurs when climbing hills and the amount of slopes the city has. For u-bike users who used to travel on conventional bicycles before they start to use e-bikes, the geography was unfriendly to travel depending on which route as chosen, the effort demanded was high. On conventional bicycles, the hilliness of a route is pointed as a negative aspect because of the increased effort required to climb hilly routes as already seen in the literature review. In the context of electric bicycle, users reported not having problems related to effort because the bicycle has the electric assistance. There is only an increase in spent time to climb slopes, and the topography of the city of Porto is not bike friendly, being a negative mention about hilliness using an e-bike.

> *"I live about 13 kilometers away from here, and it takes about 45 minutes to come, in my return I spend more or less the same time, although it is a little less than 45 minutes because it is an area which is constantly climbing despite the bike having electric assistance ... It takes longer, in terms of travel time".*

Male, 51 years old, professor, about hilliness

High Temperatures, Low Temperatures and Winds were mentioned as barriers by one user each. High temperatures offer no chance for cooling, while wind was reported to be as dangerous as the rain-soaked track, and cold were negative influences for cycling.

4.1.3 Governmental Policies and Distance Aspects

Regarding to government policies, seven out of 16 users mentioned barriers which influence negatively bike commuting: The low number of bicycle lanes and bike paths; the need for joint planning by metropolitan city halls; the lack of awareness and educational campaigns for drivers to deal and respect more with cyclists; one of the users also associated the U-Bike project's success would be in danger if any accidents happen; and the slowness in implementing pro-bicycle policies and infrastructure. As drivers, only three users mentioned positive influences, for instance; an incentive of € 250 for the of electric bicycles purchase; some investment in cycle paths and some changes in traffic legislation to benefit and encourage bicycle use, like inclusion of bus corridors for bicycle use were cited in this topic.

> *The main thing for me is the infrastructures. City halls had to unite and try to get infrastructure for the bikes ... without cars, take the cars out of the street, not only the traffic is dangerous, the Portuguese drivers are very dangerous*

Male, 47 years old, Professor, about Governmental Policies

> *The things I have seen are positive ... in fact, this year's budget was to include…an incentive of 250 € in the purchase of urban electric bicycles. I also have seen investments in cycle paths… Government has implemented incentive policies for bicycle use, although this is moving in snail steps.*

Male, 30 years old, Researcher, about Governmental Policies

Regarding to Distance, only one person reported distance as a barrier to using the bicycle as a means of transportation more frequently. The same user reported the need to use the car as having no additional time for cycling to work, as well as after-work appointments such as picking up family members and not having the habit of commuting by bike since decades earlier.

> *"…and as the distance is a quite big because I live at Foz (Porto's neighborhood), it turns out to be difficult to manage, so I have to choose for the car, unfortunately…when I ride my bike, I spend about 35 to 40 minutes. By car it depends ... if I come in the rush time, I can spend 20 and 25 minutes, on a horrible day, I expect to spend more time. When I go off peak hours, I spend 10 or 15 minutes. When the traffic is more congested, a maximum of 20 minutes."*

Female, 61 years old, Professor, about distance as a barrier

4.2 Behavioral Aspects: Barriers and Drivers to Cycling

The behavioral aspects were reported here as factors related to users' perceptions about personal aspects and attitudes in which the bike commuter is inserted, are shown here in Table 5 and described below:

Table 5 - Behavioral aspects and subcategories displayed in barriers and drivers' columns

			Barriers		Drivers	
	Files	Ref	Files	References	Files	References
Behavioral Aspects	**16**	**273**				
Psychological and Physical Well being	**16**	**147**				
Effort			2	2	16	33
Accident - Fear of Traffic			15	56		
Enjoyment					13	16
Increased Well being					11	28
Safety - Fear of Theft			7	12		
Cultural and Personal Aspects	**14**	**73**				
Lack of Bicycle Culture			9	30		
Cost					8	18
Environmental Causes					7	11
Practice (Lack of)			5	7		
Social Status			3	4	3	3
Time and Schedule	**14**	**53**				
Travel Time			*3*	*11*	*11*	*25*
Schedule convenience					10	17

4.2.1 Psychological and Physical Well being

Within the drivers, the effort, namely the need to make little effort with the electric bike is the most positive point mentioned according to U-Bike users. All interviewees said that the electric assistance positively impacts the commutes by bicycle. The electric bicycle mitigates the effort required compared to the conventional bicycle, according to users' perceptions. As the effort required is lower, according to users, there is no need to take a bath or change clothes after a bicycle trip. There is no sweating, sweating is avoided or minimized, and for commitments such as teaching a lesson (for professors), attending a lesson (for students) or coming to work (employees), it is a very positive influence, as it avoids embarrassment caused by sweating. It was also mentioned that effort and sweat was an impediment to continuing to use conventional bicycles in the past. Others also reported that e-bike mitigates the grate efforts to climb slopes, long climbs and locations with elevated topography; e-bike fills a gap between people who are not physically able to perform certain routes with the conventional bike, but would like to ride a bicycle; do not feel fatigue and the fact of being able to manage the power according to the physical need, is a great factor to have chosen the U-Bike project. As barriers, only two users reported that their frequency and bicycle travel are reduced because of the lack of fitness and the need for breaks to rest.

> *“I used to cycle. I already had a bicycle, but it was not electric, it was mountain bike. I came a few times to college, but since it has a very large topographic variation, from my house to college, I used to sweat when I arrived here. It was inadequate. It was not suitable for coming to work.”*

Male, 30 years old, researcher, about effort requirement

> *On the climbs, the electric bike does not demand anything from me, that's the biggest advantage… I often come from the lower part of the São Luis bridge, and I ride uphill about 3 or 4 km. In the E-Bike, the effort is minimal, and it is not even noticed. if I come with a normal bike, I arrive here completely sweaty.*

Male, 48 years old, Professor, about effort requirement

Within the behavioral barriers, the aspect that most negatively influences is the sharing of space (streets, roads and avenues) with larger motor vehicles (15 of the 16 users), which, in the perception of the interviewees, is perceived as the factor where the risk of accidents is high. In this barrier, the feeling of "fear of accidents" was grouped with the traffic of cars, since it is always correlated. Users often report the speed which cars overtake them, the distance very close to the vehicles, often causing cyclists to choose alternative and longer routes to escape from tracks with higher speeds, which increases the perception of unsafe trip. Within the scope of behavioral barriers, this node is closely linked to the infrastructural barriers, which it was exposed in situational aspects.

> *"The criteria I use to choose my commuting (route) is traffic. I do not like to do certain roads that have a lot of traffic because I think that is not very friendly to cyclists, there are cars passing by very fast, I choose streets that, despite a longer route and take me longer…I prefer it." –*

Male, 39 years old, senior technician, about car traffic

Another behavioral factor that functions as a driver and influences positively the users in the choice of the bicycle is the Enjoyment. 13 out of 16 users said that they had taken more pleasant routes; united the useful to the pleasant when decided to adopt bicycle; likes to use for family outings on weekends; can pay more attention to the places that usually passes by car or by public transport; and enjoys the urban landscape and eventually do breaks in the trip to photograph.

> *“There is one route that I usually choose that is pleasant, which is an extremely safe area, and if there is a sunset, I can stop to take a photo.”*

Male, 51 years old, professor, about pleasant routes and enjoyment.

Regarding the influence of Psychological and Physical well-being, namely as Increased well-being, 11 out of 16 respondents answered that the adoption of the bicycle as a means of transportation is a positive factor in these aspects. Users reported that cycling: Improved mental health; promoted physical well-being and muscles toning; mitigated anxiety and stress; use as a means of maintaining shape and exercise more often; it is a way to relax; encourages the practice of sports; use as a form of rehabilitation due to the chronic or situational diseases they have; and use as a supplement or partial replacement for the gym.

“First, I like to ride the bike, then it's another exercise I can do, and I needed to do more bike exercise to strengthen my muscle around my knee because of an injury I had had some time ago, if useful to the pleasant.”

Female, 42 years old, senior technician, about increased well-being.

“At some point I got quite aggressive, completely, because you see the hours ticking by ...That makes me in a state of anxiety and aggression...Commuting by bike has allowed me to come much more relaxed to work.

Male, 43 years old, senior technician, about increased well-being and mental health.

Safety and fear of theft (seven interviewees) is one of the barriers that have been mentioned as negative influences, because there are no suitable places to leave the bike safely; were victims of robbery or know someone who was a victim of robbery; The electric bike draws more attention from burglars because it is a different model type; there are no safe public spaces and or they just travel by bicycle to environments where they know it will be a safe park space to leave it.

"Now, doing other activities, shopping, hanging out with friends, I do not do it because it's an electric bike, it's more valuable, it's easy to steal it ... I do not want to take the risk, so, no! When I go out for leisure purposes I only stop when I get home and bike does not leave my side."

Male, 39 years old, senior technician, about urban safety

4.2.2 Cultural and Personal Aspects

Lack of bicycle culture is a barrier whose impact on perception is mentioned by nine of the 16 U-Bike´s users as practices that negatively influence bike commuting, such as the lack of "civility" and "culture" towards bike lanes, bike paths and cyclists in general. We also included in this topic the lack of culture of local people to cycle more. Cyclists report the double parking by drivers as an obstacle, the lack of culture in using the bicycle as a means of transportation as well as the drivers in perceiving the bicycle as another vehicle; using the right-lane to overtake, the demotivation for bike commuting in rainy days by cyclists (which is not the case in other countries), improper use of roadside by cyclists and the lack of patience by drivers towards cyclists inducing fear, insecurity and negatively influencing the use of the bicycle as a means of daily transport to cyclists. We included a subcategory in this topic called Daily Routine – which was reported by two users - to relate the lack of habit of cycling in daily basis or with more frequency; lack of personal organization and difficulty for cultural change or lifestyle for cycle more often.

"Sometimes they start honking because the bike goes slower ... they're a bit impatient, you have to understand a little bit of that. There are some narrow streets that cannot pass the bike and the car (at the same time), and they have to

wait for me to reach the end of the street so they can pass (on a climb), they cannot wait for me to stop and get on the side to pass, that is, to me, makes no sense."

Female, 42 years old, senior technician, about bicycle culture

"What prevented me from cycling on a daily basis, such as going home-to-work, was the fact that I had never adopted it as a daily means of transportation."

Male, 39 years old, senior technician, about daily routine

Cost reduction was also related by eight respondents as a positive impact on the change to the bicycle as a means of transportation by users, when asked if it had any influence on their lives. By stop paying single and monthly tickets for subways and buses, or even stop spending on fuel, users said they can save more money. It was also mentioned that the fact that the program offers scheduled maintenance within the services package, with no extra costs, is a strong point that positively impacts cyclists, especially student users.

"The cost impacts me because cycling is much cheaper than traveling by bus, by metro, by far is much cheaper. And it is much more versatile. And I do arrive into my destination. The cost I had was the insurance, 40€ euros, the cost for charging the battery is little and if I am at university, I do not pay anything. It's irrelevant. I paid 40 euros of insurance for a whole year, while I would pay at least 20 euros for a subway or bus pass a month. So, it is worth it!"

Male, 22 years old, student, about cost saving

From the 16 respondents, seven responded that Environmental Causes are positively influencing factors as a driver for cycling. Mentions such as not polluting and worrying about the environment, adoption of sustainable practices as mitigation for the emission from internal combustion vehicles; and the association of some physical exercise and the reduction of the cost with the fact of being contributing with sustainable practices was reported here in this topic.

"I think this kind of initiative is very important because I think there is too much environmental pollution in the air from the use of motor vehicles, motorbikes, I think it would be great if there were more bicycles to circulate in the cities."

Female, 42 years old, senior technician, about involvement with environmental causes

Another factor related to effort is the lack of practice, which was reported as a barrier by five users. Lack of confidence, skills or experience; fear of falling at the start in green traffic lights; Imbalance due to lack of practice; discouragement to those who do not have the habit of cycling in the street; lack of practice that reduces the ability to anticipate a risk situation; were the reports of those who cited lack of practice as a negative perception of cycling.

"... at first, I confess that this situation left me a bit insecure because my start was, for lack of practice, a bit unbalanced ..."

Female, 46 years old, senior technician, about lack of practice

Social Status associated with cycling was reported by three people out of 16 reported that has some negative influence on the decision to adopt the bicycle as a means of transportation. social status is related to how we want other people to see us, and with personal and cultural values. They were quoted as saying that: people had a certain shame about riding a bicycle; they were ashamed to appear to their colleagues; they wondered how they would appear on their bicycle in front of their colleagues in the first moments; got hid when got at work to avoid comments. The same number of users (three) also pointed out that social status associated with cycling could be a driver, saying that even some Dutch politicians use a bicycle to commute; and that the shame of commuting by bicycle is irrational;

"That social shame has no reason to be. Colleagues…when they saw me, they thought it was funny, they smiled at me. At first, I thought it might be a bit strange: how do I show up on a bicycle? (Before, with my conventional bicycle), even hid a little to avoid people from starting to comment and stuff."

Male, 39 years old, senior technician, about Social Status

4.2.3 Time and Schedule

Starting with situational drivers, the Travel Time compared to others travel modes is reported in 11 of the interviewees as a driver to use the bicycle for urban travel. The bicycle is perceived as the fastest travel mode for daily commuting; allows users to arrive at work early, avoid the unpredictability of delays due to heavy traffic and traffic jams, thus avoiding stress and anxiety; avoids delays and possible waiting for public transport, such as buses and metro shift. The ease and speed of parking bicycles in the facilities among University of Porto's buildings was mentioned as a drive influence on the change to the bicycle commuting, because when using the car, the user reports there is a lot of time waste in order to gain access to the parking lot and find a parking space available. In contrast, three users reported that travel time has negative influences in bike commuting. Having more than 30 minutes to ride a bike is too much time; traffic (and the lack of dedicated bicycle structure) lead to longer cycling time; commuting time discourages from cycling more often.

"Although I live relatively close and have good accessibilities to the college zone, one of the concerns that I had and deeply irritated me personally was that in many cases, to do 10 km, that is more or less distance from home to college, I took between 40 and 45 minutes. This caused me a state of anxiety because I had to get to work on time. This caused me the normal irritation of a person being permanently in traffic and unable to move. U-bike makes it possible for me to have the times out of schedule, or it allows me to get to work early, and it takes about 20 minutes to get to work, nowadays"

Male, 41 years old, senior technician, about travel time

In fact, it is a lack of time problem. I must be here very early. I must lecture at 9am.

Female, 61 years old, Professor, about travel time

An equally interesting aspect reported by users is the Schedule Convenience**.** Seven people out of 16 reported that non-dependence on schedules, especially in relation to public transport, positively impacts U-Bike users, being an important driver for bike adoption. Do not depending on bus timetables,

> *“I do not have to depend on buses, I can go wherever I want, and there are areas that public transport does not serve, and this is annoying for me, it's also very tight, crowded, and I cannot go where I want, I have to always be looking the bus timetables and it is a bit annoying.”*

Male, 19 years old, student, about dependence of schedules

4.3 Identification of patterns and links between aspects

It was also investigated, among the two main categories - situational and behavioral -, the influence between their respective individual aspects. The results of this section are displayed in Table 6.

The first cross-reference pointed out that bicycle infrastructure (roads, streets and bike lanes and paths) directly influences users' perception of the increased “risk of accidents and fear of traffic”, identified by nine users, due to the lack of dedicated bike commuting facilities that puts cyclists in the same vehicle traffic spaces. The same lack of cycling infrastructure is related to the “lack of bicycle culture”, in which six users point out that there is no proper respect for commuting by bicycle and its spaces, such as parking in the bike lanes and doing more abrupt maneuvers when sharing the same street, for example. Rain was also associated with fear of traffic and accidents, by the increased risk when the floor becomes wet and slippery.

The effort, which was pointed out as a driver in the interviews, as the electric bike requires little effort from users, was related to Facilities at work by five users, as there is no need to provide these facilities when the user cycles on a e-bike.

It can also be seen the “Safety and Fear of theft” line related to the “Parking Facilities” column, which were identified by four users.

Table 6 - Cross-references between Behavioral and Situational Aspects

Behavioral Aspects	Situational Aspects (total)	Build Environment (total)	Build Environment: Roads, streets and bike lanes	Air poll	Facilities at work	Parking facilities	Distance & Governmental Policies (total)	Gov. Policies	Dist	Natural environment (total)	Rain	Hilliness	Wind	High Temp	Low Temp
(total)	15	14	11	4	5	5	6	5	1	9	8	3	1	0	0
Cultural And Personal Aspects	11	11	9	3	0	1	3	3	0	1	1	0	0	0	0
Bicycle culture (lack of)	6	6	6	0	0	1	2	2	0	1	1	0	0	0	0
Environmental causes	3	2	1	1	0	0	0	0	0	1	1	0	0	0	0
Pratice (lack of)	4	4	3	2	0	0	1	1	0	0	0	0	0	0	0
Social Status	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psychological and Physical Well being	14	11	9	4	5	4	5	5	0	8	6	2	1	0	0
Accident and fear of traffic	11	10	9	4	1	0	4	4	0	5	4	1	1	0	0
Effort	6	5	0	0	5	0	0	0	0	2	1	1	0	0	0
Enjoyment	3	2	0	2	0	0	0	0	0	1	1	0	0	0	0
Increased well being	5	4	1	1	3	0	0	0	0	1	1	0	0	0	0
Safety and fear of theft	4	4	0	0	0	4	1	1	0	0	0	0	0	0	0
Time and Schedule	7	7	3	1	2	1	2	1	1	2	2	1	0	0	0
Schedule Convenience	2	2	1	0	1	0	0	0	0	0	0	0	0	0	0
Travel Time	7	7	3	1	2	1	2	1	1	2	2	1	0	0	0

4.4 U-Bike Service

This section is dedicated presents the results of the aspects inherent to U-Bike Service, including service barriers and service drivers. Table 7 contains all categories and subcategories in this section, divided by barriers and drivers. To better visualize the subcategories that the service offers, we proposed a division into the following structure to better evaluate the services, according to users' perception: a subcategory called Bicycle, to list and assess all vehicle features; the category called Accessories, for items that the service pack offers, such as bags, helmet, and headlight; and the General Service Aspects for maintenance, communication, service attendance and mobile app.

For better viewing, the cells with the most relevant barriers and drivers have a darker shade of red, as well as the number of references in their category.

Table 7 - U-Bike Service Aspect and subcategories displayed in barriers and drivers' columns

			Barriers		Drivers	
	Files	Ref	Files	References	Files	References
U-Bike Service	**16**	**222**				
Bicycle	**16**	**98**				
Electrical Pedal Assistance			3	5	16	34
Battery - Autonomy and Charging			6	12	9	11
U-Bike			3	8	5	8
Tires			1	1	7	7
Derailleur, Shifter			2	3		
Rear mudguard			1	2		
Anti-theft saddle					1	1
General Service Aspects	**16**	**73**				
Maintenance			9	16	11	14
Comunication and Service Attendance			7	15	8	10
Mobile App			11	12	1	2
U-bike stands (racks)			2	2	1	1
Cost			1	1		
Accessories	**10**	**31**				
Bags			2	2	4	4
Helmet			2	2	4	4
Headlight					3	4
Padlock					2	3
Lack of						
Saddlebag (suggestions)			2	3		
Mask (suggestions)			1	1		
Turn lights (suggestions)			1	1		

4.4.1 Bicycle

This section describes the results about all the features and characteristics of U-Bike's bicycle.

The Electric Pedal Assistance was mentioned by all 16 interviewees as having positively impacted their trips due to the electric bicycle. The electrical assistance is closely related to the required effort, already mentioned in the Situational Drivers. The reports of the users speak of the ease with which they make the routes; the users' lack of physical capacity and age to do the daily commuting according to their own perceptions are now mitigated by the assistance of the electric motor; the ability to cycle on climbs; users do not get sweaty for their daily appointments; never felt physical discomfort due the reduced effort. But three users out of 16 also complained about some aspects of electrical assistance that impacted negatively. The electrical assistance could be installed in the pedal, instead of the wheels, giving more precision and fast response and avoiding flaws by the electrical motor; and speed limiter.

"With the electric bike I'm fatter! Ha-ha-ha…any climb is much easier to get it. It's not that it gets easier, it gets much easier. There is not much effort. The electric bicycle is much more practical. That class at 8 o'clock in the morning, in the winter, is cold, unpleasant, sound sleepy, tired and freezing, ... with the e-bike, it is just moving the feet and it is cycling already."

Male, 22 years old, student, about U-Bike's electric assistance

"The engine that could be on the pedal instead of the wheels... I have tried the electric mountain bike (laughs)...the assistance is much more precise."

Male, 47 years old, student, about U-Bike's electric assistance

The Battery and autonomy were also pointed as positive influences for nine of the 16 users of the U-Bike in commuting by bicycle. In the interviews it was mentioned that the battery has a sufficient charge for their needs; charging is relatively fast; never ran out of batteries; got surprised with the its autonomy; after some time, they were managing the battery power so that it would last longer.

"I do not think it has a bad autonomy, even because it's only two hours charging to be complete. I think it's cool enough. "

Male, 23 years old, student, about battery life and charging time.

On the other hand, the autonomy of the battery was criticized and negatively impacted the perception of six of the interviewees in the research. Users reported being afraid of running out of battery; need to save energy by lowering or shutting down the electric motor; there is little autonomy; they find it inconvenient to have to carry the charger device with me; the battery has a high consumption with the bicycle stopped; you need to always charge the battery; low autonomy prevents you from taking walks after work; you need to remove the battery from the receptacle to avoid wearing it when the bike is stationary; manage consumption by reducing power; they hoped to have more autonomy. Until the date of the interviews, users had the expectation that the battery could have its autonomy increased due to the update of the software made by the technicians of the project.

"The negative aspect is the battery. In my case, round trip is about 15 km or 16 km. It seems to me that It cannot achieve more than 20 km, that is, if I want to go out for dinner in downtown after work, my bike will be certainly with low battery power. I do not have much freedom to cycle around after work because of battery life."

Male, 30 years old, researcher, about battery autonomy

U-Bike Bicycle was also reported in the interviews. Three users reported negative bicycle influences, but also provided suggestions for future improvements, as the larger weight of the bicycle could require full suspension (rear and front suspension); Bicycles are only made in one size and may be uncomfortable for taller or shorter people; The speed limiter (which is mandatory under European legislation); Lack of agility in cornering (which is a characteristic of these electric city bikes). For the drivers, seven users have given praise to the bike, mentioned the good quality of the materials chosen, the comfort, the amazing experience of riding an electric bike.

> *"I like cycling a lot and I particularly liked this U-Bike bike to have electric assistance. Really cool! I had never had an experience with an electric bike."*

Male, 23 years old, student, about the Bicycle of U-Bike.

> *"…bicycles were provided one size fits all and people are not all the same height, there are bigger and smaller people. For me, a little taller than average, a bike with a larger frame would be appropriate. I think this frame used is the size M, for me it would be the L, and this I think is important because of the posture that the cyclist has on the bike."*

Male, 48 years old, professor, about the Bicycle of U-Bike.

Rear mudguard and antitheft saddle were also mentioned by a user on each item, such as barriers and drivers, respectively. Regarding mudguard, the user judged it to be ineffective since on rainy days, the feature cannot contain back splashes of mud and water, while antitheft saddle was mentioned as a plus point as the risk of equipment being vandalized or stolen is mitigated by the system. The tires were evaluated positively by seven users, mainly for the low occurrence of punctures, while the Derailleur (Shifter) was criticized by two users in moments of lack of battery charge, for having few cogs, and therefore, is relatively heavy for climb the hills.

4.4.2 General Service Aspects

This topic is intended to present the results general aspects of the service such as maintenance, service, communication, app, cost, and U-Bike Racks.

Maintenance was well evaluated. Ten users of the 16 mentioned the fact that the project includes periodic maintenance, it positively influences the perception of service quality. In addition, cyclists state that due to the lack of knowledge in bike maintenance, maintenance service is a positive point. They say maintenance is good; fast; the store location is easy to find; they find the delivery service interesting, in which the workshop takes care of picking up the bike, do the maintenance, and deliver it at home, even for an extra cost; they like the maintenance being costless or to be included in the insurance package. In contrast, nine users have also reported some negatively influencing aspects such as the need to carry special anti-theft keys to do basic maintenance such as disassembling the wheel if there is a flat tire or adjusting the saddle, and only a few workshops and the authorized shop they have such tools. Soon, the user is dependent on calling someone to help him; the need for a collection and return service for bicycles when they need to do periodic maintenance, since some of the users complain that they do not have time available to take it to the bike shop and wait for it; the authorized bike shop is too far away; should have more options in Porto;

> *"Having maintenance three or four times a year for me is fantastic. I like cycling but I do not know exactly what it takes [for the maintenance], and having someone do it for me, I find it fantastic. They have always been very attentive, I send e-mails, they answer, they help ... I'm satisfied! There's nothing wrong with that. I*

took the bike to the maintenance to change the software, I'll do it (scheduled maintenance) in the coming weeks, before the summer."

Male, 22 years old, student, about U-Bike's maintenance

"I think it is a bad thing that users should have a specific tool that allows them to take a flat tire off. If there's a flat tire in those bikes, we do not have any tools. I realize that the screws must have a special design to prevent theft, but I cannot keep waiting for people because I do not have a tool. That was not well thought out. On my bikes I have a patch kit, inner tube, and I always carry them with me, because I cycle 50 km, for example, and I cannot depend on anyone if there is a flat tire, I do not have to call someone."

Male, 48 years old, Professor, about U-Bike's maintenance

The communication and service attendance (responses of the project coordination to the user's requests), e-mails, the delivery of the bicycles and the orientation regarding the functionalities and maintenance were evaluated. Seven users complained about some aspect of the service, and four users showed dissatisfaction with the delay in the delivery of bicycles and a user bought a bicycle because he did not know if the project would continue. Only one person said they could not contact the project coordinator and that they emailed and phoned and could not get their requests answered regarding scheduled bike maintenance. One user said reported that a close person did not understand the rules of the project and gave up before getting the bike because he did not know if he could achieve the goal of pedaling 10 km of average daily. However, seven users positively evaluated the care provided by the coordination of the U-Bike project, the organization, structure, reception, delivery and the explanation of the functionalities of the bicycle, such as using the padlock, removing and recharging the battery, newsletters about any precautions and maintenance that must be done on the bike (such as checking the tire pressure) and the responsiveness of managers to users.

"The project took almost two years from the day I applied and the day I got the bike. I bought a conventional bike at the time, because I no longer knew if U-Bike would continue."

Male, 39 years old, senior technician, about service attendance

"Direct contacts were given to any situation related to bicycles, and even to the management of U-bike. we have a direct access number. If something happens to me, if the bike is stolen, if there is damage, that reminds me a little of a travel assistance"

Male, 41 years old, senior technician, about service attendance

According to the interviews, the major number of complaints were the Mobile Application with 11 out of 16 interviewees have mentioned as impacted negatively the service, which was not available to the users at the project launching. Soon after launch, the app only had the GPS location function by GPS, instructions of actions to be taken in the mandatory maintenance schedule, repairs and in case the bike be stolen. Functionalities related to statistics and travel information such as average speed, kilometers traveled, travel time and altimetry have not yet been made available in the application until the last interview. Users reported here in this item, a bit of frustration, expectation and annoyance regarding the app. Users also reported that they could not download the application because it is not available for IOS. It was also mentioned that such feature would be very interesting to track progress in commuting.

> *"The application still does not work, it displays where the bike is, so I use the Runkeeper for the statistics .... I'm sorry because the bike has GPS, autonomous battery...I sometimes start cycling, (then I remember) I forgot to turn on the Runkeeper, (I have to) stop the trip to turn it on. The U-bike bike could do that. I was quite disappointed because the bikes were delivered with a year and a half of delay and the application does not work ...."*

Male, 48 years old, professor, about U-Bike mobile app.

4.4.3 Accessories

This topic will address users' perceptions of the accessories included in the U-Bike package, which were also assessed in the interviews. Some accessories which are not in the package have been included and are shown in table 7, preceding the *Lack of* line.

Bags and cellphone case: Some negative aspects were mentioned by two users, such as the cell phone cases and bags being fastened with Velcro, which could be easily stolen if left on the bicycle; and not suitable for larger-sized cell phones. Four users praised the accessories which had been offered in the project package.

> *"The bags they provided...don't fit my phone. It's too small, my phone is big. The other bag is interesting, but it is a frame bag, but I think they could let you choose other accessories that suits you best."*

Male, 30 years old, researcher, about the bags.

Negative comments were made by two users about the Helmets. The helmets had only one size (medium), so people with a different helmet size would not take advantage of the accessory; one user said he did not wear the helmet because he thought it was "ugly", and a coupon to pick a product from the partner store could solve the problem. Five users said that the fact of the project offering the helmet is a factor that adds value to the service.

> *"They should have given a voucher and the person chose the helmet. I don't wear that helmet. I'm already buying a helmet that I like, I don't like the one they gave me, so I don't use it…"*

Male, 61 years old, professor, about helmets.

The headlight was mentioned by three users as of good quality for the night trips and makes the bikes are perceived by pedestrians and drivers while padlock was reported by two users as a plus of the service and that is essential when parking on the public promenade or faculties' bike racks.

For the saddlebags, two interviewees reported as a negative aspect the lack of this accessory, claiming that the project is intended to foster bike commuting, therefore, should include such item to increase the bike usability. It has also been reported that the advertising signs on the rear of the bike prevent them from finding a saddlebag that would fit it; and due to the program has a limited period for users, soon they would lose money with the accessory if they could not renew the bike for longer.

> *"The purpose that U-Bike was made for is transport, it should contemplate a saddlebag usually brings things, and I had to buy a saddlebag with my own money to ride the bike and that's boring because when my contract ends, the saddlebag will have no use. Since there are those U-bike advertising signs on the back of the bike, it makes it a bit incompatible to find a model. They provided many things such as helmets, handbags, including a handlebar bag for the mobile phone but the saddlebag should be included in this list of accessories because it's really important!"*

Male, 36 years old, senior technician, about the bags.

Other Accessories: In the overall, the accessory package was highly praised by six of the respondents in the study. The light was mentioned as of good quality for the night trips and makes the bikes are perceived by pedestrians and drivers; that the anti-theft saddle passes unnoticed, but is very important to avoid bad surprises; the tools offered also received praises; In some faculties, the project has implemented specific stands (racks) for the U-Bikes, where it is easier to lock bicycles and there are jacks for recharging the battery. One interviewee said that the bicycle could have been designed with this feature for specific U-Bike Stands before, and the bicycle could have such as the integrated bicycle charger, a retractable or an extendable plug. Two interviewees pointed out that the plug is not useful because nobody would leave their charger and battery exposed on the bike, as there would be a risk of theft. Only one user praised the bike stands.

> *"I do not understand how the bike does not have an outer plug for charging the bike. The most they could steal is the cable. No one will carry the bikes there in the (new) bike racks. It could have the integrated charger, or an extendable plug."*

Male, 48 years old, professor, about the U-Bike Stands.

5 Conclusion, discussion and future research

The relevance of the transport sector to the economy, tourism and people mobility is vital, however, this sector also accounts for a considerable share of gas emissions. In the global context, 14% of all emissions come from this sector, while in Portugal, car dependence makes the two main urban centers in the country have high travel rates for this mode: 58.9% in Lisbon and 67.6% in Porto. Transport sector in Portugal accounted for 25% of all country's GHG emissions, being the 9th fastest growing EU member in terms of emissions by transport sector between 1996 and 2016: 70% (European Environment Agency, 2018). Data from urban mobility of Porto and Lisbon shows that up to 61% of people moving in cities have study, work and shopping purposes, with low occupancy rates per vehicle (up to 1.60), average distances per trip around 10 km, which suggests that part urban mobility could be absorbed by the bicycle travel mode.

The electric bike also appears as a sustainable option to add efforts to this shift. It is faster in terms of travel time, requires less physical effort to get from one point to another, it sustains speeds and accelerate faster, and hilly cities turn to be flat no matter age or physical condition user has. Unlike conventional bicycles, in e-bikes some barriers are softened or mitigated, such as distance, effort and hilliness, which is more linked to travel times.

Transport Sector is considered a key point both in mitigation strategy and in changing the behavior of the travel mode mainly within urban environments, therefore, governments, policymakers, private entities, scientific and academic entities, NGOs and overall society should be included in paradigm shift strategies in view of the goal of the Paris agreement, whose goal is to avoid surpassing the 1.5-degree temperature increase expected by mid-century.

This study aimed to understand, within the Portuguese urban context, namely in the metropolitan area of Porto, the barriers and drivers for the adoption of the electric bicycle as a means of transportation. For this, we use "U-Bike" project, whose users are from the academic community of University of Porto, among students, teachers, employees and researchers. Part of our goal is to contribute to the literature on bicycle mobility through a qualitative approach based on user perceptions, and to understand the barriers and drivers of e-bike use, helping to make bicycle commuting more adopted and explored, promoting physical and psychological well-being and sustainable mobility in Portuguese urban areas.

We found as the main results of this study that, within Situational Aspects, the built environment, notably the bicycle infrastructure, has a profound impact on the user's perception of the urban environment friendliness in making cyclists feel (un)safe when traveling around the city. Deficiencies in urban structure have been severely pointed out as barriers to cyclists when accessing cycle lanes or cycle paths, exclusive or not for bicycles. The relevant point to be reported in regard to the built environment was the functionality: much of the cycling network only serves leisure purpose cycling, leaving aside the users who want to use the bicycle as a regular means of transportation, especially doing round-trips, from home to work or faculty, and vice-versa. This aspect had a direct impact on the user's perception of Governmental Policies as barriers.

Other aspects such as parking facilities in faculties were praised with caveats. Users recognize efforts to increase the availability of bike racks but pointed out that these parking spaces need to be expanded. In the public space, there are few places where you can store the bikes. There is no consensus on the provision of parking facilities in commercial establishments, and distance, which is very relevant in all quantitative and qualitative bicycle commuting studies, had little relevance since this barrier is mitigated because the electric motor assistance. However, it is important to emphasize that there is an increase in the frequency of weekly trips, and a reduction in travel time when the distance between origin and destination is shorter.

As a recommendation, the promotion of cycling is likely to achieve best results when increasing the provision of safe facilities, such as dedicated bike paths, or the bike lanes between residential, commercial, service and shopping areas, ensuring convenient and secure cycle parking facilities. The publicizing of these areas for parking and commuting facilities, addressing not only utility cyclists, but also leisure cyclists, is strongly recommended.

Leisure cycling cannot be ruled out as it is considered a predecessor segment or stage of utility cycling, that is, cyclists traveling to work, shopping or school and university. Attractive scenery, bike parking, and shared bicycles are important drivers and should be considered. Cycling campaigns should promote leisure cycling as they attract new and infrequent cyclists, as well as it should address the utility cycling, acknowledging the benefits for this segment.

Regarding to the Natural Environment Aspects, rain has proved to be a natural barrier that significantly impacts the frequency of bicycle commuting. The rate of rainy days of the city of Porto shows, at first glance, high in relation to the Portuguese average. However, comparing the same rate of rainy days with European cities such as Copenhagen and Amsterdam, which have the highest cycling rates in the world, rekindles the discussion in the field of culture and habit. The same question extends to temperature issues: cities with harsher winters that have better cycling rates. Being the second natural environment aspect most cited by users, hilliness was presented to be a barrier that was mitigated or softened with the use of e-bikes, as this aspect was cited as barrier but with “caveats”, as the e-bike turns the slopes slightly “flat”. However, for a larger and broader study, this barrier tends to be more important in bicycle adoption, as it is closely linked to the effort considering the large-scale use of the conventional bicycle.

Regarding the Behavioral Aspects, for this research, we consider this to be the main group of aspects and where communication, marketing, transportation entities and policymakers should focus as a starting point for future studies. E-bike can mitigate the efforts previously required to ride a conventional bike and has filled a gap between people who would like to ride the bike on a daily basis but did not feel able to do so due to physical condition, terrain (hilliness and distance) or by age: three people are over 50 years old in the samples and one of them had sequelae in motor functions due to childhood polio. All users praised and said that electrical assistance requires very little physical effort, consequently, there is little sweat, so facilities at work for bathing, changing clothes and lockers were unnecessary. However, it is important to remember that the data collection period was not at high temperatures, as we discuss later. Hilliness, which is an intrinsic aspect of effort, is also a barrier that has been softened with e-bikes. The main outcomes achieved in behavioral aspects were the improvement in the physical and psychological well-being of users, especially the reduction of anxiety and stress levels, feeling energized to daily commitments through the regular exercises that bike travels provided, improving workforce physical and mental health, besides the enjoyment are intrinsic for those who commutes by bicycle. Such outcomes should be largely explored and reinforced by campaigns, focusing on the increased well-being, enjoyment and other benefits when switching for bicycle mode, mainly when targeting car users, will support and raise the levels of cycling.

In contrast, other behavioral factors such as fear of an accident, and the threat that larger and heavier vehicles represent to cyclists were identified as significant barriers in the study. A relationship between the (lack of) infrastructure dedicated to bicycles and the perception of unsafe cycling and governmental policies can be seen in the Matrix Coding Query, at table 6, where we cross-referenced the Situational and Behavioral Aspects. We can also see the relationship of lack of friendliness ("Lack of Bicycle Culture" line) by automobile drivers to cyclists, at the intersection of the column "Roads, Streets and Bike Lanes".

U-Bike Service Aspects

Overall, as the results show, the service is very good. All respondents praised (some even effusively) the U-Bike Project, and the project coordination has been constantly monitoring the demands of users and readjusting the service when necessary, such as for those who have schedule restrictions, collecting and delivery of bicycle by the bike shop, when the equipment requires maintenance, for a fee. However, it is necessary to bring some aspects that present themselves as opportunities for improvements. The maintenance site is a bit distant, located in Vila Nova de Gaia. If the project intends to expand, having other periodic maintenance partner stores will improve service delivery levels. Another aspect that was criticized or missed by users were the app functionalities, which, until the day of the last interview, only had only the bike's location by GPS. Other features like previous and current travel data (average speed, distance, travel time and routes) were not yet available. This is a feature that can positively impact frequency of bike use, because as the project requires the user to commute a given number of kilometers per month, having this feature would be essential to monitor performance.

The battery autonomy was mainly criticized by users who make long daily trips, whose routes are from 10 km away. At this point it is interesting to introduce the user to some power management practices of the electric motor, such as lowering power when going downhill or on flat segments which requires substantially less or no effort by the user; reassess the battery consumption of the electronics module when the bike is stationary; replace the batteries with larger capacity units (reevaluating costs) or instruct the user to carry the charger when they notice that the battery charge will be insufficient for their travel.

Another aspect was the bike racks developed especially for U-Bikes which are can be found in faculties of University of Porto: it is not possible to recharge the battery, as the system requires the battery to be ejected, being exposed to eventual thefts. For future bike design readjustments, the charger and an extendable built-in cable could be included, preventing the user from carrying the charger to faculties.

With anti-theft bicycle parts, some bolts require special tools for removing the wheels (especially if there is a flat tire) and saddle adjustment. Providing these special screwdrivers can be a solution to avoid hassle if the cyclist needs an adjustment, or even being far away from the workshop or on the weekend with a flat tire to be replaced. The mudguard was also claimed to be inefficient when the floor is wet, detaining some users to cycle in rainy days.

And finally, for the accessory pack, the project already offers a range of accessories that are already included in the project fee, however some items like helmet and cell phones bags are only available in one size. The program could provide a broader list of accessories, and if the user exceeds this quota, he would pay an additional fee. For example, instead of cell phone bags, the saddlebags. Or instead of the project helmet, a more expensive helmet.

Other factors may require further study, such as the need for lockers and showers, since the survey was conducted between March 27 and May 14, 2019 (Spring) when temperatures are milder. It is also important to remember that most interviews were conducted in early spring, and their results were influenced by user experiences during the winter period, with lower temperatures. Behavioral aspects related to Social Status can also be explored in future research.

This study shows that electric bikes should be further explored by all entities involved with the transport sector due its potential. Despite the low costs of facilities compared to automotive road infrastructure, the need for appropriate legislation and cycling adoption campaigns, these efforts should be addressed together for greater effectiveness. The e-bike meets requirements as a zero-emission mode of transport, meets and expands the segments of users who would like to combine utility and convenience, as well as enhances the individual's well-being through association with physical activity. The U-Bike Project presents itself as a program that has very good levels of satisfaction and whose acceptance is high, requires few improvements and if convenient, can be expanded.

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APPENDIX A: Literature Review's References Table

Table 8 - Literature Review's references by aspect

Main Category of Aspects		Aspects	Influence	Reference
Situational Aspects	Built Environment	Distance	Distance increase results in less cycling;	Dickinson, Kingham, Copsey, & Pearlman Hougie, 2003; Stinson & Bhat, 2004;
		City Size	small and medium-sized cities have the highest share modes for cycling	Rietveld & Daniel, 2004; Keijer and Rietveld, 2000
		Parking facilities and facilities at work	Not conclusive	Heinen et al., 2010; Dickinson et al., 2003; Berntsen et al. 2017; MacArthur, Dill, and Person, 2014; and Popovich et al., 2014;
		Infrastrucuture	dedicated cycle paths incrase cycling rates, safety levels and perceived safety	Garrard et al., 2008; Hunt & Abraham, 2007; Stinson & Bhat, 2005; Pucher, 2001; Klobucar and Fricker, 2008; Barnes, Thompson, & Krizek, 2006; Pucher & Buehler, 2006
	Natural Environment	Hilliness, weather and climate	Slopes results in less cycling; Rain, Low temperatures, and colder seasons results in less cycling;	Heinen et al., 2010; van Wee, Rietveld, & Meurs, 2006; Moudon et al., 2005; Stinson & Bhat, 2005; Heinen et al., 2010; MacArthur, Dill, and Person, 2014; Liu, Susilo, and Karlström, 2015; Stinson and Bhat, 2004; Bergström & Magnusson, 2003; Nankervis, 1999; Carr & Dill, 2003; Pucher and Buehler, 2006; Brandenburg, Matzarakis, & Arnberger, 2004; Pordata.pt, 2019; Weather-and-climate.com, 2019;
Behavioral Aspects	Well being	Effort	Effort required is proportional to distance;	Heinen et al., 2010; van Wee, Rietveld, & Meurs, 2006
		Enjoyment	Cyclists evalute their journeys as more relaxing and exciting compared to public transport users, drivers and walkers; Stress alleviation; Improves health and physical activity	Stinson & Bhat, 2004; Gatersleben & Uzzell, 2007; Popovich et al. 2014; Fyhri and Fearnley, 2015; Gatersleben & Uzzell, 2007; Iwińska, Blicharska, Pierotti, Tainio, & de Nazelle, 2018; K.C., S., & J., 2012; T. Jones, Harms, & Heinen, 2016
		Traffic, Safety	Negative perception of high traffic intensity roads;	Dill and Voros 2007; Petritsch, Landis, Huang, & Challa, 2007;
	Cultural and Personal Factors	Habits and Culture	Cycling in childhood, leisure cycling and experimentation increases bike commuting	Rose and Marfurt, 2007; M. Stinson and Bhat, 2004; Dill and Voros, 2007;
		Social Status; Enviromental causes	The way people see cyclists could influence new adoptions depending on the context; High social status is likely to cycle less; Environmental causes is not conclusive;	Skinner and Rosen, 2007; Daley & Rissel, 2011; Dill & Rose, 2012; Moudon et al., 2005; Ryley, 2006; Iwińska et al., 2018;
		Cost	Factors such as fuel prices, income and car use are linked with the use of bicycles; Offering loans increase bike commuting	Heinen et al., 2010; Bergström & Magnusson, 2003; Pucher & Buehler, 2006; Dickinson et al., 2003;
	Time & Schedule	Travel Time	Increase in trip time results in less cycling	Noland & Kunreuther, 1995; Wardman, Tight, & Page, 2007; Heinen et al., 2010; Iwińska et al., 2018; Gatersleben & Uzzell, 2007; Popovich et al., 2014; Berntsen et al, 2017;
Socioeconomic Aspects		Woman	women cycle short distances to work than men	Garrard, Rose, & Lo, 2008; Howard & Burns, 2007
		Income	Not conclusive	Pucher & Buehler, 2006; Parkin, Wardman, and Page 2008; M. A. Stinson and Bhat, 2005; Pucher & Buehler, 2008; Witlox & Tindemans, 2004; MacArthur, Dill, and Person, 2014; Popovich et al., 2014;
		Age	Cycling declines with increase	Heinen et al., 2010; Heinen, van Wee, and Maat, 2010; Fishman & Cherry, 2016; T. Jones et al., 2016; MacArthur et al., 2014;
		Employment status	Part-time workers commute more frequently by bicycle	Heinen et al., 2010; Boumans & Harms, 2004;
		Car ownership	Results in less cycling	Parkin et al., 2008; Pucher & Buehler, 2006; Stinson & Bhat, 2004, 2005; Heinen et al., 2010; Popovich et al. 2014; MacArthur, Dill, and Person, 2014; Cherry et al. 2016; Fishman and Cherry, 2016;
E-Bikes		General Aspects	electric bikes can soft the distance barrier for untested users; increases frequency; increases woman use	Hendriksen, Knaap, & Rooijen, 2015; Fyhri and Fearnley, 2015; Fishman & Cherry, 2016; Fishman et al., 2015; MacArthur, Dill, & Person, 2014; Popovich et al., 2014; Simsekoglu & Klöckner, 2019; Berntsen, Malnes, Langåker, & Bere, 2017; Cherry, Yang, Jones, & He, 2016; Dave, 2010; CONEBI, 2017
Sustainability and Transformative Service Research; Urban Mobility background			"a system that supports social connectivity and economic prosperity in a fair and equitable manner, without presenting risks to local or global environmental quality and resource use"	P. Jones, 2014; European Commission, 2015; Davies, Jefferson, Longhurst, & Marquez, 2000; Peet et al., 2019; Banister, 2007; Balaker & Staley, 2006; Banister, 2005; WCDE 1987; UNESCO, 1972; UNESCO, 2005; United Nations, 2015; Hidas and Black, 2002; Anderson et al., 2013; Anderson, 2010; Sangiorgi; 2011; Ezell, Ogilvie, & Rae 2008; European Commission, 2009; Baker, Gentry, & Rittenburg, 2005; Prahalad & Ramaswamy, 2004; Mehren, 2002;
Transport Sector, Greenhouse gas emissions and Environment Threat				Peet et al., 2019, Ambiente, 2019; Mason, Fulton, & McDonald, 2015
Urban Mobility Scenario and Metropolitan Areas				(Mason, Fulton, & McDonald, 2015; European Commission, 2014; Instituto Nacional de Estatística, 2018; Pucher and Buehler, 2008;

APPENDIX B: Informed consent form and interview guideline

Consentimento Informado

Estamos a solicitar a sua participação para um estudo no âmbito do "**Estudo da experiência do cliente de serviços de mobilidade sustentável – o caso do projeto U-Bike**", projeto estabelecido em co-promoção entre a Faculdade de Engenharia da Universidade do Porto, juntamente com um consórcio alargado de outras universidades portuguesas, incluindo a Universidade de Aveiro, enquadrando-se num projeto conjunto com a Universidade de Zaragoza (Espanha) e será co-orientado pelo Professor Jorge Sierra-Pérez, especialista em desenvolvimento de produtos sustentáveis.

Este estudo tem como objetivo estudar a experiência dos utilizadores do serviço U-Bike, em dois contextos distintos, (Porto e Aveiro) tendo em vista:

1) Perceber o contexto de utilização da bicicleta em cada cidade antes do arranque da operação U-Bike;

2) Caracterizar a experiência com o serviço prestado pelo U-Bike

3) Compreender os motivos e barreiras à adopção deste serviço

4) Propor melhorias para o redesenho do serviço que melhorem a experiência, ao mesmo tempo que mantêm o

carácter sustentável do serviço.

A sua participação fornecerá informações importantes para este projeto.

Estas entrevistas serão gravadas para possibilitar a sua transcrição e análise aprofundada. Só iniciaremos a gravação após a sua concordância, expressa através da assinatura deste consentimento informado.

A informação recolhida é estritamente confidencial e será apenas utilizada no âmbito deste estudo. Os resultados serão reportados de forma agregada, sem identificar individualmente os entrevistados. A informação poderá ser usada para relatórios, apresentações ou artigos científicos, mas o seu nome não será usado sem o seu consentimento explícito por escrito.

A sua participação neste estudo é voluntária, pelo que a poderá interromper a qualquer momento. Nesse caso toda a informação recolhida até ao momento será inutilizada.

Para qualquer esclarecimento adicional, poderá contactar Dr. Jorge Teixeira (jorge.grenha@fe.up.pt), Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n 4200-465 Porto, telefone 225083437.

O investigador: Tiago Pamplona Paolelli

Nome: **Tiago Pamplona Paolelli**

Assinatura:

Data: **10/05/2019**

O participante:

Declaro ter lido e compreendido este documento, bem como as informações verbais fornecidas e aceito participar nesta investigação. Permito a utilização dos dados que forneço de forma voluntária, confiando em que apenas serão utilizados para investigação e com as garantias de confidencialidade e anonimato que me são dadas pelo investigador. Autorizo a comunicação de dados de forma anónima a outras entidades que estabeleçam parceria com a Faculdade de Engenharia da Universidade do Porto para fins académicos e de investigação científica.

Nome:

Assinatura:

Data: 10/05/2019

ESTE DOCUMENTO É FEITO EM DUPLICADO: UM PARA O PARTICIPANTE E OUTRO PARA O INVESTIGADOR.

Template questionário - bike commuting

Dados Sócio Demográficos:
Nome:
Idade:
Gênero:
Estado civil:
Ciclistas:
Grau de escolaridade / Profissão:

Está atualmente em qual ocupação (profissional ou acadêmica) ?

Possui filhos? Quantos? Qual a idade deles? (importância: impacto na decisão de escolha entre meios de transporte)

1. **Como costuma se deslocar no seu dia-a-dia?**
    a. *Bike*
    b. *Carro*
    c. *Mota*
    d. *Transp. Público*
    e. *À pé*
    f. *Táxi / Uber - aplicativos*
    g. *Outro*
2. **Descreva o seu itinerário diário:**
    a. *Sai de casa, deixa os filhos no colégio, vai ao trabalho, etc*
    b. *Quantos quilômetros & quanto tempo gasta ?*
    c. *Sai de qual e vai para qual(ais) freguesia(s) ?*
    d. *Horários*
3. **Quais são os fatores que determinam a sua escolha por tal meio de transporte? Quais aspectos positivos e negativos dessa escolha ?**
    a. *Bicicleta*
    b. *Carro*
    c. *Mota*
    d. *Táxi*
    e. *Uber*
    f. *À pé*
    g. *Comboios*
    h. *Carona*
    i. *Transp. Público*
        i. *metro*
        ii. *autocarro*
    j. *Outro.*
    k. *Perceber a infraestrutura ou instalações para meio de transporte próprio, tais como estacionamentos, garagens (em casa, trabalho ou faculdade), incentivos de transporte (subsídios do empregador).*
    l. *Custos de transporte mensal.*
4. **Avalie o deslocamento quando está usando a bicicleta, citando os pontos positivos e negativos:**
    a. *Aspectos físicos:*
        i. *Funcionalidade:*
            1. *Instalações (trabalho, casa, bicicletário, chuveiro, locker…)*
            2. *Relevo*
            3. *Infraestrutura (ciclovias, ciclofaixas, conectividade entre ciclovias)*
            4. *Distância*
        ii. *Segurança:*

Template questionário - bike commuting

1. *Tráfego (intensibilidade, atropelamento, amigabilidade entre carros, e autocarros), velocidade dos outros veículos...*
2. *Violência urbana (roubo, assalto), estacionamentos inseguros*
3. *Iluminação*
4. *Pavimentação das vias.*
5. *Risco de avaria física alto.*
6. *falta de segurança pública*

iii. *Estética:*

1. *Poucas áreas verdes*
2. *Manutenção das vias,*
3. *Poluição*
4. *Estética*

b. *Ambiente Social*

1. *Apoio social, governo, políticas públicas pró-mobilidade*
2. *Posse do veículo*
3. *Custo combustível*

c. *Ambiente Natural*

i. *Clima*
ii. *Relevo / geografia*

d. *Psicológico /Cognitivo*

i. *Desconforto físico*
ii. *Interesse*
iii. *Tempo*
iv. *Eficácia*
v. *Satisfação*
vi. *Medo de avarias físicas.*
vii. *Status Social*

e. *Aspectos econômicos*

5. **Projeto U-Bike: Aspetos positivos e negativos, o que acha relevante relatar sobre o projecto na sua opinião?**
   a. *Acessórios, comunicação, serviço, manutenção, equipamento, funcionalidade,…*

6. **Gostaria de mencionar algo que não foi perguntado no decorrer desta entrevista?**