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INSTITUTO SUPERIOR TÉCNICO

Commuting to school by public transport: on the development of marketing strategies to change travel behaviour

Cassilda Mariza Alves Matos de Alpoim Motta Queiroz

Supervisor: Doctor Filipe Manuel Mercier Vilaça e Moura

Co-Supervisor: Doctor Pedro Manuel Amador Rodrigues Celeste

Thesis approved in public session to obtain the PhD Degree in

Transportation Systems

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Abstract

Despite its widely recognized importance, Public Transport (PT) remains insufficiently used in most countries, particularly as a tool to improve the sustainability of urban mobility. This problem can be efficiently tackled by using marketing as a solution to leverage Public Transport use. Within urban mobility, the promotion of PT in school commuting is critical for modern societies as we believe it encompasses potential and long-lasting impacts in the travel behaviour of younger generations, today and in the future. Despite the vast research, Marketing solutions are currently hampered by the challenge to identify the foremost factors determining the modal choice of households in school commuting is still challenging.

This thesis is focused on developing influential solutions for younger generations mobility choices, and hence promot an immediate and long-term change in societal public transport perception. A 4 Ps marketing mix model was developed as a novel and potentially far-reaching tool to evaluate the uptake of PT in school commuting, sustained in a Stakeholders´ triangle for action.

A case study using two paper-based surveys was conducted in pre-university schools of three municipalities of the Lisbon Metropolitan Area and during two school years. Data modelling was based on the methods Discrete Choice Models (DCM), Structural Equation Models (SEM), Latent Dirichlet Allocation (LDA) and Hazard Duration-Based Models (HBDM).

The results showed that basic features of Public Transport, like Frequency, Reliability, Cleanliness and Comfort of bus-stops, are crucial for choosing to school commuting with PT. The most impactful promotion events were those related to making available products/packages in schools and the promotion/experimentation of the Transport app. Improvement of Best Practices in Public Transport resulted mainly from the beneficial effects of bringing stakeholders closer together during Bus Papers, Think Tanks and Public Debates and giving signs to bus operators.

With the implementation of pioneering *Stimuli* to Public Transport and an easy to implement methodology to evaluate their impact, this thesis makes available a novel marketing strategy and suggestions to guidelines to promote PT uptake in school commuting and even in Mobility in general. Additionally, this work presents still missing but much needed pragmatic tools based on Communication, Mobility plans, Mobility management and schools´ management to reinforce the marketing strategy and the tactics to leverage PT. These tools cover the full actionable scope of the school mobility

PT option by providing scalable solutions from the PT user to the PT management entities.

Keywords: Public transport; Mobility; Travel Behaviour; School Commuting, Marketing strategy

Resumo

Apesar da sua importância amplamente reconhecida, o Transporte Público (TP) continua a ser insuficientemente utilizado na maioria dos países, particularmente como instrumento para melhorar a sustentabilidade da mobilidade urbana. Este problema pode ser eficazmente resolvido utilizando o marketing como uma solução para alavancar a utilização dos Transportes Públicos. Dentro da mobilidade urbana, a promoção do TP nas deslocações escolares é fundamental para as sociedades modernas, uma vez que acreditamos que engloba impactos potenciais e duradouros no comportamento de viagem das gerações mais jovens, hoje e no futuro. Apesar da vasta investigação, as soluções de Marketing são atualmente dificultadas pelo desafio de identificar os principais fatores que determinam a escolha modal das famílias no transporte escolar pendular, que ainda é um desafio.

Esta tese está centrada no desenvolvimento de soluções determinantes nas escolhas de mobilidade das gerações mais jovens e, por conseguinte, promovendo uma mudança a curto e a longo prazo na perceção social relativa aos transportes públicos. Foi desenvolvido um modelo de marketing mix dos 4 Ps como uma ferramenta inovadora e potencialmente de longo alcance para avaliar a aceitação do TP no transporte escolar pendular, sustentado num triângulo das partes interessadas intervenientes neste desafio social. Assim, esta investigação, apresenta uma estratégia de marketing pioneira para promover a aceitação do TP nas deslocações escolares.

Foi realizado um estudo de caso, utilizando dois inquéritos em suporte papel em escolas pré-universitárias de três municípios da Área Metropolitana de Lisboa e durante dois anos letivos. Na modelação de dados foram desenvolvidas múltiplas técnicas analíticas, nomeadamente modelos de escolha discreta (DCM), modelos de equações estruturais (SEM), modelos de duração baseados em risco (HBDM) e de alocação latente Dirichlet (LDA).

Os resultados mostraram que as características básicas do Transporte Público, como a Frequência, a Fiabilidade, a Limpeza e o Conforto das paragens de autocarro, são cruciais para a escolha de deslocações escolares com a TP. Os eventos de Promoção mais impactantes foram os relacionados com a disponibilização dos produtos/pacotes de mobilidade nas escolas, bem como a promoção/experimentação da aplicação Transportes. Por outro lado, os momentos em que se realizaram os Bus Papers, os

Think Tanks e os Debates Públicos acabaram por aproximar as partes interessadas e dar sinais aos operadores dos transportes públicos quanto à promoção dos produtos/pacotes de mobilidade nas escolas, bem como a promoção/experimentação da aplicação Transportes. Por outro lado, os momentos em que se realizaram os Bus Papers, Think Tanks e Debates Públicos acabaram por aproximar as partes interessadas e dar indicações, aos operadores dos autocarros, para as Boas Práticas de Transporte Público.

Com a implementação de estímulos pioneiros nos Transportes Públicos e uma metodologia fácil de implementar, esta tese disponibiliza uma nova estratégia de marketing e sugestões de orientações para promover a aceitação do TP nas deslocações escolares e mesmo na Mobilidade em geral. Além disso, este trabalho apresenta ferramentas pragmáticas, ainda em falta, mas muito necessárias e baseadas na Comunicação, nos planos de Mobilidade, na gestão da Mobilidade e na gestão das escolas para reforçar a estratégia de marketing e as táticas para alavancar o TP. Estas ferramentas cobrem todo o âmbito de atuação da opção TP de mobilidade escolar, fornecendo soluções extensíveis ao utilizador do TP e às entidades de gestão do TP.

Palavras chave: Transporte público; Mobilidade; Comportamento de mobilidade; Deslocações pendulares casa-escola; Estratégia de marketing

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List of acronyms and abbreviations

AIC	Akaike Information Criterion
App	Transports´app
AVE	Average Variance Extracted
BMST	Behavioral Model of School Transportation
BP	Bus Paper
CFA	Confirmatory factor analysis
CFI	Confirmatory Fit Index Scaled
CIM	Children´s independent mobility
CNPD	National Data Protection Commission
DCE	Discrete Choice Experiment
DCM	Discrete Choice Model
EU	European Union
FP	Free Pass
GHG	Green House Gas
GLS	Generalised least squares
GOF	Goodness-of-fit
HBDM	Hazard-based duration model
HR	Hazard ratio
ICT	Information and Communications Technology
IF	Infrastructure
LDA	Latent Dirichlet allocation
LL	Log likelihood
LMA	Lisbon Metropolitan Area
MLE	Maximum likelihood estimation
OECD	The organization for economic Co-operation and Development
OR	Odds-Ratio
OT	Operation/transport service
PCA	Principal component analysis
PD	Public Debate
PMA	Porto Metropolitan Area
PMIEF	Project Management Institute Educational Foundation
PT	Public Transport
PTIM	Public Transport Information and Marketing
PTP	Personalized Travel Plan
RMSEA	Root Mean Square Error of Approximation Scaled
RP	Revealed preferences
ROC	Receiver operating characteristic
SEM	Structural equation modeling
SM	Social marketing
SP	Stated preferences
SRMR	Standardized Root Mean Square Residual Scaled
ST	Operators´ stands
STP	School travel plan
TB	Travel behaviour
TLI	Tucker-Lewis Index Scaled
TPB	Theory of Planned Behaviour
TSG	Traffic Snake Game
TT	Think Tanks
UN	United Nations
UP	Users´profile
WHO	World Health Organization
WTC	Willingness to change

1. Introduction

1.1 Background

The global problem and its magnitude

The Synthesis Report (SYR) of the IPCC Fifth Assessment Report (AR5) for Climate Change (IPCC, 2014) indicates that human activity has played a relevant role in the climate system and that global warming is undeniable. CO2 is responsible for 63% of world global warming being its concentration in the atmosphere 40% higher than in the industrial era. Urban Mobility and its associated transport aspects largely contribute to these CO2 emissions. Since 2014, Green House Gas (GHG) emissions from transport have been increasing. In 2016, transport emissions were 26.1 % higher than in 1990. Primary estimates from EU Member States indicate that GHG emissions from transport were in 2017 28 % above 1990 levels (EEA, 2019).

Road transport was responsible for almost 72% of total greenhouse gas emissions from transport in 2016 (including international aviation and international shipping) (EEA, 2019). Of these emissions, 44% corresponded to passenger cars, while 19% came from heavy-duty vehicles. Emissions need to fall by around two thirds by 2050, compared with 1990 levels, in order to meet the long-term target of 60% reduction of greenhouse gas emissions as set out in the 2011 Transport White Paper.

The Portuguese outlook is similar to that of Europe. Energy production and transport are the most relevant emission sources, with 29% and 24% respectively of the total of national emissions (without AFOLU[1]) (APA, 2019).

The problem in the city context

Despite the need for a decrease in the GHG, recent statistics show the opposite. The car continues to be the favorite transport for commuting in metropolitan areas. When looking in detail for the modal split (Figure 1.1), it is possible to see that in Portugal as well as in other countries, the share of private car is greater than any of the other modes.

[1] AFOLU- Agriculture, Forestry and Other Land Use

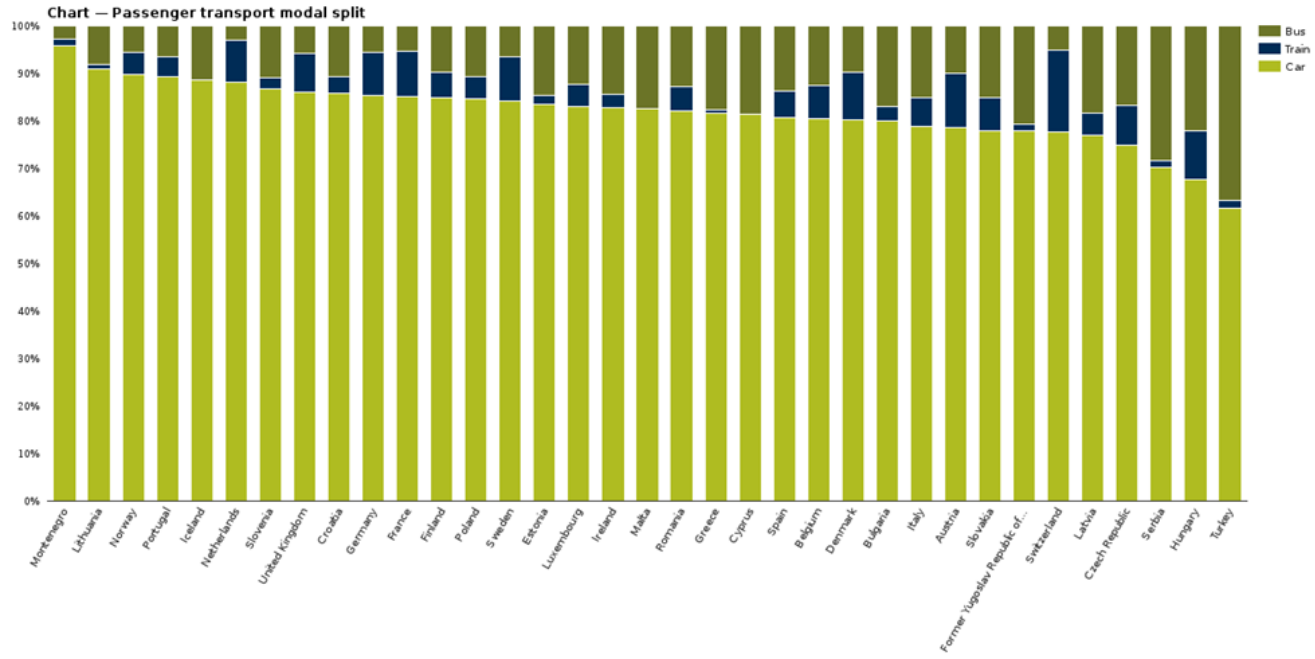

Figure 1.1 - Passenger transport moda split. Source: EEA, 2019

At the global scale, the currently unsustainable mobility patterns in cities are an urgent problem due to its fast-growing rate. More than 54% of the world population live in urban areas and this is expected to increase up to 60% in 2030, and 67% in 2050. At the EU scale, the urban mobility problem is equally expressive (United Nations, 2016 and ITF, 2017).

The EU has set itself targets for reducing its greenhouse gas emissions progressively up to 2050. Key climate and energy targets are set in the 2020 climate and energy package (COM, 2008) and in the policy framework for climate and energy in the period from 2020 to 2030 (COM, 2014). One of its targets is to cut 40% in greenhouse gas emissions (from 1990 levels). The 2018 European Commission communication 'A Clean Planet for all – A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy' sets out the necessary targets. These targets are defined as guidelines to reach the transformation towards a low-carbon economy by 2050 (COM, 2018).

These EU objectives align with the Paris Agreement aiming to keep the global temperature rise below 2 degrees Celsius though efforts to limit temperature increase and additionally, promote the ability of countries to deal with the impacts of climate change (United Nations, 2016).

Not surprisingly, this emissions-mobility problem also applies to the Portuguese context. Road transport dominates the Portuguese transport sector and its emissions increased 68% in the 1990-2017 period. Regarding the road transport modal split, the use of private cars is 47.7%

and the PT is 34.2% (INE, 2011). Regarding the two Portuguese metropolitan areas: the Lisbon Metropolitan Area (LMA) and the Porto Metropolitan Area (PMA) and from 2001 to 2017, the proportion of car use in the PMA increased from 47% to 68% and, in the same period, the LMA increased from 38% to 59%. These results dramatically highlight the downward trend of sustainable mobility and emphasize the limited success of implemented counteractive measures.

The actors

Current urban mobility systems are not designed to operate and to offer seamless experiences to their users (Preston, 2012), which are challenged with varied products and ever evolving services as part of an increasingly consumer-oriented economy. One of the most effective approaches to streamline the user experience is to understand and anticipate their needs and to involve them in designing integrated mobility systems. Hence, solving urban mobility challenges requires active strategies and propositions, which engage the societies travel at large and in particular that of younger people given their potential for maximizing beneficial short and long-term mobility impacts. In the short term, young urban citizens can effectively promote changes upon the mobility of their families and, in the long term, contribute to societal changes through their adult mobility behaviour.

So far and concerning transport policy, there have been some discussions on children's involvement on the policy balancing power relations between adults and children (Mason and Hood, 2011; Hillman et al., 1990). We believe that the children's' involvement in policy decisions develops their skills and prepares them for citizenship. It would be an added value for them to be prepared for this engagement. Still, there are some studies (Flanagan and Levine, 2010) (Checkoway, 2011) showing that most active youth participants in public affairs are usually of higher income groups, education, and socioeconomic status than the general population. As such, social stratification plays a vital role in this discussion. The involvement of children in public policies was also investigated by the author (Tisdall, 2008). Additionally, mechanisms were examined to incorporate the views and mobility needs of children into transport policy, considering them as political citizens (Barker, 2003). As mentioned by the researchers, one of the key features of current research with children is the adoption of the children's participation principle, putting their voices in the center of the research. This study argues that children's involvement in formal mechanisms of transport policy by informing their family can reduce congestion when commuting to school (Barker and Weller, 2005). Moreover, Checkoway (2011) states that "youth participation is important, because when young people participate, it draws upon their expertise, enables them to exercise their rights as citizens, and contributes to a more democratic society. It also promotes their personal development and provides them with substantive knowledge and practical skills".

Hence, we can conclude that the literature points out that there is empirical evidence corroborating with the importance of children's involvement in the planning of school commuting journeys. Ultimately, they are the final receptors of the travel decisions, and the end of any policies aiming to promote such new mobility habits transformations.

The young people process of urban commuting to school affects their quality, families and citizens in general. For example, it is important to outline that increased car use is having significant effects on the urban commuters´ health (Karanasiou, et al., 2014) and particularly in children´s health (UNICEF, 2016; Buka et al. 2006). On the other hand, reducing car use and dependence presents potentially positive opportunities to enhance environmental quality and children's well-being. This will decrease potentially energy consumption, pollution and more importantly improve children's health through more outdoor activities and by providing healthy environments (Freeman and Quigg, 2009). These reasons alone justify their involvement in policy decisions. However, and despite the subject immediate and future importance, existing literature focused so far on environmental impacts and on youth health, whilst sustainable mobility options are largely overlooked.

Exploring an actor-based solution

Public Transport (PT) can play an important part in any solution for sustainable transport and has become one of the vital elements for quality of life and economic competitiveness in urban environments.

The home-school commuting involves the students, parents, other relatives, friends, neighbors, teachers, and employees of the school directly and also others responsible for the logistics involved. The numerous environmental and climate change impacts of transportation, specifically home-school trips, have also been highlighted in the sustainable mobility assessments reports and recommendations by prominent international organizations including OECD[2], WHO[3], EU[4], among others. The findings generally imply that these trips are significant in the total trips of a city and have strong integration with the land use. This type of commuting is relevant since they overlap with other routines of the households (morning and afternoon peak time) and the space context.

[2] The Organization for Economic Co-operation and Development (OECD; is an intergovernmental economic organization with 35 member countries, founded in 1960 to stimulate economic progress and world trade

[3] The World Health Organization (WHO) is a specialized agency of the United Nations that is concerned with international public health. It was established on 07 April 1948 headquartered in Geneva, Switzerland.

[4] The European Union (EU) is a political and economic union of 28 member states that are located primarily in Europe.

The literature refers that children's transportation being mainly by private car travel does not only affect school traffic but can also influence the household's quality of life by adding trips or limiting the work schedule or job opportunities (Novaco and Gonzalez, 2009).

Furthermore, when teenagers and children are car-reliant, they become less responsive to policies that encourage car use reduction, making it important to understand youths' intentions when they decide to commute by car (Davison et al., 2007).

An ideal solution to change existing mobility behaviours from private to communal mobility requires tackling the urban population as a whole. The difficult implementation and high-level variation at this scale triggered the present work to focus on the young population segment and their specific needs. The opportunity to promote a sustainability conscience from early life stages offers a promising multi-level and prolonged influence throughout their lifetime. Hence, the objective of this work was to develop a solution framework promoting the active use of public transportation by young citizens.

The target age range of this study was from 6 to 18 years. The underlying and so far untested assumption of this work is that during this life stage - specifically the pre-university years developed behaviours will endure throughout adult life, especially when it comes to mobility. Results indicate that experiences in childhood are significant in explaining public transport propensity and car ownership. Modal choices in adulthood are formed in part by experiences and influences of the childhood (Long et al., 2019; Basington, 2008). Morevover, direct childhood experiences and parental influences get internalized and replicated in the adulthood, such as parents´ values and practices (Grusec, 2012). Exposure to technologies in childhood allows them to be considered in the choices of modes of transport in adult life. Policy makers should give equal ICT access to children to enable this diversity in modal choices (BouMjahed and Mahmassani, 2018). As such, a child who is driven everywhere is expected to become an adult who will prefer the car to other modes and will also drive his/her offspring more often, thus perpetuating this travel behaviour cycle as studied by Morris et al. (1998) and Davison et al. (2007).

We believe that the long-term travel behaviour of a citizen over his life can be significantly influenced by travel habits during childhood. Though and to our knowledge, there is no literature sustaining such theory. However, other research limited to the Millenials generation (born between 1981 and 1997) suggests that young people do not imitate previous generations. Those studies concluded that this younger segment of the population embraces a “Mobility culture” instead of “Car culture”, hence potentially shifting from the traditional mobility behaviour, ie. Individual transport, towards a more sustainable one (Circella et al., 2016; Lee et al., 2019).

So far as we know and for the target age group of the present study, i.e. those who have not reached the adulthood (born between 1990 and 2010- the Generation Z), there are no updated

studies on their uptake of a replicative behaviour with former generations, probably because these students still live with their parents and have not begun their career and household budget management. Furthermore, increasing exposure to a variety of mobility solutions within the students´ families will likely result later in life in an uptake of other transport solutions rather than individual transport. The postulate of replicating the past travel behaviour exposure will be analyzed within the literature review due to its important potential impact on urban mobility planning.

Given that children´s independent mobility is an important societal problem, advances in Information and Communications Technology (ICT) solutions can make the difference in the management of daily mobility routines (Gerosa et al., 2015).

We particularly focused on the young segment of the population because they are under the legal driving age. Also, because parents play a central role in the policy analysis phase of young student mobility, we anticipated that the final decision-maker (parents/carers or students) will differ with the various age stages covered in the study and will depend on the maturity levels and mobility independence.

The daily commute by our population segment continues to be made mainly by private transport, as opposed to the ideal PT option. Although today's younger generations participate in various extracurricular activities, this study focuses primarily on commuting to and from school, as it may be considered the main daily activity and, therefore, delivering the highest potential for intervention impact. The main hypothesis addressed in our research is that planting the seeds of sustainable mobility in younger generations will promisingly persist throughout their adult life.

Other novel aspects of this study rely on the focus on the young citizen and on going beyond the traditional infrastructure interventions in school mobility. We considered an integrated approach to the educational triangle, in which all the elements influencing children's education must be present, and also on promoting the autonomy and the PT leveraging in school commuting. Hence, the study's main methodological approach is based on the following Stakeholders´ triangle (Figure 1.2).

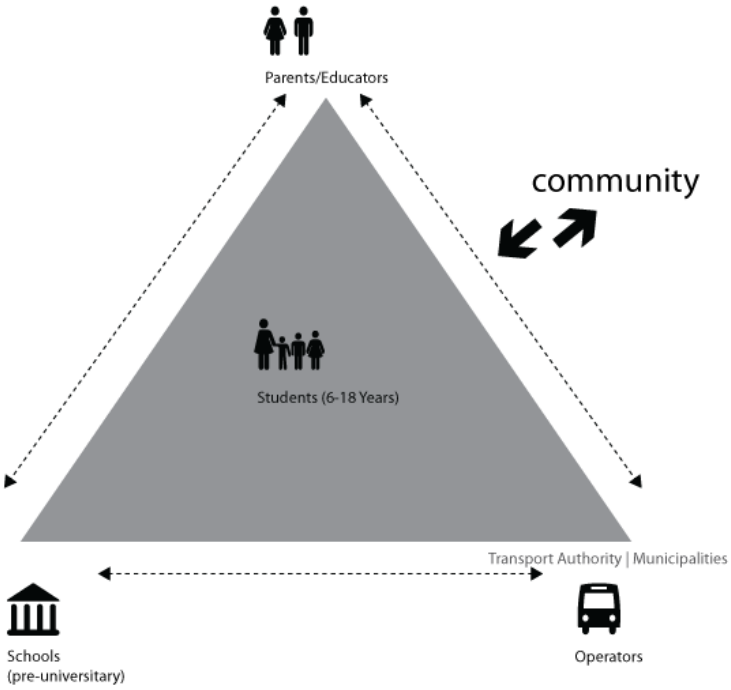

Figure 1.2 - Stakeholders´ triangle for action for PT leveraging in school commuting

A focus on programs and initiatives promoting alternative modes that reshape the mobility culture among young people is highly promising due to their adaptability and receptivity to alternatives. The main motivation of our study results from the unsolved problem of low uptake of Public Transport by the general population despite the high and continued investment in the public transport infrastructures by the State/Municipalities.

1.2 Research questions, objectives and impact

Research questions

This work aims to review and propose the basis for defining marketing strategies to promote PT at school commuting. The following three key research questions derived from the objective:

Q1. How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?

Q2: Which marketing mix is adequate to influence parents and children in their school commuting?

Q3: What is the time delay for behavioural and modal choice changes to occur?

These questions provided the guideline for a more detailed approach described in the Figure 1.3.

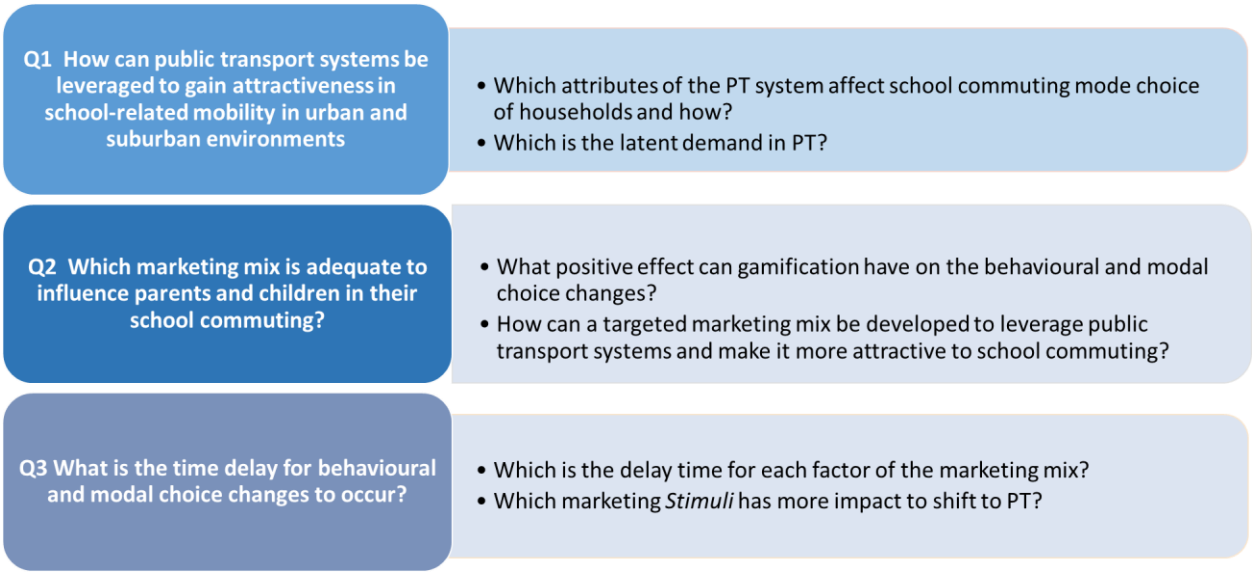

Figure 1.3 - Summary of the research questions for this thesis research plan

The specific objectives of this thesis were:

- Optimizing the use of PT in school mobility;
- Engaging the sector's stakeholders to contribute to solving the problem;
- Mobilizing citizens towards more intensive use of PT, specifically for school commutes;
- Using a methodology for the implementation of field incentives involving the various stakeholders;
- Introducing novel marketing methodologies in the PT sector as a way to assess the reaction to such incentives, such as the Marketing Mix 4 Ps, which are used by more aggressive and proactive business sectors to capture users.

  Hence, this thesis aimed to develop an unprecedented marketing strategy based on the 4 Ps marketing mix and to achieve that, it focuses on identifying the key factors conditioning the modal choice when commuting to and from school. The novel aspect of bringing Marketing approaches to the transport sector was a major driver of this research, rendering it of high potential interest for PT providers in the future.

Additionally, the experience gathered in stakeholders' management and their effective engagement in solving the problems in the sector positions the thesis findings into potentially useful work to other countries facing similar challenges.

Research Impact

The outcomes of this work are of high potential interest for four main stakeholders' types (Figure 1.2).

Firstly, PT operators could benefit from the identification of the characteristics of services that are more attractive to children and youth (e.g., value consciousness, online interaction, and communication), to better balance potential benefits, costs, as well as risks of intermodal alliances (e.g. flexible resource configuration, customizability). As such, they become empowered to i. recognise which inputs should be collected to support the decision on whether to collaborate with other operators; and ii. what type of collaboration and investments should be respectively performed and made (e.g., fleet of buses, E-business, gamification, operational adjustments)?

Secondly, transportation authorities and municipalities can benefit from additional knowledge of how a complex transport system might be improved and optimized without implying any significant investment. Such asset would also promote the balancing of operators' improvement in the transport systems by maintaining competitive pressures that in turn, foster improved service.

Thirdly, users, and more particularly children and youth, are the key stakeholders addressed. They can benefit by increasing their PT travel satisfaction and, indirectly, perceive a better value for money of PT services when commuting to school, and potentially on other trips. Complementarily, they would gain a rewarding sense of active participation in the PT solutions through the proposed marketing strategy.

Finally, the community as a whole would profit by engaging citizens in long-term strategic planning and hence promote a new culture in which citizens are active in improving the planning and city operation.

1.3 Main concepts

To harmonize the research terminology and clarify its interpretation in this study a glossary for the main research concepts is given next.

Table 1.1 - Main research concepts organized alphabetically, their interpretation and references

Concept	Meaning	Literature reference
Active mode	The physical movement of citizens is made by transport modes involving physical energy expenditure (e.g., walking, bicycling, scooter riding, skating, public transport). Public transit is considered an active mode because many riders walk or bicycle to and/or from the bus stop or train station. In some studies, it is called soft mode, as it is more associated to the environmental impact and less to physical one.	Van Dych, 2010; Carson, 2010; Souza et al., 2019.
Bus Paper (BP)	"Learning Public Transport Rally", a competition which requires students to take different modes from base to base. In each stage, students answer different kinds of questions, perform some activities. Students are then awarded points at each of the stages depending on their answers and the winners have a prize. The BP combines knowledge, mobility knowledge, speed, humor, skills and a little bit of luck. It is mainly an outdoor activity.	Braun-La Tour, 2007 Duhigg, 2014
Children	A young human being below the age of puberty. 6-12 years in the study	NA
Children´s independent mobility´ (CIM)	Children's independent mobility i.e., freedom to move around without adult accompaniment.	Hillman et al., 1990; Hillman and Adams, 1992
Hard factors/measures	Attributes of supply side related with Infrastructure and Operation/Transport services.	Gärling and Fujii, 2009
Individualised Marketing	Individualised Marketing - short: **IndiMark®** - is an innovative marketing approach targeted an increasing the use of environmentally friendly modes (EFM) in the area in a fast and cost-efficient way.	James, 2017
Intermediate School	Schools that include 5th and 6th grade and mostly involves the following range of ages: 11-12 years. Education between primary school and secondary school.	NA
Latent demand	Clifton, K. & Moura (2017) as referred previously, latent demand's broader definition includes what has yet to be realized and that the next step is to understand the behaviour of customers and how we can interact with them. From the literature, no methods are defined for some of the less obvious	Clifton and Moura, 2017

	forms of latent demand, thus again confirming that this field of transport still needs to be further explored and that experiences are few and far between called unrealized demand.	
Marketing Mix	**4 Ps approach:** **Product:** What do we expect from the product/service? What does it look like? What attributes do we need? Which is the Brand image? How can we get a Mobility Package: integration with others? **Price:** Which are the possible transport tickets? Which are the possible combinations for integrated mobility: physical and/or online sales? **Promotion:** Which are the Campaigns? Which targets? Segments? Which are the means of Communication? **Place/Placement:** How can we access the product? Which is the network? How can we know the possible alternatives and the interfaces with other modes?	McCarthy ,1960
Passive mode	The physical movement of citizens is made by transport modes which do not involves physical energy expenditure, usually the private vehicle.	Van Dych, 2010; Carson, 2010; Souza et al., 2019
Primary School	Schools that include from 1st up to 4th grade and usually involves the following range of ages: 6-10 years.	NA
Public Debate (PD)	Workshops in the schools that involve the study stakeholders in the design of mobility solutions.	Checkoway, 2011 Barker and Weller, 2005
Public Transport (PT)	Transit services owned and operated by state, regional, or local public agencies. Travel by collective transport, operated by public or private operators.	NA
Secondary School	Schools that include from 7th up to 12th grade and generally involves the following range of ages: 13-18 years.	NA
School travel plan (STP)	A School Travel Plan is a document produced by a school that promotes sustainable ways for the whole school community to travel to and from school. It encourages walking, cycling, car sharing and public transport use and aims to reduce the number of car journeys to and from schools.	Buliung, 2011
Social Marketing (SM)	Social marketing seeks to develop and integrate marketing concepts with other approaches to social change. Social marketing aims to influence behaviours that benefit individuals and communities for the greater social good.	Sauvage-Mar et al., 2019

Soft factors/measures	Attributes (measures) of demand side related with Users´ profile and Travel Behaviour.	Bamberg et al. , 2011; Möser, 2008; Juhász, 2013
Stands (ST)	Operators´ informative stands which improve information and communication.	Schmitt et al. , 2011 Haryanto et al. ,2017
Students	Pre-university students. A person who is studying from primary to secondary grade. Range of ages: 6-18 years.	NA
Teenagers	A person who falls within the ages of 13 to 19 years old. A synonym is adolescent. Usually study at intermediate and secondary schools.	NA
Think Tanks (TT)	Stakeholders´ brainstorming and meetings to discuss and propose PT solutions.	Keengwe and Schnellert, 2012; Schmitt, 2011; Barker and Weller, 2005
Traffic Snake Game (TSG)	It is a game developed by a Belgian organization and its objective is to incentive sustainable trips (walking, cycling, using buses or other shared modes. They have to make *a priori* accountancy of the sustainable trips they have and fix an objective to obtain an increase of sustainable trips when commuting to school. 10 days to play the game Three weeks after the game finishes, a new survey is done one to compare with former results.	Moura et al., 2019
Travel Blending	Travel blending is a technique, developed in Australia, for encouraging people to make more efficient and environmentally transportation choices.	James, 2017

Legend: NA- Not Applicable

1.4 Methodological approach and thesis structure

The dissertation was divided in six parts, in most part reflecting a custom-made methodology and novel approach for addressing the research questions above.

The current chapter introduces the reader to the background, the basic concepts of this investigation, presents the research questions and objectives, the thesis structure and its main contributions.

Chapter 2 deals with the literature review and state-of-art of the following relevant research areas: Worldwide commuting; Children´s independent mobility; Child, satisfaction and well-being; Modal choice to school; Marketing, campaigns and school travel.

Chapter 3 presents the research methodology and the modelling tools used. The chapter includes a detailed assessment and contextualization of the case study of this dissertation, the Lisbon Metropolitan Area, with a special focus on the municipalities Cascais, Oeiras and Sintra. The chapter ends with an analysis of the empirical intervention on the field, the paper-based surveys that were developed (First and Second survey) and addresses the data for the model development.

Chapter 4 addresses the determinants of school travel strategy and policy implications. Introduction, methodology, results and discussion, conclusions of each model are presented therein. Different approaches were used to measure the importance of PT attributes and to respond to the Research Questions. The chapter ends with considerations and conclusions obtained from the models and establishes connections with the Research Questions.

Chapter 5 provides what to expect from marketing mix strategies´ impact in school travel behaviour. It starts with a Hazard-Based duration model (HBDM) to explore the duration between marketing actions and modal changes to PT. Then a Latent Dirichlet Allocation (LDA) is used, which consists of data mining to explore the open-ended part of the survey where usually information is not treated and crossed with other sources. The chapter conclusions are presented, answers are given to the related Research Questions, and connections are made with the modal choice.

Chapter 6 contains one of the key elements of the dissertation, the integration of the overall methodologies in a 4Ps framework and the main contributions of this research and their possible future implementation. Finally, it proposes suggestions for the development of marketing strategies – recommended guidelines for the promotion of PT at school commuting.

The following flowchart portraits the structure of the dissertation (Figure 1.4):

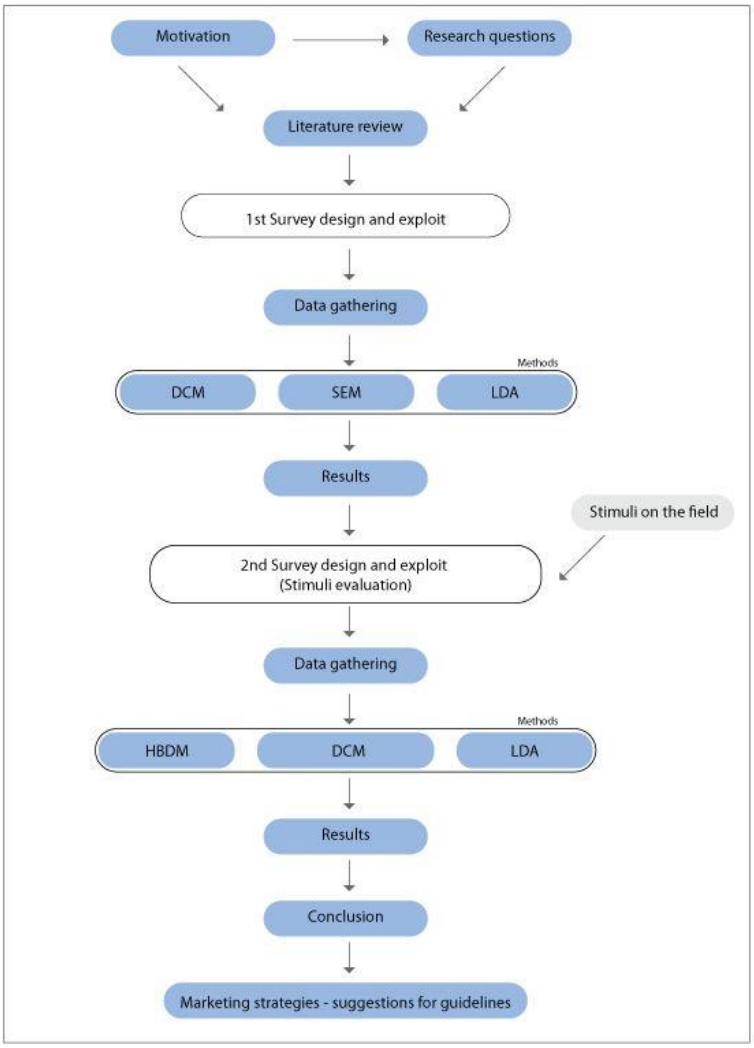

Figure 1.4 - Methodological framework

Legend: DCM (Discrete Choice Model); HBDM (Hazard-Based Duration Model); LDA (Latent Dirichlet Allocation); SEM (Structural Equation Modelling)

1.5 Main contributions

This dissertation provides an in-depth analysis of PT commuting to and from school and Stimuli to its leverage. This research represents an effort to understand what drives this group of pre-university students.

The contributions of this work are the following:

- Demonstrates the added value of the stakeholders´ involvement;

- Models the mode choice behaviour using Discrete Choice Models, Hazard Based Duration Models, Structural Equation Models and Latent Dirichlet Allocation;
- Creates a methodology that assesses the shift reaction time for PT after the introduction of field *Stimuli*. A case study of three municipalities of the LMA is applied and used to demonstrate the methodology.

The current research is expected to add value in the scientific community and provide helpful suggestions for policy makers or private parties interested in mobility planning. More specially:

- Contributes to the state-of-the-art in understanding the possible impacts of implementation of Marketing strategy and the link to transport Policy;
- Proposes a methodology for the PT leverage focused on Marketing approach and furthermore it takes full advantage of intervention on the field and the stakeholders connection;
- Proposes a new theoretical framework on the shifting to PT that will contribute to the planning and decision-making levels in transport public policy.

1.5.1 Publications

Next are listed the peer-reviewed publications and other scientific contributions that were developed or are under development from this dissertation.

1) QUEIROZ, M.M., CELESTE, P., MOURA, F.. The Influence of sociodemographic characteristics and distance to school on the latent demand for Public Transit, 2019. Oral communication and Conference proceedings at 9º Congresso Rodoviário Português.

A Binary Logit Model is presented therein and aims to understand the impact of Socio-demographics and distance when commuting to and from school. This paper is presented in Chapter IV.

2) QUEIROZ, M.M., CELESTE, P. , MOURA, F.. School commuting: the influence of soft and hard factors to shift to public transport – 2019. Presented at 22nd EWGT2019, Barcelona, Spain and publication at Transportation Research Procedia. https://doi.org/10.1016/j.trpro.2020.03.140.

A Principal Component Analysis and a Logit Model are developed therein. The goal is to model the willingness to shift to PT when commuting to and from school and considering Hard and Soft Factors. This essay is presented in Chapter IV.

3) QUEIROZ, M.M., CELESTE, P., MOURA, F.. Matching users´ expectations in school public behavior: where are we in public transport? – 2020, April 27-30. Transport Research Arena, Helsinki, Finland. Oral presentation approved (Conference cancelled).

A Principal Component Analysis and a Discrete Choice Model are developed therein. The aim is to understand the effects of the attribute of each alternative presented (Car or Bus) on the decision maker´s choice and it is presented in Chapter IV.

4) QUEIROZ, M.M., ROQUE, C., MOURA, F., 2020. Shifting from Private to Public Transport using a Duration-Based Modeling of a School-Based Intervention. Transportation Research Record (TRR) 2674(7):540-554. doi: 10.1177/0361198120923666.

A Hazard Based Duration Model is developed therein to explore the impact of a set of marketing events on the duration to shift to PT by children when commuting to and from school: presented in Chapter V.

5) QUEIROZ, M.M., MARÔCO, J.P., MOURA, F., ROQUE, C.A., 2020. On the importance of parents´ decision to escort children to school with private cars: a structural equation model analysis. Submitted to Travel Behaviour and Society (July 2020), and it is presented in Chapter IV.

A Structural Equation Model is developed therein to explore the latent demand which conditions the escorting choice when commuting to/from school.

6) QUEIROZ, M.M., ROQUE, C.A., MOURA, F., MARÔCO, J.P.. Understanding the expectations of parents regarding their children´s school commuting using Latent Dirichlet Allocation method, was submitted to *Transportation Journal*, and it is under review. It is presented in Chapter V.

A Latent Dirichlet Allocation model is developed therein to explore the concerns and improvements occurrences related to Public Transport by exploring the reviews in open-ended questions of the collected surveys.

1.5.2 Non-scientific outreach

Next are listed the non peer-reviewed publications that were developed from this dissertation.

1. **Transportes em Revista**

   Transporte escolar- Tese de doutoramento aborda impacto do marketing estratégico nos alunos School transport – (PhD Thesis addresses impact of strategic marketing on students) - April 2018 - *(http://www.transportesemrevista.com/).*

2. **Jornal Expresso**

   Só 20% dos jovens usam transportes públicos (Only 20% of young people use public transport)- 19-04-2019 - Newspaper Expresso (by Raquel Albuquerque) (https://expresso.pt/sociedade/2019-04-19-So-20-dos-jovens-portugueses-usam-transportes-publicos).

3. **Newsletter Vimeca**

   VIMECA participa em BusPaper (Vimeca participates in BusPaper)- January- June 2018- GONewsletter – (https://www.vimeca.pt/).

4. ***Schools websites and Facebook***

   - Agrupamento de Escolas de Alvide-Cascais:
     - Brainstorming about Public Transports (*http://aealvide.com/2018/02/18/brainstorming-sobre-transportes-publicos/)*
     - Mobilidade nas Escolas (Mobility in schools) (*http://aealvide.com/2019/05/08/mobilidade-nas-escolas/*).
   - Agrupamento de Escolas de Carnaxide- Oeiras:
     - All the activities during the 2 school years were posted in Agrupamento de Escolas de Carnaxide (*https://www.facebook.com/ecarnaxide/photos*)

- Escola Alfredo da Silva- Sintra:
    - Albatv Silva (Escola Alfredo da Silva- Sintra). App Lisboa Viva. (https://www.facebook.com/albatv.silva.7)

5. Youtube (vídeos)

- Vimeca Vídeo (*https://www.youtube.com/watch?v=AYeUNVWaghw*)
- Scotturb Vídeo (*https://www.youtube.com/watch?v=ghcFVHl-oCE&feature=youtu.be*)

2. Literature Review

2.1 Context

This chapter reviews existing research on public transport use that relates to the main topics of this thesis, i.e., capturing the non-users of public transports that commute to and from school. This information will enable defining marketing strategies to capture latent demand of school commuters.

2.2 Worldwide commuting to and from school

This review evaluates different approaches worldwide regarding school commuting mobility and the Key categories of Marketing mix involved: **Product, Price, Promotion and Place.**

There is an extensive research on this topic in several countries (Herrador-Colmenero et al., 2014; Panter et al., 2008).

Table 2.1 presents the information from the Europe, whilst Table 2.2 does the same for United States of America and Table 2.3 from other continents/countries.

Table 2.1 - Commuting to school (research in European cities)

Literature Reference	Country (City)	Sample size and (Age)	Topic	Transport modes	Outputs
Cooper et al., 2003	England (Bristol)	114 (10 y)	Typical mode of commuting to and from school	Car, cycle, bus and walk	As children get older, they become less active. Children that walk are more active than those that commute by car. Necessary to have initiatives to increase physical activity.
Cooper et al., 2005	Denmark (Odense)	323 (9,7 y)	How do you travel to and from school	Car, motocycle, bus, train, bicycle, foot	Walking to school was associated with higher physical activity compared with traveling by car, although some of this increase was due to the journey itself.
Bere et al., 2008	Netherland (Rotterdam)	1,361 (12-15 y)	How many days travel to school by which mode	Walk, cycle, public transport, car	Ethnicity associated with mode commuting. Adolescents non-Dutch and from a low level socio-economic is an important target to active modes.
Bringolf-Isler et al., 2008	Switzerland (Bern and Biel)	1,031 (6-14 y)	Parents reported motivations for supporting travel to and from school (winter and summer)	Walk, bicycle,kick scooter,inline skates, car, bus, tram, train, etc.	Age, daycare attendance, parental safety fears, number of cars in families and French-speaking population were significantly associated with regular car trips. Campaigns promoting non-motorized travel to school have to consider different cultural attitudes.
Landsberg et al., 2008	Germany (Kiel)	626 (14 y)	Commute to and from school	Walk, cycle, bus, car, others	The importance of mode of commuting to school as part of adolescents' Physical Activity. It is necessary to promote initiative to active commuting early in daily routines.

Literature Reference	Country (City)	Sample size and (Age)	Topic	Transport modes	Outputs
Bere and Bjorkelund, 2009	Norway (City of Kristians)	106 (11-12 y)	How many days a week and which mode	Walk, cycle, car, bus	Questionnaire, to assess the frequency of the different active modes when commuting to and from school and work in the different seasons. Reliable among 6th graders and their families.
Santos et al, 2009	Portugal (Barcelos)	721 (13-18 y)	How usually travel and the mode	Walk, bicycle, bus, car	Active modes increase Physical activity among adolescents. After school activities do not predict active travelling.
Johansson et al., 2011	Sweden (Stockholm)	1,008 (13-14 y)	Active commuting to and from school	Walk, cycle or family car ownership	Girls experiencing fears (darkness, environmental, and coping with fears) and to boys the type of housing and traffic environment limit active mobility as having good socioeconomic conditions indicate fewer fears and better mobility.
Van Dyck et al., 2010	Belgium (Flanders)	1,281 (17-18 y)	Transportation mode to school	Walk, cycle, passive transportation	The criterion distance to Active transportation is 8 km for cycling and 2 km for cycling. Interventions are needed to adolescents living further 8 km to increase physical activity.
Coulter and Woods, 2011	Ireland (Dublin)	663 (5-14 y)	Travel to/from school yesterday	Walk, cycle,car or bus	Initiatives to increase active commuting are necessary. Considering that children´s favorite subject is Physical Education teachers should capitalize this fact to promote active modes.

Literature Reference	Country (City)	Sample size and (Age)	Topic	Transport modes	Outputs
Martinez-Gomez et al., 2011	Spain (Madrid)	2,029 (13-17 y)	Habitual mode to school	Walking, cycling, bus/subway, car or motorcycle	The need for strategies to encourage adolescents to cycle to school, by providing adequate facilities and safe routes to school in metropolitan areas. The associations of sleep duration and breakfast consumption with active commuting to school in our study might be mediated by a deprivation status. Adequate sleep duration is positively associated with active commuting to school in adolescents, whereas adolescents who eat breakfast are less likely to commute actively to school.
Kyta et al., 2012	Finland (Turku)	1,837 (10-15 y)	Child most often travels to and from school during ongoing week	Foot, bicycle, bus, car, other mode	Moderate urban density guarantees a short distance to attractive places. On the other hand, green structure nearby a child's home was positively associated with child's perceived health. Children do not move actively if the environment does not offer them challenges for diverse activities. Socio-demographic variables were not considered in the study.

Table 2.2 - Commuting to school (research in United States of America)

Literature Reference	Country (City)	Sample size and Age	Topic	Transport modes	Outputs
Heelan et al., 2009	United States (Nebraska)	320 (9-11 y)	Check how they got to and from school	Walk, bike, skateboarding, scooter, bus, car	Active commuting is not sufficient to Physical Activity but attenuate the excessive weigh.
Sirard et al., 2005	United States (Columbia, South Carolina)	219 (10 y)	Each day of consecutive five students were asked how they get to and from school	School bus, parent´s car, other car, walk, bus.	Walking to school was associated to 24 minutes of moderate physical activity. Deep research is necessary to evaluate the impact on physical activity and health well-being.
Eyler et al.,2007	United States (Missouri, Massachussets, California, Washington, South Carolina, North Carolina, Colorado)	4,137 (6-10 y)	Influential factors to active transportation to and from school	Walk, bicycle	Active transportation initiatives should consider: Collaboration between all the players involved, Policies to address Safety, Policy context (e.g. bus policies, school choice, etc.), Influential factors (infrastructures, geography of school surroundings, crosswalks, etc.). Intervention in diverse population of schools is necessary to make robust results.
Ham et al., 2008	United States (Columbia)	49,883 (5-18 y)	How students get to school	School bus (charge/no charge, public transport (charge/no charge), walk, cycle automobile (driver/passenger), motorcycle, other	The results suggest that the percentage of students who walked or biked decreased substantially from 1969 to 2001. Multidisciplinary strategies to promote active commuting.

Literature Reference	Country (City)	Sample size and Age	Topic	Transport modes	Outputs
Martinez et al., 2008	United States (California)	800 (6 y)	In a typical week, how many days and which mode	Walking or riding car/bus	Number of days a child walked when riding car/bus or walking to/from school.
Heelan et al., 2009	United States (Nebraska)	324 (5-11 y)	A tool designed to capture mode of transport to and from school during a week	Walk, bike, riding in car or bus	Active commuting does not appear to be sufficient to physical activity. It is necessary to determine how to mitigate parental perceived barriers to active commuting and the health impact.
Bungun et al., 2009	United States (northern Utah community)	2,692 (10-15 y)	How usually get to and from school	Car, bus, walk, bicycle or other	It is estimated that 15% of American youth walk or cycle (less than European and Asian youth). Street connectedness and gender (boys) are variables that favor active commuting. Urban planners should decide the schools' location considering the desire to improve active modes.
Zhu and Lee, 2009	United States (Austin, Texas)	2,695 (5-18 y)	On a normal day your child travel to and from school	Walk (alone, accompanied), bike, school bus, public bus, private car, carpool	Parents' education, car ownership, personal barriers, and school bus availability were negative correlates to walk to school; positive correlates were parents' and children's positive attitude and walking behaviour, and peer influences.

Table 2.3 - Commuting to school (research in other continents/countries)

Literature Reference	Country (City)	Sample size and Age	Topic	Transport modes	Outputs
Tudor-Locke, et al., 2003.	China (eight provinces: Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, and Shandong	2,675 (6-18 y)	Describe Physical activity and inactivity levels	Motorized vehicle, bicycle and walking	Approximately 84% of Chinese youth actively commute to school for a median of 100–150 min/week. Only 8% of Chinese school children, regardless of gender, watch television ≥2 h/day; less than 1% watch ≥4 h/day. They do not perform housework cores due to scholastically family pressure.
Fujii and Taniguchi, 2005	Japan (Sapporo)	222 (10-11 y)	CO2 reduction and environmental reduction	Walk, cycle, motorcycle, taxi, bus, subway, car	15% reduction in CO2. To formulate behavioural plan can be an effective and cheap tool for changing travel behaviour.
Merom et al., 2006	Australia (New South Wales)	812 (5-12 y)	Active commuting to school among NSW primary school children: implications for public health.	Walking/cycling	Broader definition of active commuting, i.e., any “leg” of trip to or from school that includes walking or cycling. Low prevalence of active commuter (median of 50 min/week actively commute) and similar to previous Canadian research. Active commuting should be viewed as a planned behaviour negotiated between parents, schools, workplace (flexibility in working hours, travel plans to worksites) and media could play an important role (to create favorable social norms and climate necessary for active and sustainable transport)

Literature Reference	Country (City)	Sample size and Age	Topic	Transport modes	Outputs
Timperio et al., 2006	Australia (Melbourne)	235 (5-6 y) 677 (10-12 y)	Personal, family, social, and environmental correlates of active commuting to school.	Walk or cycle	Distance (> 800 m), busy intersections, poor access to lights/crossings, hilly routes, are negatively associated with walking and cycling. To increase active modes, it is necessary to create child-friendly environment and provide skills to interact with the environment.
Booth et al., 2007	Australia (New South Wales)	2.750 (10-16 y)	Characteristics of travel to and from school among adolescents in NSW	Walking, train, bicycle, car, school bus, other bus, ferry, others.	Among grade 6 -20% used PT and in secondary student 50% used PT. Among those who walked the median times were 10-15 min. and those who used PT, spent 5 min. per trip. Primary students who changed to PT will increase 3% of activity energy expenditure.
Robertson et al., 2008	Canada (Ontario)	21,345 (14-18 y)	In the last 7 days how get to and from school	Actively (walk, bike); Inactively (car, bus) or mixed	Smoking is negatively associated with active commuting. School type and location is associated with active commuting (walk, bicycle). Rural schools are less likely to use active modes as they may live further, they may have to use inactive transportation (i.e., bus).
Hohepa et al., 2009	New Zealand (south Auckland)	3,471 (12-18 y)	Number of trips to and from school the previous five days	Bike, walk	Few high school students are active during school time (e.g., morning recess, lunchtime and after-school period), which represents an opportunity to develop school intervention to increase physical activity and increase active commuting.

Literature Reference	Country (City)	Sample size and Age	Topic	Transport modes	Outputs
Silva et al., 2011	Brazil (Caxias do sul)	1,672 (11-17 y)	Mode used	Walk, bike, bus, motorcycle, car, other	In Brazil, children who go to public schools usually belong to lower income families, which can be an indirect measure of socioeconomic level. The associate barriers to passive commuting are distance, crime/danger and traffic. Environmental variables (areas for pedestrians, bike lanes, places to park bicycles and developing educative campaigns) are associated with active commuting.
Costa et al., 2012	Brazil (Florianopolis)	1,232 (7-10y)	Mode on usual weekday and the previous day	Walk, cycle, car, motorcycle, bus	In spite of decreased active commuting in 2002 and 2007, children entering adolescence rised active commuting from 40% to 49%. Policies should focus on safety and environmental factors to increase active commuting.
Trang et al., 2012	Vietnam (Ho Chi Minh)	759 (11,8y)	Mode to and from school every weekday	Were driven, took bus/minibus, motor bike or walked	The decline in active commuting among adolescents over the 5 years (2004-2009) was 8.2%. Taking bus/minibus was considered as passive commuting. The study highlights the need of development of urban physical environments favorable for active commuting and promote education campaigns.

Thirty-three studies were included in this aggregate analysis. Twenty-two studies (66%) included the public transport in the analysis, but only one considered it as an active mode (Edwards, 2008). Only three studies in this review are longitudinal studies (Ham et al., 2008; Costa et al., 2012 and Trang, 2012), i.e., not tracking the effects of the field intervention. These studies demonstrate that the main motivation to the research study was the health impact by physical activity and not the impact on their independent autonomy or even in CO_2 impacts.

From this review we can infer that there is a need for additional studies that track interventions on the field and promoting PT as an active mode and not inactive one. Whereas the aim of most of these studies is to determine the factors that influence the modal choice of travel to school, there is a lack of marketing interventions on the field to track the modal shift towards the Public Transport.

2.3 Children's independent mobility

The topics' importance and relevance are well accepted. The CIM (Children Independent Mobility) is pointed as an elementary part of children development helping building competencies necessary in other domains of their lives, such as to interact with the environment (Bixler et al., 2002, Rissotto and Tonucci, 2002), improve spatial intelligence (Rissotto and Tonucci, 2002) and build friendships (Prezza et al., 2001) and psychological sense of community (Prezza and Pacilli, 2007).

Moreover, from the 1990s onwards, countries like New Zealand, Austria, the United States, the United Kingdom and other European countries more recently, developed awareness-raising activities to influence the travel choices of children, young people and parents towards transport modes that are safer, more beneficial for the environment of the children and teenagers themselves. These activities were achieved by designing personalized travel plans or by promoting active transport modes (e.g., "Safe Routes to School[5]","Walking Bus[6]").

[5] Safe Routes to School (SRTS) is a public health effort to increase the number of children walking and cycling to school. Originating in Europe, SRTS came to America in the 1990s. (https://www.saferoutespartnership.org/)

[6] A walking bus (crocodile, walking school bus) is a form of student transport for schoolchildren who, chaperoned by two adults (a "Driver" leads and a "conductor" follows), walk to school along a set route, in much the same way a school bus would drive them to school. Like a traditional bus, walking buses have a fixed route with designated "bus stops" and "pick up times" in which they pick up children.

Our literature review identified a potential for defining a School Travel Planning as a tool that can match the transport policies and needs of this segment of the population. The process behind the development of school travel plans should be simple, school focused, and aimed at reducing car trips to school and increasing other modes, particularly active and public transport. The school plans should also incorporate an innovative and community engagement travel planning method as experienced in 33 schools in Canada (Page et al., 2005). A similar intervention to Canada has emerged in the UK where a reduction in "school run traffic" by an average of 8-15% with some UK schools achieving more than 20% reduction (Cairns et al., 2004).

Historically, there is a worldwide perception that children have lost their mobility autonomy in last decades, as evidenced in the large-scale comparative study that was conducted in 16 countries (Shaw et al., 2015). In this study Portugal ranks 10th in the independent children's mobility ranking. The top positions of this ranking are occupied by Finland, Japan, and the lowest by Sri Lanka and Italy.

In recent years, there has been extensive research to identify the factors limiting the development of young people's autonomy and independence, such as: i. family background (Barron, 2014; Jensen et al., 2014), ii. socio-cultural (Depeau, 2001; Valentine, 2004; Karsten, 2007), iii. environmental context (Mitra and Buliung, 2014, Alparone and Pacilli, 2012), iv. parents' employment (Valentine, 2004; Witten et al., 2013), and v. parental security fears (Shokoohi et al., 2012; Carver et al., 2012) among others. These studies clearly indicate that it is a multidisciplinary problem requiring coordination between the multiple stakeholders involved in this research area.

2.4 Child, satisfaction and well-being

Developments in PT services may influence users´ satisfaction regarding travel conditions and consequently, improve the individuals' perceptions on quality of life as a whole (Ettema et al., 1995). The integration of a ''transport happiness'' vector as part of an individual's well-being should be a target for policymakers (Duarte et al., 2010).

Waygood et al. (2017) examined the association between children´s subjective psychological well-being and the travel modes used, together with their preferences and attitudes towards those modes. Younger children preferred active modes and older had stronger preferences for car (Stark et al., 2019).

Through a tailor-made Satisfaction Travel Scale for children, Westman et al. (2017) showed that as children grow up, they need to gain confidence and ride public transport so that they acquire independent mobility, can interact with other fellow humans, learn to accept differences, communicate politely with strangers and respect boundaries.

The literature refers that children's transport secured mainly by private car travel does not only negatively affects school traffic but can also influence the household's quality of life by adding trips or limiting the work schedule or job opportunities (Novaco and Gonzalez, 2009). Furthermore, when teenagers and children are car-reliant, they become less responsive to policies that encourage car use reduction, which triggers a need to understand youths' intentions when they decide to commute by car (Davison et al., 2007).

It is important to outline that increased car use is having significant effects on the urban commuters´ health (Karanasiou et al., 2014) and particularly in children´s health (UNICEF, 2016; Buka et al., 2006). The motivation on active school transport is appropriate given that adequate physical activity during childhood and adolescence could be critical to the prevention of chronic diseases in longer term. Research shows that adult physical activity such as walking and cycling, can enable longer term health benefits by decreasing the risk of obesity, chronic diseases and type II diabetes, and by improving quality of life. Recommendations advise people of all ages to include at least a minimum of 30 minutes of physical activity of moderate intensity and physical activity appears to improve psychological well-being (DHHS, 1996; Saris et al., 2003)

Experimental evidence on children is restricted, but those who actively commute to and from school, and subsequently adapt to an active lifestyle, may also enjoy a healthy active lifestyle (Faulkner et al., 2009; Tudor-Locke et al., 2001). The studies containing measures of body weight/BMI[7] reveal that the difference in body weight/BMI between active and passive commuters was occasionally significant and not in the long term. For instance, Cooper et al. (2003) concluded that of those who walked to school, 42% had a journey of less than 5 min, while the majority (82%) had a walk of less than 15 min. Therefore, the weak link between active commuting and BMI may be related to the distance to school considering that the children who lived farther than 0.75 km of the school were less probable to walk.

[7] Body Mass Index- is a value derived from the mass (weight) and height of a person. The BMI is defined as the body mass divided by the square of the body height, and is universally expressed in units of kg/m^2, resulting from mass in kilograms and height in metres. Commonly accepted BMI ranges are underweight: under 18.5 kg/m^2, normal weight: 18.5 to 25, overweight: 25 to 30, obese: over 30.

Overall, transport-related physical activity is an important issue of research and policy concerning since it comprises health and transport benefits (Badland and Schofield, 2005), and avoid the production of harmful emissions (e.g., particulates, CO, NOx, HC).

Besides, reducing car use and dependence presents potentially positive opportunities to enhance environmental quality and children's well-being. This will decrease energy consumption and more importantly improve children's health via increased outdoor activities and by providing healthier environments (Freeman and Quigg, 2009).

2.5 Modal choice to school

School trips constitute a significant part of the total transport movement within a city and are strongly integrated with the land use. This commuting type carries a relevant weight in the daily activities since it overlaps with other household routines (morning and afternoon peak time) and the urban daily traffic. Mitra (2013) reviewed the literature related to school travel behaviour of children and youth and proposed a conceptual framework - Behavioural model of school transportation (BMST) - which involves multilevels of influences: external influences (natural environment and policy and social-political context), urban environment (urban spatial structure, neighborhood built environment and social environment (neighbors and friends), the household (composition, patterns of mobility, and Attitudes/Beliefs/Social Norms), the child (attitudes and beliefs) and the Travel (independent or not and which mode). This theorization of school travel behaviour enables an improved understanding of school commuting stressing also the negotiation between the caregiver – child travel of an independent or escorted school trip established on a perceived importance of an escorted trip, the mobility options and the household daily activities (work and school scheduling).

There are other proposed frameworks in school commuting in the literature such as the author proposed (McMillan, 2005) and which relates the neighbourhood built environment with mode choice behaviour for a child’s school travel but as a product of parental decision processes and not including the child’s role in school travel decision processes. Besides a different framework, Panter et al. (2008) based on current empirical evidence and sustained in four domains of influence (e.g., attitudes, socio-demographics), the built environment (neighbourhood and travel route), external domains of influence (e.g., weather, cost, government) and main moderators (e.g., age, sex, distance) focused on the active travel behaviour of youth, and hypothesized that both parents and youth may participate in the travel decision processes. This

proposal presents a summary of the correlates of active travel, but it was unclear in explaining the behavioural methods that correlate these factors with the active modal choices.

However, this framework is not modelled on empirical research. Nevertheless, scoping reviews on school travel behaviour are also available (Arksey and O'Malley, 2005; Brien et al., 2010). Scoping reviews are a relatively new approach to search broad fields of evidence and there is little guidance regarding the decision to choose between systematic reviews or scoping reviews to synthesize evidence. Although scoping reviews still involve rigorous and transparent methods to guarantee trustworthy results. Scoping reviews may help reviewers to identify and analyze gaps present in a given knowledge base, by confirming their *a priori* criteria and guarantee that the research questions are able to be answered by available, related evidence (Munn et al., 2018).

European and American children, who have access free school bus service, commute by car to school (Ewing et al., 2007). The factors enabling or limiting the use of active modes in this negative trend has received much research interest and incorporate different fields of investigation, such as socio-demographic (e.g. age, gender, income, job, etc.) or environmental context (traffic and land use) (Davison et al., 2008; McDonald et al., 2014), (Carver et al., 2019), among others.

There is evidence supporting an association between child´s age and the modal choice (Babey et al., 2009; Bere et al., 2008; Johansson et al., 2011; McDonald, 2008a, 2008b; Robertson-Wilson et al., 2008). The present work argues that transitions from primary to intermediate education, can be prime timings facilitating changes in mode choices towards more sustainable options (Cooper et al., 2012). This study concluded that interventions could focus on children who live within a distance of 2.5-3 km to promote active commuting and to maintain active commuting during secondary school to reduce the trend of decreasing physical activity during adolescence.

2.6 Marketing, campaigns and school travel

The empirical evidence suggests that PT is mass-oriented rather than market-oriented and driven by the functioning of the operators. This can be inferred by PT operators' organigrams and the marketing's role and strength in their company's strategy, and also by the scarcity of academic research on this field. However, transport operators need to be more market-oriented in order to increase ridership, maintain passengers´ loyalty, capture new users and consequently improve their financial performance (Lai and Chen, 2011).

McCarthy (1960) introduced the concepts of **Product, Price, Place and Promotion** (the 4 Ps in Marketing) as the key decision elements in marketing and, likely due to its simplicity, this has become the most cited classification system for the marketing mix. Kotler (1972) extended the traditional concept of marketing beyond profit organizations such as universities, museums, municipalities and states. As stated by Andreassen (1995), one explanation for the loss of PT market share is that the sector pursued the wrong strategy of mass marketing a standard service, instead of taking into account a heterogeneous market. Good marketing practices develop consumer-customised products and services to fulfil their needs and, consequently achieve customer satisfaction. Some researchers believe that marketing in the 21st Century has to be broadened from the traditional focus on consumer behaviour to all stakeholders involved in the operations planning (Harvey et al., 2017).

To understand the Marketing context, it is important to analyse how it emerged, its historical evolution and its applicability. The marketing discipline has been investigated from three main approaches the commodities (Copeland, 1923), institutional (Breyer, 1934), functional (Alderson and Cox, 1948), and environmental approaches (Holloway and Hancock, 1964). Some researchers suggest that marketing in the 21st century has to be broadened from consumer behaviour to involving all stakeholders and consider the performances of all players taking into account not only the strategic marketing but also administrative and operations planning (Harvey et al., 2017).

Public transport information and marketing campaigns aim expressly to encourage public transport use by combining two different communication approaches, the Personalized Travel Plan (PTP) and Public Transport Information and Marketing (PTIM) (Sanjust et al., 2015). These two approaches are soft measures to encourage a more efficient and sustainable use of the transport system. PTIM are mass campaigns conducted by providing households with information about the public transport mode being promoted (e.g., services, schedules, fares, pocket sized public transport timetables; and in some cases a free public transport trial ticket for non-users), as well as information about opportunities related to different mobility combinations. PTP uses tailor-made information.

The PTP and PTIM approaches are used jointly and separately in order to behavioural change. The implementation of a Voluntary Travel behaviour change under a proposed methodological framework in Italy and using PTIM and PTP resulted in a changed travel behaviour of 27% (35 individuals) of the participants involved. The PTP program showed that

30% of the participants switched to the light rail and 9 % of the participants involved in the PTIM campaign also changed.

Several European Commission programs have been purposely created to change mobility patterns towards sustainability. Some examples of these projects are: INPHORM (Information and Publicity Helping the Objective of Reducing Motorised Mobility) (1998), its successor TAPESTRY (Travel awareness, Publicity and Education supporting a Sustainable Transport Strategy in Europe) (2003), and MOST (Mobility Management Strategies from Largest European Mobility Management Project) (2003). Interestingly, the research projects INPHORMN and TAPESTRY (2003) evidenced that using information, marketing and students as part of an integrated transport plan can leverage public awareness, influence public attitudes and engage people to change their travel behaviour, i.e. switching from car to cycle, walk and the use of public transport.

Inspired in *The Walk to School* campaign which took place annually since 2006, primary students from Victoria (Australia) walked or cycled to and from school more often. Schools who participated in the campaign had access to promotional and action-calling materials including posters and classroom calendars and teachers recorded active travels in these calendars. Schools had support from the council to host activities such as competitions and one-day events and their results could be tracked on a smartphone application and the website. Data collected indicated that 78.628 primary school students participated, corresponding to a 15.5% increase in active school travel. The study concluded that the most active students were girls and children who lived within 1 and 2 Km from school. In this study, carers were self-selected to be involved in the study, potentially leveraging the predisposal to adhere to the active mode. However, the essay did not consider psychological analysis, attitudes and perceptions of safety to explain the impact of this campaign (Sahlqvist et al., 2019).

Marketing in transport modes has also been studied using focus groups such as that in Canada which evaluated 79 girls between the ages of 7 and 15 (Sauvage-Mar et al., 2019). Records and poster data were classified using the ‘4Ps’ from social marketing (Product, Price, Place and Promotion). The aim of the Social Marketing approach (SM) was to increase girls' Physical Activity through active modes. The study showed a segmented response based on “core values”. Primary students valued fun and health, the intermediate school students valued helping the environment and socializing, and secondary students stressed the importance of autonomous mobility. It is worth highlighting the study consideration of a broader scope of active transport as it included walking, cycling, skating, and public transport.

Some studies show us the importance of creating targeted campaigns for the group under analysis, creating appropriate claims to their language and concerns (Lee and Kotler, 2011; Panter et al., 2008; Sauvage-Mar et al., 2019). For instance, transit service created a study based on cluster analysis to develop customer profiles on the perceived quality of service (De Oña, 2015). The Data source (3664 interviews between 2008 and 2011) resulted from customer satisfaction surveys conducted by the Transport Consortium of Granada (Spain). The methods used cluster and decision trees approach. The three clusters considered showed the following response: *young passengers undertaking frequent trips for academic reasons* valued mainly Information and Safety; *passengers owning a car* identified Speed as the reason for their modal choice and finally, the *Elderly* valued Information. Based on these findings of studies like this, transport authorities and operators can develop segmented and hence more efficient marketing strategies through passenger profiling and their perceived service quality.

James (2017) developed a critical assessment of Individualised Marketing and Travel Blending Intervention in Canada from 1986-2011. According to the author and despite the efforts in all the initiatives, the positive results were insufficient to maintain political support. To be sustainable the initiatives need to have consistent success and potentially not target households as a whole but segments such as companies, universities, schools, all with specific needs.

School Travel Planning has the potential to change behaviour from passive (e.g., car, bus) to active transport as found by a Canadian regional two-year intervention in 13 elementary schools (Buttazzoni et al., 2019). In fact, there were some interventions in North American schools (U.S. and Canada) to increase physical activity by promoting active (walking and cycling) to commute to school (Buttazzoni et al., 2018).

Several studies have focused on field interventions to leverage PT and, more specifically, school commuting (e.g., Bilbao Ubillos and Gifford, 2004; Fuji et al., 2003; Macharis et al., 2006; Beirão and Cabral, 2007). In these studies, the main incentives for PT are ticket discounts and free travel passes, i.e., the focus is on the price. Experiencing public transport can reduce car users' negative perceptions by offering free or reduced fares and may have the potential to change habits, attitudes and travel mode choices (Beirão and Cabral, 2007; Outwater et al., 2003).

2.7 Gaps in knowledge and study novelty

The literature review shows a flagrant lack of the use of targeted marketing strategies to leverage commuting by PT for young adults (i.e., students from primary and secondary schools),

and when occasionally implemented is limited to one-shot interventions. Clearly, children are an understudied population group in terms of travel behaviour. However, their travel needs have a direct impact on household travel patterns and hence should be considered as an input variable in the development of new land uses linked to children's activities.

Finally, there is a lack of development of better policies and marketing strategies to influence school-travel behaviour and hence leverage the use of PT.

Based on the assessed literature, no evidence-based research has ever been done on children from 6 up to 18 years, and previous studies have only examined this phenomenon locally, within a municipality. This is the first study examining targeted marketing for a latent demand in school travelling for three simultaneous municipalities of the Lisbon Metropolitan Area. Additionally, the study is also novel in considering an ambitious sample scope across all schooling levels before university.

Considering the literature review and the need to reverse current car-centered mobility patterns rather than sustainable commuting modes, there is a need to segment the population to address this societal challenge. Assuming that the approach of society must be split in small segments to be more effective, and in this case study it was chosen the pre-university students.

Why this segment and not another? On one hand because we believe that it is in this phase of life, that is, from pre-university studies, that behaviours that will remain in adulthood, i.e., it is easier to plant sustainability seeds in people who is still not car addicted (prior to driving license); and on the other hand they are part of a generation that is more aware of the impact of unsustainable mobility than the previous ones.

Taking into account the LMA modal split and the impact of trips to school (IMob, 2017), three municipalities were selected, since they are a significant sample within the metropolitan area, i.e., 22% of the LMA student population. The choice of the School Groups in the three Municipalities, resulted from a first interview with the Board of the respective group and in which the theme “School Transport” was identified as one of the points of concern in the schools involved in this study.

The empirical evidence also suggests that Public Transport is mass-oriented and driven by the operation of the operators itself rather than be market oriented compared with other sectors (retail shops, car industry, tech/software industry, etc.) This can be inferred by PT operators’ organigrams and the marketing’s role and strength in their company’s strategy and suggest that there is a potential to research forward thinking and seek for a close brand relationship between transport operators and the actual and potential PT users.

3. Methodology

One of the goals of this dissertation is to create a methodology to gather quality data related to the portrait of the mobility to and from schools of the study and afterwards implement *Stimuli* to leverage the commuting by PT and consequently evaluate its impact on the modal shift to PT.

This chapter describes the sample studied, in order to understand the conclusions and the extrapolation to other contexts and case studies.

The Figure 1.4 (Chapter 1) summarizes the methodological approach of the present research.

3.1 Methods

3.1.1 Surveys and survey design

Revealed preferences (RP) and Stated preferences (SP) are experiments which are often used in transports studies to analysis choices between different modes of transport. Revealed preferences surveys (RP) are about choices that individuals have made. In terms of PT surveys, the revealed information would be the actual trip or trips made by the user considering origin, destination, origin stop, destination stop, journey purpose, and the mode of transport they chose to use from the available alternatives. The strong point of this type of survey is that it provides us with the real choices made by users in a determined context. On the other hand, stated preferences surveys (SP) collect replies to hypothetical situations presented to users, in this case about PT and private car. Users are consulted on their perception of existing hypothetical alternatives. Each alternative will have a series of attributes which the user needs to consider (e.g., fares, journey time, flexible solutions) which allow asking users to choose from existing and hypothetical alternatives.

This dissertation was also designed to develop a methodology enabling the acquisition of high-quality data on school mobility through two surveys. The surveys were purposely paper based because the case studied schools believe the paper method to be more effective based on past experiences. The surveys dissemination and delivery were made through the schools.

The sampled schools were chosen based on their representativeness in the municipalities where they are inserted, whereby a group of each municipality was selected. According to the

objective of the study, it was defined that schools educational offer should cover the entire pre-university cycle of the system- 1st cycle, 2nd cycle and secondary - and that accessibility to public transport was one of the weaknesses of the school under analysis. This last handicap criterion was identified in prior interviews with the school board before the initiation of the investigation.

The National Data Protection Commission approved the surveys´ procedures and design (CNPD Ref. 02.02-Ofic nº 5935/2018).

A database target was set at 4.071 responses of students and respective families, encompassing ten schools (primary and secondary schools):

- Municipality 1. Agrupamento de Escolas de Alvide (Cascais): Escola S. de Alvide; Escola Básica no 4 Cascais, Escola Básica de Alvide; Escola Professor Manuel Gaião: n= 960;
- Municipality 2. Escola Básica Alfredo da Silva (Sintra): n= 730;
- Municipality 3. Agrupamento de Escolas Camilo Castelo Branco (Carnaxide/Oeiras) - E. S. Camilo Castelo Branco, EB 2,3 Vieira da Silva, EB 1 Sylvia Philips, EB 1 Antero Basalisa: n= 2.380.

Considering the two types of choice data as a primary source of choice response, known as revealed preference (RP) and stated preference (SP), we designed two surveys. RP data refer to choices made in real market situations and in contrast SP the choice is based on hypothetical scenarios.

Thus, to collect detailed and accurate information about school mobility of this sample population in research and also to extract possible future solutions regarding the car-bus trade-off, we designed the 1st survey using revealed and stated preferences experiments, respectively.

On the other hand, the 2nd survey was designed to evaluate the impact of implementing the *stimuli* in the field through their impact on the shift to Public Transport, using the revealed preferences experiments.

First survey

The main purpose of the First survey was to collect data regarding user satisfaction, current mode choices for school commuting and their perceptions and expectations towards public transport. The ten pages survey was split into revealed and stated preference data, deployed in February 2018 and divided into the following sections (Annex 1):

- Socio-demographic information (parents and students);
- Mobility routines (parents and students);
- Transport assessment (parents);
- Personality type (parents only) and
- Environmental awareness and attitudes (parents only).

There were nine types of surveys because, in the stated preference scenario and for one of the questions, parents/educators were asked to choose between hypothetical bus and car options from a binary choice set. This approach requires commuters to make trade-offs between the different attributes included in the utility functions of both modes (car and bus). To obtain effective responses for our modelling approach, an experimental design was applied to secure a representative observation of the choices by parents regarding their children's commuting options to school, by manipulating the levels of a set of explanatory variables (Hensher et al, 2005). Before setting the possible levels of the attributes, several options were pre-tested with a smaller sample of respondents in a pilot survey.

The mode-choice attributes and their levels are defined in Table 3.1.

Table 3.1 - Attributes, corresponding levels and values

Attributes	Variables	Levels	Corresponding values
CAR			
Morning duration trip	TMCAR	2	15 min;30 min
Afternoon duration trip	TTCAR	2	15 min ;30 min
Cost (month)	CCAR	2	25 euros; 60 euros
BUS			
Morning duration trip	TMBUS	2	20 min; 30 min
Afternoon duration trip	TTBUS	2	30 min; 60 min
Cost (month)	CBUS	2	20 euros; 40 euros
Tracking the trip	ACOMP	2	1: yes; 0: no
Flexible schedule	FLEX	2	1: yes; 0: no

Note: * Degrees of freedom= (2*3) + (2*5) + 1= 17

The next stage in the Discrete Choice Experiment (DCE) was to elicit the choice sets to be presented to the commuters as studied by Arentze et al. (2013). For our experimental design, we used DCE macros in the statistical programme SPSS to generate optimal orthogonal design with nine profiles. This method considers orthogonality, level balance and minimal overlap (Kuhfeld, 2010). The profiles were combined to generate 27 choice sets, which is aligned with the

literature and within an acceptable range for DCE studies. A choice set of the stated preference survey is shown in Table 3.2.

Table 3.2 - Choice set submitted to commuters

Block	Card	TMCAR	TTCAR	CCAR	TMBUS	TTBUS	CBUS	ACOMP	FLEX
1	4	15	15	25	20	30	20	0	0
1	12	30	30	60	30	60	40	0	1
1	18	30	30	60	30	60	40	1	0
2	7	15	15	25	30	60	40	0	1
2	15	30	30	60	20	30	40	0	0
2	16	30	30	60	30	60	20	0	0
3	3	30	30	60	30	60	20	1	1
3	10	30	30	60	20	30	40	0	0
3	24	15	15	25	30	60	40	0	0
4	9	15	15	60	30	60	20	1	0
4	23	30	30	60	20	60	40	0	1
4	26	30	30	25	30	30	40	0	0
5	5	15	15	60	20	60	40	1	1
5	8	30	30	60	30	30	20	0	0
5	14	30	30	25	30	60	40	0	0
6	1	15	15	60	30	30	40	1	0
6	11	30	30	25	20	60	20	0	1
6	22	30	30	60	30	60	40	0	0
7	13	30	30	25	30	30	40	1	1
7	25	15	15	60	30	60	20	0	0
7	27	30	30	60	20	60	40	0	0
8	19	30	30	60	30	60	40	0	0
8	20	15	15	60	30	30	40	0	1
8	21	30	30	25	20	60	20	1	0
9	2	15	15	60	20	60	40	0	0
9	6	30	30	60	30	30	20	0	1
9	17	30	30	25	30	60	40	1	0

The layout of this question: *Which of two options (Car/Bus) will you choose to take your children to school,* included in the questionnaire, is illustrated in Figure 3.1.

	CAR	PUBLIC TRANSPORT
		
Morning trip duration Daily commute to/from school and extracurricular activities	15 minutes	20 minutes
Afternoon trip duration Daily commute to school and extracurricular activities	15 minutes	30 minutes
Cost (month) Fuel consumption when travelling to/from school and extracurricular activities	25 Euros	20 Euros
Tracking the trip By mobile phone APP / text message	-	No
Flexible schedule and bus routes	-	No
Choose your preference:	☐	☐

Figure 3.1 - Example of stated preference question to respondents (1 out of 3 choices for each respondent)

Second survey

The main purpose of the Second survey was to assess the impact of the implementation of *Stimuli* towards the shift to PT use. This survey type enables collecting preferences data, which in turn reflect observations on past choices and behaviour and satisfaction for existing services. This survey was launched at the end of the second School Year, in May 2019, after the total *Stimuli* implementation which lasted two school terms: 2017-2018 and 2018-2019.

This four-pages survey consisted of four main sections (Annex 2):

- Socio-demographic information (families);
- Public transport assessment (parents only);
- Shift to PT assessment (parents and children): When and Why?;
- Evaluation of the measures implemented (parents and children).

The survey aimed to:

- assess the children and parents' participation or acknowledgement of the 7 marketing events that characterized the intervention in the field;
- evaluate the impact of these events in the level of PT satisfaction;

- identify if there was a travel behaviour shifting to PT of these families when commuting to and from school, since this research field intervention;
- Identify the time gap between the change in mobility behaviour and the date when the marketing events took place.

The chosen *Stimuli* is presented in Figure 3.5 *and* are described in Chapter 3 and section 3.2.2 Action research.

Figure 3.2 - Marketing events in the 4Ps framework

3.1.2 Analytical methods

The following analytical methods were used to identify which factors influence the modal choice, namely the PT instead of private vehicles when students commute to school and to respond the research questions formulated in Chapter 1.

3.1.2.1 Discrete Choice Models

Discrete choice models (DCM), or qualitative choice models, describe, explain, and predict choices between two or more discrete alternatives.

Discrete choice models theoretically or empirically model choices made by people facing a finite set of alternatives. They can be used in a static context (comparison between two hypothetical alternatives) or differential (modification of the attributes of an alternative).

In Transports, DCM have been used extensively to model mode choice and using different categories of logit models, grouped into ordered and unordered frameworks. The unordered models aggregate the multinomial logit (MNL), nested logit, probit and mixed logit models. On the other hand, the ordered group includes the ordered probit or logit and generalized ordered ones. Considering this diversity of models, researchers usually base their option mostly on the nature of the dependent variable and the available data.

The most commonly employed unordered discrete models – the multinomial logit model (MNL) and its extensions – have their origin in the random utility domain. The latent variable *per* alternative is referred to as the alternative utility and the alternative with the highest utility is designated as the chosen alternative.

The ordered response models explicitly recognize the inherent ordering within the decision variable whereas the unordered response models neglect the ordering or require artificial constructs to consider the ordering.

Multinomial logit (MNL) allows the modeling of multiple variables, and it is the most widely used method for discrete choice analysis. Binary Logistic regression is a method of data analysis used to find relationship between the variables response that is binary with predictor varibales which can be categorical or continuous.

These models are based on Stochastic Utility Theory, in which each alternative has a Utility for the decision maker and the knowledge before the decision is imperfect.

The attributes most often considered in the deterministic part of the utility function are: a specific parameter of each mode, often travel time, price, number of transfers and sometimes the service frequency and the level of comfort.

The Utility of each alternative is described as an algorithm with a deterministic term (function of its attributes) and a random term (which dimension depends on the accuracy of the *a priori* information and the variety of preferences in the population).

It can be expressed in the following formula:

$$U(A) = V(A) + \varepsilon = A_0 + \sum [(w_k X_k(A)] + \varepsilon \quad (1)$$

Based on these utility functions it is possible to calculate the probabilities of choice of each alternative. The probability of choosing alternative A is the probability that its utility is greater than that of all other alternatives.

The models have been used to examine, e.g., the choice of which car to buy, which mode of transport (car, bus, rail) to take to work among other applications, among others.

Discrete choice models statistically relate the attributes of the person and the attributes of the alternatives presented to the person. For example, the choice of which car a person buys is statistically related to the person's income and age as well as to price, fuel efficiency, size, and other attributes of each available car. The models estimate the probability that a person chooses a specific alternative. The models are often used to forecast how people's choices will change under changes in demographics and/or attributes of the alternatives.

Somehow, it is not possible to know all factors affecting individual choice decisions as they are partially observed or imperfectly measured. To overcome this handicap, discrete choice models rely on stochastic assumptions and specifications to account for unobserved factors related to a) choice alternatives, b) interpersonal heterogeneity and intra-individual choice dynamics over time, and c) heterogeneous choice sets. The different formulations have been summarized and classified into groups of models (Hensher et al., 2005; Ben-Akiva and Lerman, 1985; Ortúzar and Willumsen, 2001).

Binary Logit

The Logit model is based on the Stochastic Utility Theory, with a hypothesis set about the error term in the utility expression: Error terms are independent and have the same distribution and parameters for all alternatives; the Error terms distribution is a Gumbel distribution, and the error term takes small values compared with the deterministic part of the alternatives´ utility.

One of the models of choice discrete most used in the demand for transport is the logistics (Ortúzar and Willumsen, 2011). The Logistic Regression differs from Linear Regression in that its calculations involve qualitative rather than quantitative dependent variables.

Logistic regression is characterized by the number of values to be discretized. If there are only two options, the Logistic regression is called binomial, if there are more options, regression is generalized and named multinomial.

Considering the prevalence in car choice when commuting, the response variable is binary (car use=1 and other modes =0), and a Binary Logistic Regression was used in the modelling.

This regression model is based on the transformation of the binary dependent variable, i.e., it does not estimate the probability of an event but rather the logarithmic ratio between this probability and the probability that the event does not happen ("Log-Odds") (Long, 1997) and can be expressed in the following formula:

$$\boldsymbol{L(pi) = \ln\left(\frac{pi}{1-pi}\right) = \alpha + \sum_{j=1}^{k} \beta j x} \qquad (2)$$

where, L (pi) represents the logarithm of the Odds Ratio;

pi represents the probability of modal choice (car - 1; other - 0);

α, βj represent utility function calibration parameters; and

x_j represents the independent variables collected from the survey

Utility Based Model

Discrete choice models can be derived from utility theory, as it is useful to link the statistical model to a theoretical construct. In microeconomic theory, traditional approaches sustain that decision makers choose among a set choice of alternatives and by maximization of their utility (satisfaction). One of the handicaps of this theory is that any purchase affects the others, as they are not independent, and for this reason we have to assume that consumption among different groups of products is independent.

Some studies predict the behaviour of users regarding modal choice, based on utility theory (McFadden, 1974; Domencich and McFadden, 1975; Dios Ortúza and Willumsen, 2001; Washington et al., 2003; Muro-Rodríguez et al., 2017), which undertakes that the preference of

choice of an alternative is taken by a value, called utility, and decision-making selects the alternative in the set of choices most satisfactory (Taniguchi et al., 2014).

Assuming the utility as considered by Hensher et al. (2005) for individual n and alternative i consists of the two parts:

$$Uin = Vin + \varepsilon in \quad (3)$$

Where, $\mathbf{Vin}$, is the systematic utility and is a function of AS (alternative-specific) and SD (socio-demographic characteristics) observable variables

$\boldsymbol{\varepsilon in}$, is the random component, corresponds to unobservable part of the utility function

Some of the limitations of this method are the following:

- Omission of relevant variables from the model;
- Measurement error;
- Proxy variables;
- Difference between individuals may be ignored;
- Dynamic variations in the choice context may be ignored.

3.1.2.2 Hazard-Based Duration Model

Hazard-based duration models are typically used to study the conditional probability of a time duration ending at time t, given that the duration continued until time t (Washington et al., 2011).

According to Washington et al. (2011), probabilities that change with time are ideally suited to hazard-function analyses. To determine the event duration in the study (time until shifting to PT), hazard-based models consider the probability that a duration T is greater than or equal to some specified time t, with the survival function, S(t), written as follows:

$$\mathrm{S(t)} = \mathrm{Pr(T > t)} = 1 - \mathrm{Pr(T \leq t)} = 1 - \mathrm{F(\delta t)} \quad (4)$$

where F(t) is the cumulative distribution function of durations until the shift to PT (in this research).

The hazard function, h(t), is defined as the conditional probability of a shifting occurring at some time t, given that has not shifted until time t, and is written as follows:

$$h(t) = \frac{f(t)}{1-F(t)} = \frac{f(t)}{S(t)} \quad (5)$$

where f(t) is the density function of durations until the shift to PT. In this case, gives the rate at which event durations are ending at time t, given that they have lasted to time t. If the hazard function is downward sloping over the event duration ($dh(\delta)/d\delta < 0$), then the probability of the outcome decreases the longer the event has already lasted. And, if the hazard function is constant over the event duration ($dh(t)/dt = 0$), then the probability of the end of the shifting to PT is independent of its duration.

The Kaplan–Meier estimator measures the event duration until the shift to PT. In addition, this duration is affected by several factors. A primary objective of this study is to accommodate the effects of the explanatory variables on the event duration. The impact of these variables can be considered using a proportional hazards approach. In this case, the explanatory variables act multiplicatively on the baseline hazard function (Washington, 2011; Vadeby et al., 2010) as follows:

$$h_i(t) = h_0(t)\exp(\beta X_i) \quad (6)$$

where $h_0(t)$ is the baseline hazard denoting the hazard that occurs when all elements of the explanatory variables vector are zero, X_i is a vector containing the p explanatory variables, which may depend on time t, and β is a p×1 vector of the estimable coefficients.

Two alternative methods can be used to account for the effect of the explanatory variables, including fully parametric and semi-parametric hazard-based duration models (Van der Berg et al., 2012). Either method can be employed to study the time until shifting to PT. The fully parametric method comprises extensions of existing parametric failure time models (e.g., Weibull, exponential and log-logistic models) and uses re-parameterizations to include covariates (Yang et al., 2015). Conversely, a semi-parametric approach is distribution-free and contains less severe assumptions regarding the underlying distribution of failure time (Balakrishnan and Rao, 2004). According to Bhat (2000), the estimates generated using a semi-parametric method are consistent, and the loss of efficiency may not be significant even when a parametric form is appropriate.

The Cox proportional-hazards model has the flexibility to accommodate a wide range of hazard function forms and is the most commonly used semi-parametric hazard-based duration model (Yang et al., 2015; Moore, 2016). The individual hazard function $h_i(t)$ is semi-parametric

and consists of two parts: a non-parametric part, $h_0(t)$, and a parametric part, $\exp(\beta X_i)$. In a nonparametric proportional hazard-based duration model, the baseline hazard function $h_0(t)$ follows a discrete distribution, and observations are grouped into duration intervals rather than exact times to the observed shift (Sharman et al., 2012).

In the Cox proportional-hazards model, the hazard ratio (HR) is a measure of the relative importance of the explanatory variables concerning hazard, while controlling for distance. The HR is often used to interpret results predicted by the Cox proportional-hazards model (Li et al., 2009) and can be obtained by the exponentiation of each regression coefficient. Specifically, the HR indicates the time rate of stopping at any distance during the study period, compared to that of the reference category. If HR = 1, then the explanatory variable in the model does not affect and does not change the baseline hazard, $h_0(t)$. If HR < 1, then the time rate of stopping is decreased throughout the study period. Conversely, if HR > 1, the time rate of stopping is increased throughout the referred period (Roque and Jalayer, 2018).

Cox proportional-hazards models are widely cited in the literature. For a detailed description of these models, readers are referred to Cox and Oakes (1984) and Moore (2016). In this study, we use likelihood ratio statistics to calculate the goodness-of-fit of the models.

3.1.2.3 Structural Equation Model

Structural equation modeling (SEM) is a causal modeling technique that aims to explain the relationships among multiple variables expressed in a series of equations. SEM is sustained in two multivariate techniques: factor analysis and multiple regression analysis (Washington et al, 2003; Marôco 2014; Hair et al., 2006).

SEM has the ability to consider latent variables in the analysis. A latent variable or construct is a hypothesized and unobserved concept. It is measured indirectly by examining consistency among measured variables (i.e., manifest variables or indicators).

Most concepts require multiple measures (items) for acceptable representation and have many dimensions as such a collective set of questions characterize better than a single item. Considering this holistic approach SEM should not be attempted without a strong scientific basis to specify the measurement and the structural models, as it is the representation of the Theory (Marôco, 2014; Hair et al., 2006; Washington et al., 2003).

A conventional model in SEM consists of two models: the measurement model which examines the relationship between the latent variables and their measures, and the structural model shows the relationships among the latent variables (constructs) (Marôco, 2014).

The method enables the following added values:

- Represent theoretical concepts by considering multiple measures of a concept and reduce its measurement error
- Estimate multiple and interrelated dependence relationships
- Allows to consider both the unobserved “latent” constructs and the observed indicators
- Define a model to explain the entire set of relationships

We used the LISREL (LInear Structural RELationships) model notation (Jöreskog and Sörbom, 1989; Bollen, 1989; Marôco, 2014) as follows:

Measurement model (showing the relationship between latent variables and their indicators):

$$y = \Lambda_y \eta + \varepsilon \quad (7)$$

$$x = \Lambda_x \varepsilon + \delta \quad (8)$$

Structural model (showing potential causal dependencies between endogenous and exogenous variables):

$$\eta = B_\eta + \Gamma\xi + \zeta \quad (9)$$

Where:

- ε, η are independent
- δ, ε are independent
- ζ,ξ are independent
- ζ, ε, δ are mutually independent
- expected error values are 0
- $B_{ii}=0$ (a dependent variable does not cause and effect at the same time)
- ($\mathbf{I}$ - B) is an invertible matrix (non-singular), where $\mathbf{I}$ denote the identity matrix

The structural equation system is generally estimated by comparing covariance matrices demonstrating the relationships among variables and the estimated covariance matrices of the best fitting model. This is obtained through estimation different possible methods: maximum likelihood estimation (MLE), generalized least squares (GLS), asymptotically distribution-free (ADF), scale-free least squares (SLS), unweighted least squares (ULS) and Browne´s method (Arbuckle and Wothke, 1995; Hoyle, 1995; Arminger, 1995; Washington et al, 2003; Marôco, 2014).

The methods more commonly used are MLE, GLS, and ADF. MLE, the most widely used and is the default in most SEM programs. It is more efficient and unbiased when the assumption of multivariate normality is met. MLE is a flexible approach to parameter estimation in which "most likely" parameter values to achieve the best model fit are found. The potential sensitivity of MLE to non-normality created a need for alternative estimation techniques. GLS method estimates the parameters by weighting the residual errors with the corresponding weights of the inverse covariance matrix. It has the same asymptotic properties as ML (consistency and efficiency) but estimates have an asymptotic normal distribution. ADF has as its main differential its insensitivity to non-normality of the data but under the condition of a rather large sample size which limits its use (Washington et al, 2003; Marôco, 2014).

Model goodness-of-fit (GOF) measures are an important part of the model assessment. Somehow measures in SEM are an unsettled topic as a result of lack of consensus of which measures and some authors discuss the multitude of SEM GOF (Mulaik et al., 1989; Steiger 1990; Bollen and Long, 1993; Arbuckle and Wothke, 1995). As there are different approaches to assess the fit of models and different measures capture different elements, it is appropriate to report a selection of different fit measures. Some of the more frequently used measures of fit are presented in the Table 3.3.

Table 3.3 - Fit indices

Fit indices	Meaning	Reference of values
X^2	Chi-square	The smaller the better: p>0.5
$\frac{X^2}{gl}$	Normed Chi-square	<5–bad fit]2-5] – acceptable fit]1-2] – acceptable fit ~ 1- very good fit
AIC	Akaike information criterion	The smaller the better Just to compare models (mainly non-nested models)
RMSEA	Root Mean Square Error of Approximation	>0.10–non acceptable [0.5-0.10[- acceptable ≤0.5- very good
SRMR	Standardized Root Mean Residual	The smaller the better >0.10 non acceptable
CFI	Comparative Fit Index	< 0.8 - bad fit [0.8-0.9[- poor fit ≥0.9- good fit
TLI	Tucker-Lewis Index	< 0.8 - bad fit [0.8-0.9[- poor fit ≥0.9- good fit
GLI	Goodness-of-fit index	< 0.8 - bad fit [0.8-0.9[- poor fit ≥0.9- good fit

Source: adapted from Marôco (2014)

The model may need to be modified in order to improve the fit, thus estimating the most likely relationships between variables. *Modifications indices* are provided from many softwares which may guide minor modifications. *Modification indices* report the change in χ^2 that result from releasing fixed parameters: usually, therefore adding a path to a model which is currently set to zero. Modifications that improve model fit may be identified as potential changes that can be made to the model; therefore, it is necessary to match with the theory being tested, or accepted as limitations of that theory (Maccallum, 1986).

Using this method aims to understand the unobserved factors in order to develop strategies to increase the market share of PT.

It enables us to reflect on how an individual perceives a commuting mode and which is not observable but might explain preferences beyond most traditional attributes like cost, travel, time or comfort.

There is some research in analyzing passengers´ perceptions in terms of satisfaction using the SEM methodology (Eboli and Mazzulla, 2012; Zhou et al., 2016; Muro-Rodríguez et al., 2017, among others).

All computations and analyses were performed using R Studio Vers. 1.1.456.

3.1.2.4 Latent Dirichlet Allocation

Latent Dirichlet Allocation (LDA) has been thoroughly explained in the original paper by Blei et al. (2003), Griffiths and Steyvers (2004), Heinrich (2005), Blei and Lafferty (2009), Berry and Kogan (2010), Blei (2011), among others. LDA has become one of the most popular probabilistic text modelling techniques in machine learning (Wei and Croft, 2007).

Similar to previous research (Ghazizadeh et al., 2014; Mehrotra and Roberts, 2018; Roberts and Lee, 2014), the first step was data preprocessing, i.e., text reviews were imported as a corpus data structure and punctuations were removed. Words that do not provide useful information (e.g., connectors in sentences: and, but, the, a, etc.) can be tagged as stop words and deleted (Manning and Schutze, 1999).

LDA relies on the bag-of-words assumption (Blei et al., 2003) in which the words in a document are commutable, and their sequence is not important. This leads to a so-called document-term matrix (DTM) in which the frequencies of words in documents are captured. This method is based on an unsupervised Bayesian learning algorithm, where the number of topics that the model discovers is a free parameter and does not incorporate manual code into the learning procedure of topics. This language is organized by latent proportions that actors may not even be aware of (McFarland et al., 2013). The number of latent topics (K) to be estimated by the LDA algorithm is a problem of the model, as initially is unknown but necessary to initiate the model. LDA uses Bayesian inference to estimate the model distribution based only on the words in the texts. As such, it requires the pre-definition of k to beginning the modelling process.

There is not a direct measure to identify the optimum number of the topics to include in the model. Thus, some studies recommend different approaches to define the optimal K (Zhao et al., 2015; Arun et al., 2010, among others). The simplest way to evaluate topic models is to look

at the qualities of each topic and recognize their reasonability and risk of overfitting (McFarland et al., 2013; Dyer et al., 2017).

The relationship between two words can be analyzed by counting how often word X is followed by word Y. This two-word phrases (i.e., bigrams) are more informative than the individual as they provide more information related to the phenomenon in analysis and hence to improve the PT service. Also, it is important to discover the correlation between two words and determine how often words appear together and separately in the same document. The mean square contingency coefficient does this evaluation, and it measures the extent and direction of correlation between two variables (Selby et al., 2014).

To perform the text mining procedure, the statistical open-source tool R Version 3.4.2 (R Development Core Team, 2011) was adopted. Specifically, the “tm” (Feinerer et al., 2008) and “topicmodel” packages (Grun and Hornik, 2011) were chosen. The former provides text mining functions, while the latter implements the LDA algorithm.

3.2 Case Study

3.2.1 Context and case studies

The Lisbon Metropolitan Area (LMA) has the largest population and economic concentration in Portugal. Here, there are almost 3 million inhabitants corresponding to about 30% of the Portuguese population and, concentrated in just 3.3% of the national territory (INE, 2015). The LMA includes the following 18 municipalities: Alcochete, Almada, Amadora, Barreiro, Cascais, Lisboa, Loures, Mafra, Moita, Montijo, Odivelas, Oeiras, Palmela, Seixal, Sesimbra, Setúbal, Sintra and Vila Franca de Xira. The three municipalities of our study represent 26% of the population in the LMA (see Table 3.4).

Table 3.4 - Population distribution by municipality of the Lisbon Metropolitan Area (LMA), whereby the three municipalities of the present study are highlighted.

LMA Municipalities	Inhabitants 2011	% LMA
Alcochete	17.569	1
Almada	174.030	6
Amadora	175.136	6
Barreiro	78.764	3
Cascais	206.479	7
Lisboa	547.733	19
Loures	205.054	7
Mafra	76.685	3
Moita	66.029	2
Montijo	51.222	2
Odivelas	144.549	5
Oeiras	172.120	6
Palmela	62.831	2
Seixal	158.269	6
Sesimbra	49.500	2
Setúbal	121.185	4
Sintra	377.835	13
Vila Franca de Xira	136.886	5

Source: INE(2011 Census)

Figure 3.3 presents a map of the Lisbon metropolitan area (with 3.015 km^2) and the relative location of the three LMA municipalities considered in this research case study.

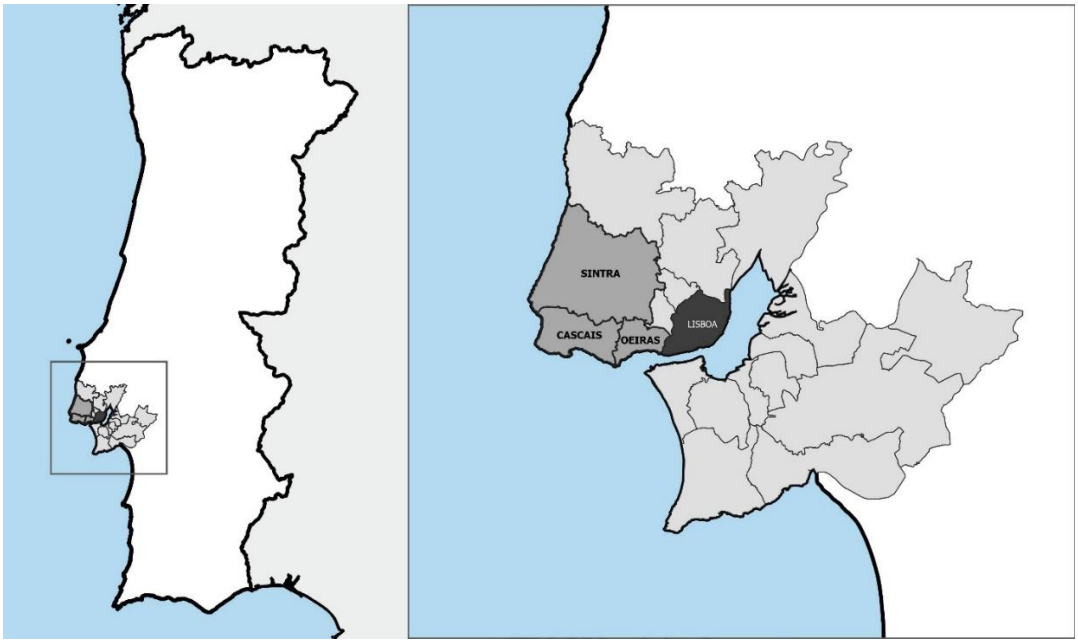

Figure 3.3 - Spatial representation of the Lisbon Metropolitan Area (light grey) - and of the relative location of the three case study municipalities: Oeiras, Sintra and Cascais (dark grey)

Each municipality is an administrative unit with a Municipal Council and an Executive body led by a Mayor.

The Municipality of Cascais (97.40 km^2) is located at the southern western tip of the Lisbon Peninsula, bordering with Sintra at North, and on the East with Oeiras. It distances 32 km (by car) from Lisbon. The population was 206.479 people in 2011.

The Oeiras Municipality (45.88 km^2) is located is surrounded by the municipalities of Sintra and Amadora (to the north), by Lisbon (to the east), and by Cascais (to the west). It distances 16 km (by car) from Lisbon. The population was 172.120 people in 2011.

The Municipality of Sintra (319.23 km^2) is bordered to the north by the municipality of Mafra, to the east by Loures, Odivelas and Amadora, to the southeast by Oeiras, and to the south by Cascais. It distances 27 km (by car) from Lisbon. The population was 377.835 people in 2011.

The employment rate in the LMA, was around 65.4% in 2011 (INE, 2011), within which Oeiras had one of the highest rates of 68.1% (Fig. 3.4).

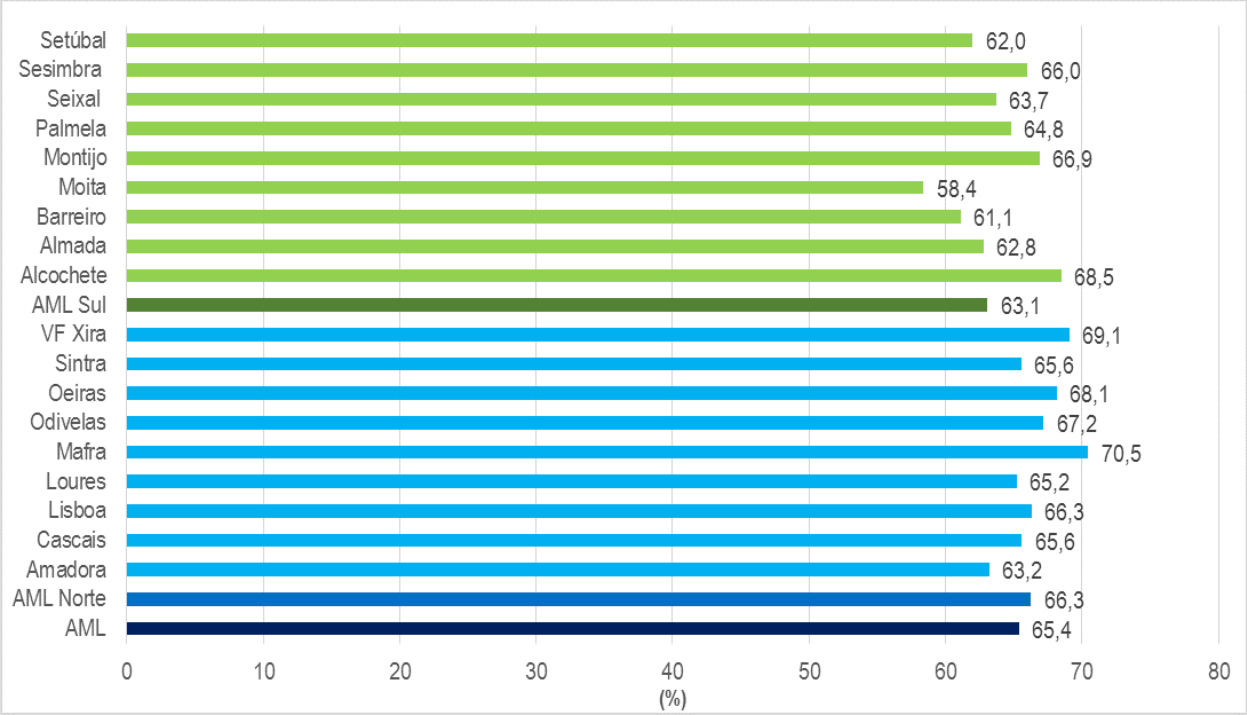

Figure 3.4 - Employment rate by municipality of the Lisbon Metropolitan Area (Census, 2011) colours separate the north and south areas (Lisbon)

A summary of the latest Mobility survey in the LMA (IMob2017) Metropolitan Area Mobility Survey is presented next.

Private car is the main mode of transport in the LMA, representing 56.3% of the weekday trips, while PT corresponds only to 15.8% of those trips (IMob2017).

Table 3.5 - Transport Modal split on weekdays in the Lisbon Metropolitan Area (IMob2017)

Transport mode	Percentage of trips on weekdays
Private car	56.3%
Bus	10.2%
Train	7.5%
Walk + Bicycle	23.3%
Motorcycle	1%
Ferry	0.4%
Other	1.4%

The main drivers of the use of individual motorized transport were time saving (62.5%) and comfort (50.4%). Other factors were also highlighted: “public transport networks have no direct connection with destination” (30.3%), “no alternatives” (23%), and “transport services without the required frequency or reliability” (24.8%). “Not driving / not having individual transport” was identified by 43% of the AML residents as the main reason for underlying the use of public transport. The “absence of alternative“ followed immediately with 37.9%.

Due to the present case study approach, a closer analysis is presented next on the three specific municipalities.

The village of Cascais has become one of the main tourism destinations in Portugal in recent years due to its geography (the existence of several beaches), temperate climate, attractive tourist infrastructures, and the presence of diverse sports infrastructures, some of them attracting international visitors. The municipality of Cascais has several public transport services covering 89% of its territory, but with low adherence by the population (16% to 17% corresponding to territorial coverage of 29% to 34%) (Cascais, 2014). The services are provided by four operators:

- *Scotturb*, a private company providing public road transport services throughout the municipality and also to neighbouring municipalities;
- *MobiCascais*, a public-owned operator responsible for road links in the municipality, as well as the municipal bicycle, vehicle and car park sharing network;
- *Vimeca / Lisboa Transportes*, a private transport company with terminals in the neighbouring areas of the municipality;
- *CP,* a public railway company that connects the municipality to Oeiras and Lisbon through the Cascais Line. The PT network is substantially denser in the coastal zone of the municipality than in the inland areas (TIS, 2010).

Oeiras Municipality is an autonomous economic pole and is one of the most developed and richest municipalities of the Iberian Peninsula (INE, 2019).

With the highest per capita income in Portugal, it is also the second largest municipality with the highest purchasing power and the second largest municipality to collect taxes in Portugal. The economic level is directly linked to the education level and hence, Oeiras is the municipality in Portugal with the highest concentration of population with higher education and the area of Portugal with the lowest population rate without studies (Oeiras, 2013). Many multinational companies are located on its territory (Oeiras, 2013;[8]), it also concentrates around 30% of the

[8] Nestlé, McDonald´s, L´Oréal, Oracle, HP, General Electric, Unisys, Volvo Cars, etc.

country's scientific capacity and is one of Europe's leading R&D hubs (Oeiras, 2008). It is positioned as a destination of excellence for investments that create benefit for the region.

The Oeiras Municipality is surrounded by good road accesses, including the A5 highway, the Marginal road (National Road 6) and the 149-3 national road. However, the public transport network is very small. It has a rail line connecting Lisbon to Cascais and a limited bus network. It has a SATU (Automatic Urban Transportation System) operated by the municipality which consists of a fully automatic suspended electric monorail (1.15km), connecting the historic centre of Paço de Arcos to the Oeiras Parque Shopping Center Forum). This system always had a very low use rate and the service has been suspended indefinitely because it is a large, cost-ineffective and low-efficiency project serving only a shopping centre, in a region where private car use is strongly encouraged, and even indirectly subsidized by the municipality.

Sintra is the second-most populous municipality in Portugal after the capital, and the village with the most inhabitants, followed by Cascais and Oeiras (CMS, 2014). It has a very heterogeneous territory, with several forest and rural locations along the coast and northern regions. In contrast, the southern areas are very developed and urbanised due to the improvement of their accessibility and proximity to the capital (Lisbon). The relative proximity of the Tagus estuary, and the neighbourhood of Lisbon, a cosmopolitan city and emporium of trade, made the region of Sintra an early target of intense human occupation. The municipality has mild thermal amplitudes, with very scarce rainfall summers characterized by abundant humidity in the air, high cloudiness and frequency of fog.

This municipality also functions as dormitories mainly due to the proximity and good accesses to Lisbon. In Sintra natural spaces predominate representing 30% of the territory whereas 26% is urbanised and occupied by compacted housing. Different urban spaces, agricultural (24%) and forest (16%) areas follow this.

The municipality of Sintra is served by several modes of public transport, with particular relevance to the rail transport that makes it the municipality with the largest relative rail use. In 2011, 240.191 individuals were commuting to Sintra, making it the second municipality of LMA (North) in terms of the importance of the absolute flows of people. Of these, the majority (135.350 people) had as destination other municipalities, mostly to Lisbon (57.835 individuals) and Oeiras (13.974 individuals) (PAMUS, 2016). The internal mobility in the municipality is ensured by the services provided by *Scotturb, Vimeca / Lisboa Transportes, Mafrense, Rodoviária de Lisboa, Comboios de Portugal (CP)* and *Elétricos de Sintra.* There is also a diverse offer of touristic transport due to its high demand.

During this field intervention (2017-2019) there were the following governmental and municipal decisions that influenced school commuting. The dates for the 4-18/Sub23 and child discounts for the last three years are as follows:

·**February 2017**

- Free transport for children up to and including 12 years of age, for the Navegante Urbano and Rede travel passes

·**September 2017**

- Extension of 25% discount to all university students who do not benefit from social support (Sub23 travel passes).

·**September 2018**

- 25% discount extended to all children from 4 years of age and youngster under 18 who are not covered by school transport (4-18 travel passes).

·**April 2019**

- Launching of Navegante 12 travel pass, valid until the month the child reaches 13 years of age, valid for all journeys covered by the Navegante Metropolitano travel pass.

September 2019

- Since September 1, 2019 Cascais has a free monthly mobility package for young residents aged up to 14 years.

3.2.2 Action research

The essence of the present research is the promotion of action for PT leveraging in school commuting. Hence, the methodological approach was based on the Stakeholders´ triangle (Figure 1.2).

Portuguese primary and secondary schools of three municipalities of the Lisbon Metropolitan Area (LMA) were sampled including Cascais, Oeiras and Sintra. The sample encompassed ten public schools of these municipalities and was composed by 1760 households (including responses by parents and students) and a total of 445 primary (1st - 4th grade), 990 intermediate (5th – 9th grade) and 325 secondary (10th - 12th grade) students.

The intervention and action-driven research phase (Lucas, 2013; Tripp, 2005) and in this study focused on promoting shifting to PT when commuting to and from school. The intervention lasted two school terms, from February to June 2018 and from September 2018 to June 2019.

The intervention included several activities summarized in Table 3.6.

Table 3.6 - Marketing Stimuli applied in the action research

Field experiment (Code)	Variable Code	Objective	Technique	Marketing Mix (Table 1.1)	Date	Number of Participants	Stakeholders	Relevant Studies
Public Debate (PD)	P1	Involve children´s stakeholders in the design of PT solutions	Workshops	Product	Fev.2018	175	Students, parents, teachers, school employees	Barker et al., 2005; Checkoway, 2011
Bus Paper (BP)	P2	Improve intermodality, mobility literacy, urban mobility, develop PT habits	PT experience/observation/gamification	Product	Ap.2018 May 2019 *(Cascais)	154	Operators, Students, Teachers	Klementschitz and Roider, 2015; Braun-LaTour, 2007
Free Pass (FP)	P3	Experience PT	Prize/ PT experience	Price	Jul. 2018	25	Sponsor Operators, students	Duhigg, 2014; Tomanek, 2017
Traffic Snake Game (TSG)	P4	Gamification of sustainable ridership.	Gamification	Place	Ap.2018	282	Teachers, Students, parents, ACA-M	Moura et al., 2019
Think Tanks (TT)	P5	Involve children´s stakeholders in the design of PT solutions	Meeting, video, PT campaign	Place	Oct.2018	9	Teachers, Students, parents	Checkoway, 2011; Molander et al., 2005; Schmitt, 2011
Stands (ST)	P6	Operators' market oriented. Improve information, communication Interchange information between students, parents operators	Informative stands	Product	Sep.2018	+400	Operators, Parents, children, School boards and employees, teachers.	Haryanto et al., 2017; Barron, 2014
Transports APP (APP)	P7	Digital literacy. Improve information and how to organize a trip chain; Know how to check different operator schedules	Informative workshops/merchandising	Promotion	Jan.2019	695	APP Developper, Students, teachers, parents.	Allan et al., 2006; Civitas, 2019; Washington et al., 2011

Legend: * in Cascais; **ACA-M – Non-profit NGO to raise public awareness for more sustainable urban mobility in Portugal

A timeline chart corresponding to the study design in 2 school years is shown in Figure 3.5.

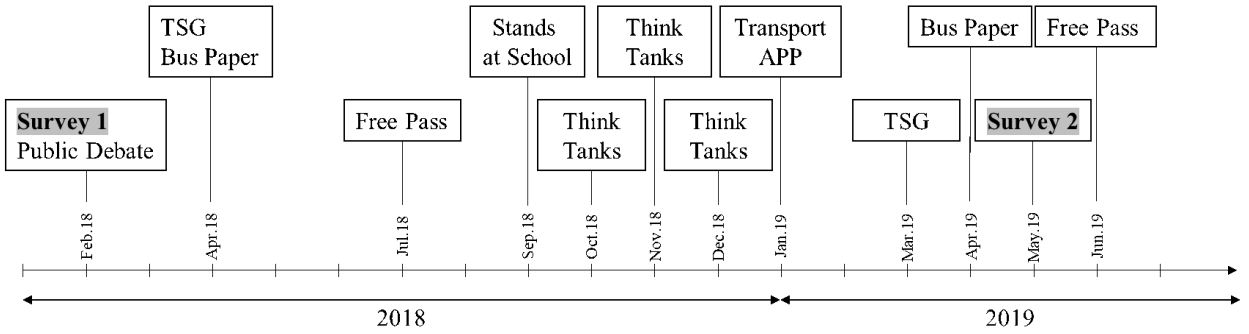

Figure 3.5 - Stimuli on the field- timeline

Legend: PD: Public Debate; **TSG**: Traffic Snake Game; **BP**: Bus Paper; **FP**: Free Pass; **ST**: Stands; **TT**: Think Tanks; **APP**: Transports APP; **S-1 S_2**: Surveys

Our methods were guided by procedures in another school-based research (Chadborn et al. 2013; Spurr et al., 2016 and Sauvage-Mar et al., 2019).

Several evidence (photographs, stats, testimonials, merchandising, etc.) were retained from the different activities.

Public Debates

This event represents the kickoff to the student community and the focus was placed on young people in order to help them understand their responsibility in the future development of the mobility. This is an innovative approach as it intends to be a general improvement in young generation perception of the Public Transport and to serve as an engine for behavioural change.

The event at school was to explain the students the advantages of using sustainable modes of transport or how switching to such transport can contribute to a cleaner city. With this measure, meetings were organised to encourage school students to reflect on their own tranport habits. They shared their point of view and it was necessary to vote of the urgent PT measures.

We believe that many of the participants would afterwards talk with friends, family and colleagues, spreading the message even further. These sessions were disseminated in the Newletters and in the websites of the schools.

Figure 3.6 - Public debates (PD) in schools and polling

Bus Papers

Regarding the realization of Bus Papers, BP, which are named “Learning Public Transport Rally", it was a competition which required students to visit different locations. They had to walk, run, take the bus, a train, or other modes from base to base. In each stage, students answered different kinds of questions, read some printed material, using the storytelling, and performing some activities, such as: sing a popular song, dance or other activities. Students were then awarded points at each of the stages depending on their answers and the winners will have a prize (1- or 3-months free PT pass). The BP combined knowledge, mobility knowledge, speed, humor, and other skills. It was mainly outdoor activities.

Students were organized in teams for the contest as well as the materials which they could use to perform the activities. The materials include things such as dictionaries, transport schedules, leaflets with operators´ campaigns. Teachers included curricular questions using vocabulary and structures suited to the students' level, making sure that they are always challenging.

The aim was to change the user experience and the operators´ image and communication. A deep involvement of the operators was needed to make a successful campaign.

An innovative aspect was a new relationship between the stakeholders, especially when this is not a common practice in the PT. During the BPs it was also possible to bring the stakeholders involved closer together to address some of the improvement issues in PT that serve schools involved in research. Some of these issues referred to drivers' attitudes, missing routes, coordination of bus timetables and entry and exit aulad, and also the need for transport specialists

in the companies to clarify doubts about the whole transport system and not only about a particular transport company.

The researcher served as a catalyst to introduce stakeholders meetings as a completely new approach between Academia and mobility operators and critical to achieve commitments among the stakeholders. Stakeholders involved in these events: Vimeca, Scotturb (transport operators), Agrupamento de Escolas de Carnaxide, Agrupamento de Escolas de Alvide and Escola Alfredo da Silva (Schools), SonaeMC, Decathlon (retail shops), MobiCascais (Mobility), Transportes em Revista (Media sponsor).

Figure 3.7 - Bus Papers (BP) in schools

Free Passes

The BP (Bus Papers) winners had a prize (1- or 3-months free PT pass) and there were open sessions in the school to distinguish these students and strength relations between the school and the operators.

Figure 3.8 - Prizes (Free Passes –FP) - presence of various stakeholders: Operators, Schools boards, Teachers, Parents, Students, and Researcher

Traffic Snake Game

Concerning the Traffic Snake Game**,** it is a game developed by a Belgian organization and its objective is to incentive sustainable trips (walking, cycling, using buses or other shared modes) when commuting to school. As soon as the school links the campaign, they had to make *a priori* accountancy of the sustainable trips they have, and fix an objective to obtain, usually at least a 20% increase of sustainable trips, every week. The objective was to settle for the class as a whole, and not only for the student as an individual. During 10 days of the game, they had to report the number of the sustainable trips daily of children and check if they can achieve the goal settled. If the class achieved the objective, students receive rewards which might include no homework, extra playtime, a visit etc. (TSG, 2017). Three weeks after the game finishes, a new survey is done on the children's mobility behaviour, which balances the data collected *a priori* and during the game and enables the global evaluation of the sustainable objectives.

Implicitly, this TSG includes some of the aspects of the habit loop "Cue-Routine-Reward" that is fundamental in shaping new behaviours and habits. All the data is inserted in the platform of https://www.trafficsnakegame.eu/ and by the partnership with ACA-M[9].

[9] ACA-M Associação de Cidadãos Auto-Mobilizados (https://sites.google.com/view/aca-m-pt)

Figure 3.9 - Traffic Snake Game (TSG)

Think Tanks

In this approach we had the opportunity to have the youth engaging in a think tank development and proposing solutions. There were three monthly sessions during the school year in which the PMIEF (Project Management Institute Educational Foundation)[10] methodology was used.

Participants were recruited by the School Board assessment and based on their skills (topic sensitive, creative and critical thinking, good level of communication and collaborative), under the condition that the group should represent different stages of school and if possible special needs and handicapped students, parents and school representatives.

The selected members of the groups were supposed to act as “mobility ambassadors”, promoting mobility solutions to their peers and create a snowball effect among students by setting a good example. These groups reflected on and communicated their experiences and perceptions with PT and the objective was to identify ways to leverage it through the youth lens.

The solution proposed by the students was a campaign (with posters and a video to promote on YouTube) made by the young people and with the guidance of the researcher. Visual data such as posters-making and a video represent (with language appropriated to the youth target) were the deliverables of these sessions, as shown in Figure 3.10.

[10] PMIEF- Projects from the Future Kit-Project Management Institute Educational Foundation (https://pmief.org/)

Figure 3.10 - Think Tanks (TT) in schools

Students created posters when attending the Think Tanks. The messages therein valued most independence from parents and the family vehicle, socializing and the acknowledgement of the digital app.

Concerning promotion, all groups suggested youthful and humorous language should be used. The posters were later posted at the strategic points and in the video walls of the schools. These posters are shown below:

Figure 3.11 - Campaign posters

Table 3.7 shows in detail the 15 Campaign messages created by the students.

Table 3.7 - Public Transport campaign messages

Original Messages (Portuguese)	Messages (in English)
Cotas, não se preocupem, o passe já está carregado por isso chego a horas	Old folks, do not worry, my travel pass is loaded so I'll arrive on time
Deixa de ser beto e anda de autocarro	Stop being preppy and take the bus
Bro, vem daí..não fiques por aí..vem de Bus	Bro, come on… don't stay there… take the bus
Mor, já escolheste o filme? A 1 está a passar e temos que nos despachar!	Babe, did you choose the movie yet? Bus 1 is coming and we have to hurry!
Vais ter com os Friends? Vais na 12 ou na 13?	Are you meeting your friends? Are you taking the 12 or 13?
Mano, achas que és fitness sem andar de Bus?	Bro, do you think you're fit without riding a bus?
Puto, deixa os cotas e vem de Bus!	Kid, leave the old folks be and take the bus!
Deixa a tua mãe dormir e vem de autocarro	Let your mother sleep and take the bus
What ?! Estás fora da Transporlis?	What? Are you out of Transporlis?
Atreve-te a entrar no Bus, vais Chillar..	Dare to take the Bus, you'll chill.
Larga a boleia dos cotas e baixa a APP da Transporlis	Quit asking your old folks for a lift and download the Transporlis APP
Que estás à espera para baixar a APP?	What are you waiting for to download the APP?
Andar de autocarro é pausado	Riding the bus is cool
Bora People! Vamos para a night. Apanha a carreira 13!	C'mon people! Let's hit the night. Take bus 13!
Táxi ou Papá? Nada disso…Vem de Bus!	Taxi or Daddy? Neither… take the bus!

Stands

At the beginning of the 2018-2019 school year, operators set up booths to publicize their products and clarifying routes doubts. It was also possible to expedite the process of requesting passes. The measure allowed operators to leave their comfort zone and schools to present their mobility products and solutions in the beginning of the school year, which is innovative for this sector.

Figure 3.12 - Operators´stands (ST)

Transports app

The aim of these sessions was to promote the Lisboa Viagem app, in order to make it easier for students to go to school, in the following stages of education: 1st cycle, 2nd cycle and secondary, from the municipalities of Cascais, Oeiras and Sintra. The sessions were directed by the selected ambassadors and guided by the researcher.

In these sessions 2 Videos made by the school students were showed (1 for the Municipality of Oeiras with the participation of Vimeca and 1 for the Municipality of Cascais and Sintra with the participation of Scotturb), lasting about four minutes (section 1.5.2).

The Promotional Campaign Posters (15) were posted at strategic school locations and distributed cardholders to the mobiles.

Silicards (mobile cardholder) to place the pass with the Lisboa Viagem logo (1,000 in total) were distributed when students downloaded the app. The related app had a total of 4.514 vistitors during these sessions.

Figure 3.13 - APP - Lisboa Viva demonstration

3.3 Field Surveys profiling

Two surveys were made targeting the participation of 4070 households. The two-survey data was further analysed to establish the sample profile. The studied variables were response rate, commuting and sociodemographic characterization, calculation of distances between home and school and, the level of importance and satisfaction regarding PT.

There were 1640 participants in the First Survey (February 2018) and 1761 in the Second Survey (May 2019), covering a total of ten schools (Table 3.8).

Oeiras was the school with the largest number of participations (957 in the Second survey) but Sintra had the highest response rate (53%). The overall response rate for the First survey was 41% and 43% in the Second Survey.

Table 3.8 - Analysis of the survey responses according to sampled school

School	Education level	First Survey			Second Survey		
		Surveys launched (n)	Surveys collected (n)	Response Rate (%)	Surveys launched (n)	Surveys collected (n)	Response Rate (%)
Cascais	**Total**	**960**	**369**	**38.4%**	**960**	**417**	**40.2%**
Escola Secundária de Alvide	Intermediate / Secondary	571	202	35.3%	571	238	41.7%
Escola Básica n.4	Primary	104	74	71.1%	104	72	69.2%
Escola Básica de Alvide	Primary	124	42	3.,8%	124	80	64.5%
Escola Professor Manuel Gaião	Primary	161	51	31.6%	161	27	16.7%
Oeiras		**2.380**	**934**	**39,2%**	**2.380**	**957**	**40.2%**
Escola Secundária Camilo Castelo Branco	Intermediate / Secondary	1.169	542	46.4%	1.169	445	38%
EB 2,3 Vieira da Silva	Intermediate	612	188	30.7%	612	246	40.1%
EB 1 Sylvia Philips	Primary	270	89	32.9%	270	163	60.3%
EB 1 Antero Basalisa	Primary	217	59	27.1%	217	65	29.9%
EB1 S. Bento Valejas	Primary	112	56	50%	112	38	33.9%
Sintra		**730**	**337**	**46.1%**	**730**	**386**	**52.8%**
Escola Básica Alfredo da Silva	Intermediate	730	337	46.1%	730	386	52.8%

The participant's majority is female, and the main age group represented is 35-44 years (about half of the sample). Concerning education level, about 40% of our sample has a graduate

level, and 37% a high school degree. Regarding the number of own cars, only 9% of participants do not have any car in their household. This information is summarized in Table 3.9.

Table 3.9 - Commuting to school variables and sociodemographic characterization

Variables	Classes/Options	Description	First Survey	Second Survey
Mobility			Freq (%)	Freq (%)
CHOICE	CAR	Modal choice to go to school	72	NA
	BUS		13	NA
	WALK		15	NA
Sociodemographics			Freq (%)	Freq (%)
PARENT	No Parents	Relationship with the students	9	10
	Parents		91	90
AGE	Class 1	≤ 20 years	1	2
	Class 2	20 – 24 years	0	1
	Class 3	25 – 34 years	8	9
	Class 4	35 – 44 years	53	49
	Class 5	45 – 54 years	36	35
	Class 6	55 – 64 years	2	3
	Class 7	≥ 65 years	0	1
FEM (Female)	No	Gender	30	34
	Yes		70	66
WRK (Work occupation)	No work	Employment	16	13
	Work		84	87
STUD (Level of education of the respondent – parents only)	Class 1	primary	22	23
	Class 2	secondary	34	37
	Class 3	grade level	44	40
INC (Income)	Class 0	Live without financial restrictions	22	27
	Class 1	Live modestly	64	60
	Class 2	Live with financial restrictions	14	13
NCAR (number of cars)	None	0	9	9
	0	1	42	42
	1	2	44	42
	2	3	4	5
	3	>3	1	2

Legend: NA = not applicable.

The student's zip code was used to calculate the distance to school. The following procedures were made:

1. The approximate coordinates of the zip code were calculated by the Google Maps Geocoding API. The zip code does not exactly match the residence but provides a good approximation.
2. Routes (which give the distance and time) were calculated using the Plugin OSM Tools – Open Route Service, which is based on Open Street Maps information. This tool offers a good level of detail for pedestrian mode, and a good calculation of time for both modes. This tool was preferred in detriment of Google Maps does not provide yet accurate calculations for the pedestrian mode in Portugal.
3. The shortest possible walking path (in cases where we cannot walk, for example crossing the river, it turns to the ferry, and goes back on foot) was used for the pedestrian mode calculations. This variable provides a good approximation of the distance between residence and the school attended. Walking time was calculated at 5 km / h according to API documentation[11].

4. The fastest possible road was used for the car mode calculations, albeit it is not necessarily the shortest route. The time was calculated according to the road characteristics as indicated in the API documentation. The results of this calculation are shown in Figure 3.14.

[11] https://github.com/GIScience/openrouteservice-docs#pedestrian-speeds

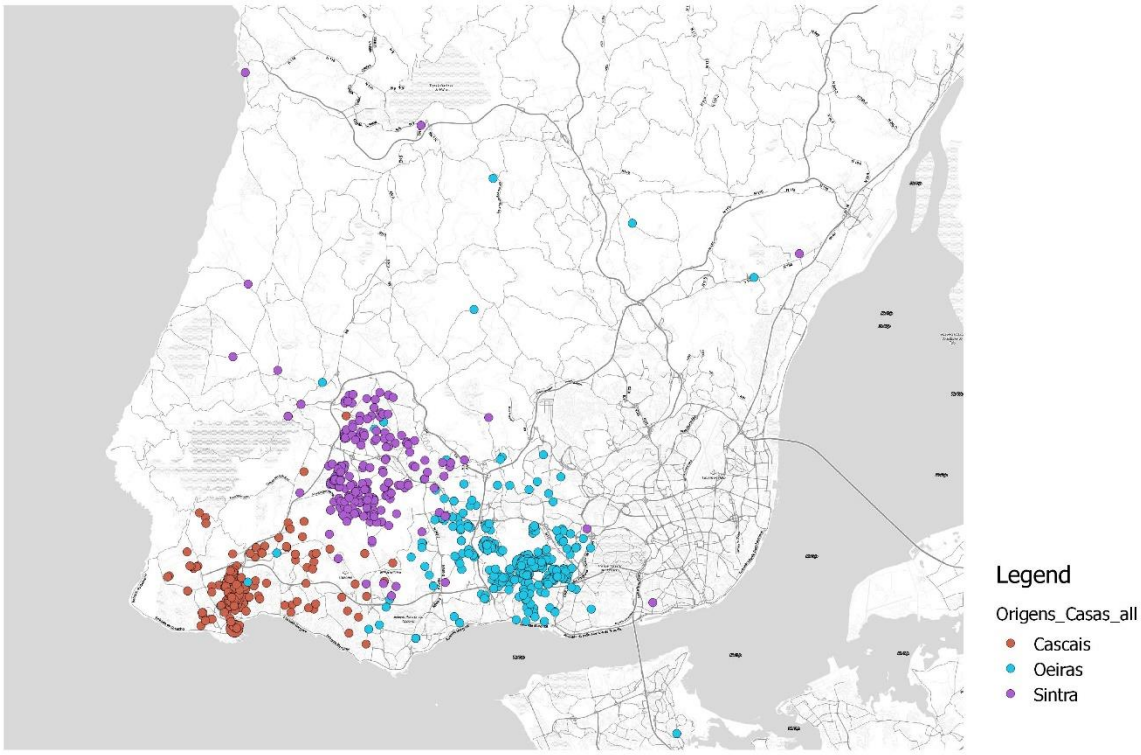

Figure 3.14 - Spatial distribution of residences segmented by municipality (Cascais, Oeiras and Sintra)

The average distance to school was 2.8 (SD=3.031, Max=32.954, Min=0.007).

It is widely accepted that the transport service importance and satisfaction influence the modal choice to which a large body of literature was dedicated to assessing. The closer the gap between the expected and the experienced service, the higher satisfaction to PT users (Mouwen, 2015; Del Castillo and Benitez, 2012; Dell´Ollio, 2011; Eboli and Mazzula, 2009, among others).

Due to the study in analysis, i.e., school commuting to school, the attributes related to PT importance and satisfaction were assessed.

Table 3.10 identifies the factors used to assess the commuter's perception of transport service satisfaction and importance.

Table 3.10 - Assessment of the mean PT Importance and Satisfaction perception (1-7 Likert Scale)

PT Factors	Importance Mean (SD)	Satisfaction Mean (SD)
#1-Frequency	6.02(1.847)	3.01 (2.373)
#2-Schedule Reliability	6.20 (1.786)	3.10 (2.450)
#3-Access to destinations	5.76 (1.848)	3.32 (2.533)
#4-Without or low number of transfers	5.35 (2.060)	3.11 (2.493)
#5-Transfer time	5.42 (2.041)	3.15 (2.484)
#6-Trip duration	5.75 (1.919)	3.14 (2.474)
#7-Ticket/Pass cost	5.88 (1.993)	2.62 (2.330)
#8-Seating	4.64 (1.998)	3.10 (2.451)
#9-Easiness in acquiring tickets/Passes	5.16 (1.917)	3.21 (2.507)
#10-Way of payment (on bus. in the internet)	5.24 (1.860)	3.34 (2.537)
#11-Good PT stop condition	5.68 (1.893)	3.08 (2.455)
#12-No crowdedness	5.59 (1.910)	3.08 (2.433)
#13-Safe. comfortable and calm trip	5.98 (1.820)	3.27 (2.524)
#14-Information availability	5.66 (1.916)	3.09 (2.464)
#15-PT stop proximity	5.95 (1.852)	3.36 (2.601)
#16 Aesthetics (inside/outside bus)	5.24 (1.917)	3.32 (2.468)
#17 Drivers´ attitude and appearance	5.48 (1.914)	3.22 (2.474)

Both satisfaction and importance were graded on a 1-7 Likert Scale (7 is the best mark). On a scale of 1 to 7, the overall average satisfaction was 3.1. Regarding satisfaction per attribute, *PT stop proximity* (average 3.4) and *way of payment* (average 3.3) were the variables with greatest satisfaction. In contrast, ticket*/pass cost* (average 2.6), and *frequency* (average 3.0) had the lowest satisfaction ratings.

Regarding importance, *schedule reliability* (average 6.2), *service frequency* (average 6.0), and *Ticket/Pass cost* (average 5.9) were the most important factors. In contrast the least important factors were *seating* (average 4.6), and *ease to buy tickets/passes* (average 5.26). An interesting aspect was that attributes with higher average importance had a smaller standard deviation than attributes with smaller average importance.

4. Determinants of school travel strategy and policy implications

4.1 Introduction

This chapter describes part of the presentations and publications achieved during the thesis research. These relate to Survey 1 and are referred in 3.1.1, match with the research questions and sub-questions (mentioned in 1.2.).

The first publication identified the family demographic variables conditioning the modal choices for school commute (QUEIROZ, M.M., CELESTE, P. & MOURA, F.. The Influence of sociodemographic characteristics and distance to school on the latent demand for Public Transit, 2019. Oral communication and Conference proceedings at 9º Congresso Rodoviário Português).

Next, the the barriers limiting the choice of public transport were assessed. The barriers were been divided into hard and soft, respectively depending on whether they are associated with public transport infrastructure/operation or with the profiles of current or potential users (QUEIROZ, M.M., CELESTE, P., MOURA, F.. School commuting: the influence of soft and hard factors to shift to public transport – 2019. Presented at 22nd EWGT2019, Barcelona, Spain and publication at Transportation Research Procedia. https://doi.org/10.1016/j.trpro.2020.03.140).

Additionally, the most valued attributes of the optional PT or car use were identified to enable developing more adequate design mobility packages by matching the needs of the respondents (QUEIROZ, M.M., and CELESTE, P., MOURA, F.. Matching users´ expectations in school public behavior: where are we in public transport? – 2020, April 27-30. Transport Research Arena, Helsinki, Finland. Oral presentation approved (Conference cancelled)).

Finally, the parental decisions process was further examined in particular, whether to escort or not children on trips to and from the schools. A model of structural equations was developed based on Norms and Attitudes, the perception of the quality of public transport service and socio-demographic characteristics (distance to school and school stage) (QUEIROZ, M.M., MARÔCO, J.P., MOURA, F., ROQUE, C.A., 2020. On the importance of parents´ decision to

escort children to school with private cars: a structural equation model analysis. Submitted to Travel Behaviour and Society (July 2020)).

4.2 Determinants of public transport use in school commuting

The present section addresses the following research questions:

Q1. *How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

Q2. *Which marketing mix is adequate to influence parents and children in their school commuting?*

4.2.1 Introduction

The aim of this section is to identify the relevant factors that condition the modal choice in school travel in order to identify the factors to be considered in the analysis of latent demand needed for this subgroup of the population. For this, it will be necessary to identify those factors that are apparently invisible neither to the users nor to the providers of these mobility services, and that influence the decisions of families regarding the transport of young people to school (Clifton and Moura, 2017).

This study explores the choice of transport mode when travelling to school through a sample of respondents from different geographical areas, i.e., from three municipalities in the Lisbon Metropolitan Area. The objective is to assess what factors weigh on the decision and then to understand the latent demand allowing to define the future solutions of collective Public Transport Systems in the school context. This analysis may also contribute to the definition of strategies and implementation of mobility plans in current and future school establishments.

This study of Revealed Preferences on the modal choice in commuting to school was based on the survey that was carried out to families in the schools of the three municipalities of AML (Cascais, Oeiras and Sintra) (Section 3.1.1.).

4.2.2.Methodology

A Binary Logistic model was used to identify the factors that could influence the modal choice when commuting to school. This method is presented in section 3.1.2.

In recent years there has been extensive research to identify factors that may limit the development of young people's autonomy and independence, such as family background (Barron, 2014, Jensen et al., 2014), socio-cultural (Depeau, 2001; Valentine, 2004; Karsten, 2007), environmental context (Mitra and Buliung, 2014; Alparone and Pacilli, 2012), parents employment (Valentine, 2004; Witten et al.,2013), parental security fears (Shokoohi et al.,2012; Carver et al.,2012), and distance (Nelson et al., 2008; Mitra, 2014; Fyhri and Hjorthol, R., 2011) among others, and revealing that it is a multidisciplinary problem which needs coordination between the different entities involved in this research area.

Based on this literature review, two groups of information were chosen:

• **Sociodemographic data**, with the variables:

"Parent", "Age" (Age_resp), "Gender" (Fem), "Level of Education" (Stud), "Labor Status" (Wrk), "Income" (Inc), "Number of cars" (Numbcar), "education level" (Level)

• **Spatial location**, with the variables:

"municipality" (Municip) and "distance to school" (log_dist).

4.2.3Results and discussion

The models analyzed considered the various combinations of independent variables and their influence on the choice of car mode as the solution to school commuting. All variables were found to be significant or very significant, except for the parameter of the modal option "Car" and the variable "Fem", where the level of significance was close of 10% (p-value).

The results obtained after calibration of all variables are presented in Table 4.1.

Table 4.1 - Binary Logit model results

Variable	β	Std.Err.	Z value	p-value	sig
Intercept	0.48192	0.30558	1.577	0.11479	
GenderFemale	-0.20410	0.13783	-1.481	0.13867	
Wrk	0.53475	0.16457	3.249	0.00116	**
Stud2	0.41403	0.16016	2.585	0.00973	**
Stud3	0.93752	0.17923	5.231	1.69e-07	***
Inc2	-0.31759	0.17684	-1.796	0.07251	.
NumbCar	0.49821	0.08270	6.024	1.70e-09	***
Level2	-0.51110	0.25469	-2.007	0.04478	*
Level3	-1.66711	0.18711	-8.910	< 2e-16	***
Log_dist	0.22368	0.05845	3.827	0.00013	***
MunicipOeiras	-0.75239	0.17121	-4.394	1.11e-05	***
MunicipSintra	-0.50819	0.29209	-1.740	0.08189	.

Signif.codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Interestingly, the specific parameter of the "car" option (p=0.48) confirms the intrinsic preference for this mode of transport to drive children to school when the other variables are not considered.

The measures of association (odds ratio - OR) of each variable for the use of the car when travelling to school (OR) and for the use of other modes of transport (1 / OR), are presented in Table 4.2.

The OR of the Stud3 variable shown in Table 4.1 indicates that the household person with these qualifications is 2.55 more likely to drive to school than other modes more sustainable. For working people ("Wrk"), the chance to travel by car is 1.70 higher than other modes of transport. On the other hand, students studying in the 2nd and 3rd cycle ("Level2") and in secondary education ("Level3") are, respectively, 1.66 or 5.29 times more likely to move to school in other more sustainable ways instead of the car. Of the three municipalities under analysis, the Municipality of Oeiras is the one with an OR of 2.12 for school trips which means is more likely to use sustainable mobility modes than the other 2 municipalities (Cascais and Sintra).

It is understood that students in middle and high school have more autonomy in their travel mode and more likely not to use the car since they do not have age to have a driving license, as

corroborated by the research by Fyhri and colleagues (2011) where age influence autonomous trips to school.

On the other hand, guardians with professional occupations and/or with higher education are likely engaged in more daily activities, which due to logistic reasons, may directly influence the student transport mode to ensure schedule compatibility, as investigated by the authors Gliebe and Koppelman (2005) and consequently influence the way the child moves to school.

Regarding the presence of cars in households it is understandable that if there is this availability, the propensity for their use will also be higher. There is likely a lower tendency for the use of the car in the Oeiras municipality because the school is located in a more urbanized environment and well served by PT or accessible on foot.

Due to trips´ distance, the results confirm the greater dependence on the car, which reveals that the PT is not serving these trips, but it would be necessary to better understand the origins of student travel to better tailor the service to their needs (possibly).

Table 4.2 - Odds ratio (OR) and 95% confidence intervals (CI)

Variables	OR	1/OR
GenderFemale	0.81	1.22
Wrk	1.70	0.58
Stud2	1.51	0.66
Stud3	2.55	0.39
Inc2	0.72	1.37
NumbCar	1.64	0.60
Level2	0.59	1.66
Level3	0.18	5.29
Log_dist	1.25	0.79
MunicipOeiras	0.47	2.12
MunicipSintra	0.60	1.66

The goodness-of-fit quality of the final model is presented in Table 4.3. When the LL (Log Likelihood) ratio is less than 0.005 it indicates that at least one of the variables is explanatory of the dependent variable. The Hosmer-Lemeshow test had a p-value of 2.2e-16, showing that the logistic model fits the data satisfactorily. Although McFadden's Pseudo R^2 is 0.147, the area of the Receiver Operating Characteristic (ROC) curve is approximately 0.76, so the model presents a satisfactory breakdown.

Table 4.3 - Goodness-of-fit results of the final model

Dependent variable: school commuting by car	
Log likelihood (LL)	LL ratio-913.97 Df-11 Chisq 268.84 Pr(>Chisq) < 2.2e-16 ***
McFadden Pseudo R^2	0,147
Hosmer-Lemeshow	X-squared 7,3816 df=8, p-value=0,4961
ROC curve	Area under the curve: 0.757

The approach enabled the identification of the variables that contribute both positively and negatively to opting for the car, in detriment of other more sustainable modes.

The variables that most influence the choice of the car when travelling to school are the families' higher education, the fact that they work and the greater number of cars in the household. These results are consistent with studies reported in the literature and that support an association between higher education, working and number of cars available to use and the car option (Heath and Gifford, 2006; Schlossberg et al., 2006; Wong et al., 2011; among others).

However, the complexity of the process puts forward the possibility of other variables playing a role, and which were not taken into account in this analysis. However, the results should be carefully analyzed, as there may be other variables that were not included in this section, namely those intrinsic to the quality of PT service and the way it is perceived, and that should be studied in further research.

4.2.4Conclusions

This section aggregates the analysis of three LMA municipalities, thus allowing a comprehensive perspective of the context of pre-university school mobility. Hence, we believe that these results can be replicated to other municipalities with similar infrastructure and school mobility behaviours, considering also that our sample size included three municipalities and wide student diversity.

The results show that the factors positively influencing car travel are a higher number of cars in the household, the higher education qualifications and greater distance from home to school. In opposition, the factors positively influencing the use of Public Transport are being a high school student and living with financial difficulties (particularly evident for Oeiras).

Considering the population universe under study (6 to 18 years old), the level of autonomy in mobility and decision is very different. There are situations in which the student decides autonomously and others in which there is a joint decision in the modal choice between parents and students. In future research should incorporate these variables to pinpoint the role of the individual choice behaviour in the modal choice decision when traveling to school.

The following paragraphs attempt to answer the questions for this research:

Q1. *How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

Chapter 2 enabled to identify, sociodemographic and distance to school as the major factors influencing modal choice and preference for the car, instead of PT. One solution to PT leverage is a shift to prefer PT in school commuting, hence we researched which factors promote this shift. For achieving this aim, we applied marketing approaches to the transport sector for the first time which enabled us both to identify the target and where to focus to make a PT modal choice a more frequent reality.

As a main focus of the marketing strategy, we should focus on the group of respondents who have excelled in this study as prominently users of the car to go to school. As for Promotion (one of the 4 Ps of the Marketing mix), we found that the families with higher education and working full time are those most in need to improve for a more positive perception of public transport when travelling to/from school. Linked with Place, we also found that the greater the distance the school is from the students' residence, the more dependent they are on the car.

Regarding the distance variable and in order to adjust the necessary Public Transport supply, it would be necessary to detail the daily journeys and not just the distance between the school's postal code and the residence.

In summary, we propose an adjustment on the PT supply, by being adequate to parents who work and at same time increase the dissemination of the products/ mobility packages that they and their children can use (schedules, routes, transfers adapted to their need) when they and their children commute to school, as the best tools/approaches to leverage PT use.

Q2. *Which marketing mix is adequate to influence parents and children in their school commuting?*

Potential users are not all the same. The marketing approach to meet their needs can be segmented according to their socio-demographic profile identified in this research and the following Marketing Ps:

Product: the service is not suitable for working families, with higher education and who live far from the school. Operators together with schools should design flexible service in order to adjust to this target identified needs.

Promotion: Considering the Target identified in this study, the development of possible products (more flexible and adjusted), will have to be more disseminated to potential users of the PT and monitored as to their experimentation and consolidation of sustainable mobility habits.

Place: For families living further away from school, services should be adjusted to minimize the number and/or time of transfers. This adjustment of supply to needs will require more thorough work and coordination between school, households and operators. A possible solution could be the creation and management of an annual school travel plan at the school, which would include the needs identified and the dissemination of sustainable mobility solutions.

4.3 School commuting: the influence of soft and hard factors to shift to public transport

The following overall thesis research questions are addressed by the current section:

Q1. *How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

4.3.1 Introduction

Despite the vast literature on school commuting, scrutinizing the foremost factors that determine the final modal choice of households when students commute to school is still challenging and prone to further research, a car is still the main transport mode in many situations. Such factors are often categorized into “hard” and “soft”. Although the literature has not yet clarified the concepts of “hard” versus “soft” factors or measures, there is a general consensus that the former is more related to indicators and interventions on the supply side of the transport system, while the latter is more related to the demand side, which includes voluntary change measures, psychological and behavioural strategies (Bamberg et al., 2011; Möser, 2008; Juhász, 2013).

In Figure 4.1, we seek to stylize the relationship of “supply” and “demand” sides with “hard” and “soft” factors and measures. On the supply side of the system, the authors include infrastructure (IF) and, on the demand side, the characteristics of the users (i.e., users´ profile – UP; and travel behaviour - TB). PT operation and services (OT) mediate the relationship between the infrastructure and the users. As such, it is unclear where to include transport operations and services, i.e., whether these should be considered soft or hard factors. Here, we opted for addressing attributes related to the operation of transport services as hard factors or measures.

For example, “driver´s attitude” determines the performance of the transport services. As such, it was classified as a hard factor. Conversely, psychological or environmental consciousness attributes were classified as “soft factors” as they are determinant for the users´ behaviour, that is, on the demand side of the equation.

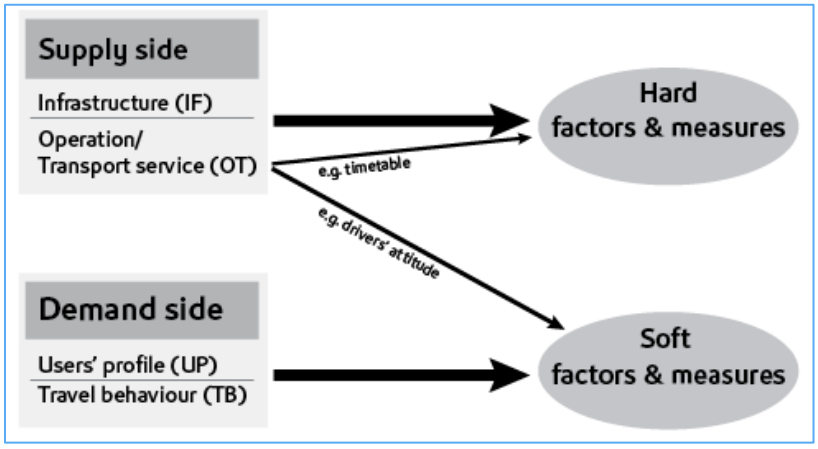

Figure 4.1 - Classification of hard and soft factors

The main goal of this research is to understand the relative impact of “hard” (i.e., infrastructure; operations) and “soft” (profile; travel behaviour) factors on the willingness to shift to PT instead of using the private car.

This study is structured in two parts. First, we identify the willingness to shift to PT, the transport barriers to modal change (infrastructural and operational barriers related to hard factors that can potentially be changed with hard measures) and characterize the personality and environmental profiles of the respondents (related to soft factors that can potentially be influenced by soft measures). Secondly, we modelled the modal choice of school commuting, using a Bivariate Logit Model to estimate the binary response-variable *Willingness to shift to PT (Yes/No)*. The model includes a set of independent variables, related to both soft and hard factors, aiming to jointly simulate the stated preferences of respondents on whether they would be willing to shift to PT in face of a set of technical attributes (see section below). The joint probability of each outcome is quantified with three components: calibration parameters, marginal probabilities and odds ratio; in order to compare the marginal impact of each factor on the respondents’ choices, when compared to all other factors included. The independent variables include both alternative specific attributes and socioeconomic attributes from the respondents.

Data

The data collected to this study considered the survey detailed in section 3.1.1 The sample studied here, eliminated the students that already commute to and from school by public transport, which represent approximately 13% of the total survey respondents. On the other hand, considering the range of ages involved in this study (6 to 18 years) and in order to assess students' autonomy in their trips to school, the following variables related to type of School (Context) were added: School1, related to the primary (6 - 10 years), School2 related to the intermediate type (11 - 12 years) and School3 to the secondary (13 - 18 years).

The physical barriers (hard factors), resulted from an open question in the survey where respondents were asked:

“*Would you be available to have your children travel to School by PT if the barriers were eliminated?”.*

Furthermore, the respondents were asked to rank the chosen barriers in decreasing order of importance, from “the most important”, to “the second most important” and “the third most important”. Due to this fact, it was essential to classify into generic groups and not aggregate

these barriers to better analyse them in detail and then propose improvements with specific and better targeted measures. The barriers grouped into types of barriers are presented in Table 4.4. as well as the corresponding descriptive statistics of these variables suggests that the “most important barrier” to shift to PT identified by the majority of respondents (32%) was “13 - Security”. The “second most important” barrier chosen more often (26%) was “8 - Lack of buses connecting school/home/school”. Finally, the “third most important barrier” to shift to PT selected by respondents was “6 – Cost”.

On the other hand, regarding the type of personality, respondents were asked to rate their own personality according to the following eighteen personality traits:

> *1. optimist, 2. adventurous, 3. like routines, 4. spontaneous, 5. like being outdoor,6. risk taking, 7.like to stay close to home, 8. efficient, 9. variety seeking, 10. punctual, 11. like to be alone, 12. independent, 13. creative, 14. calm, 15. anxious, 16. like being in charge, 17. participative, 18. lazy.*

These traits were placed in a three-factor scale: “Yes, that is me”, “Somewhat”, “No, not all”, as studied in two suburban neighbourhoods in the San Francisco Bay Area, by Redmond (1996).

Moreover, the environmental awareness evaluation contained 15 statements related to environmental concerns that respondents rated on a five-level Likert psychometric scale: from “1- Completely disagree” up to “5- Completely agree”, following the methodology proposed by Redmond (1996), as well.

Table 4.4 - Type of Barriers

BARRIERS BY LEVEL OF IMPORTANCE										
			MOST IMPORTANT		SECOND MOST IMPORTANT		THIRD MOST IMPORTANT		TOTAL	
		BARRIERS	N	%	N	%	N	%	N	%
HARD	IF	1- TRANSFERS Transfer	101	11%					101	6%
		2- STOP- Bus stop conditions	1	0%	18	3%	5	8%	24	2%
		3- WALK- Sidewalk conditions			1		1	2%	2	0%
	OT	4- ATDRIV- Drivers´attitude			2				2	0%
		5- CONF- Comfort			10	2%	5	8%	15	1%
		6- COST- Cost	13	2%	81	14%	20	35%	114	7%
		7- TRIPDURATION- Journey time	21	2%	60	11%	6	10%	87	6%
		8- LACKOF_BUS- Lack of buses	83	9%	149	26%	10	18%	242	16%
		9- FREQUENCY- Frequency	62	7%	59	10%	2	4%	123	8%
		10- SCHEDULE- Incompatible schec	66	7%	34	6%			100	6%
		11- ONTIME- Bus punctuality	20	2%	7	1%			27	2%
		12- BUSNETWORK- Bus network	17	2%	8	1%			25	2%
		13- SECURITY-Safety and Security	299	32%	21	4%			320	20%
		14- INF- Lack of information	9	1%					9	1%
SOFT	TB	15- CHILDRENAGE- Children´s age	61	7%	22	4%	2	4%	85	5%
		16- NO_NEEDPT- No need to go by	46	5%	16	3%	1	2%	63	4%
		17- DISLK- Not liking Public Transpo	2	0%	3	1%			5	0%
		18- CAR Owning a car	11	1%					11	1%
		19- DISTANC- distance home/schoo	114	12%	79	14%	5	9%	198	13%

The fifteen statements related to environmental concerns are the following:

1- We are getting the limit of population on earth;

2- Human beings can modify the environment when they need;

3- The interference of human beings in nature frequently results in disasters;

4- Human skills will prevent earth to become uninhabitable;

5- Humans are using excessively environmental resources;

6- Earth has many natural resources as far as we learn how to exploit them;

7- Plants and animals have the same right to exist as human beings ;

8- Nature equilibrium is strong enough to cope with the impacts of the modern industrial societies;

9- In spite of our special skills, human beings are vulnerable to laws of nature;

10- The “ecologic crisis” our humanity faces has been exaggerated;

11- Earth has limited space and resources;

12- Human beings should dominate the rest of nature;

13- Nature equilibrium is delicate and easily disturbed;

14- Human beings will learn enough how nature works so as to control it;

15- If current behavioural and consumption patterns remain as until today, an ecologic catastrophe will occur.

4.3.2 Methodology

In terms of modelling, the willingness to change (WTC) to PT (i.e. based on the question related to the level of intention to use PT for daily travel to school) was defined as the dependent variable and coded zero to affirmative (i.e., if the decision is to shift to PT) and one for negative answers (i.e., if the decision is to avoid PT). From the total of answers, 84% were affirmative and 16% negative, suggesting an overall willingness to change to PT (and, possibly, showing some bias towards the socially desirable options of choosing PT, instead of the private car).

As independent variables, the following were considered: identified soft and hard barriers (Table 4.4), personality type and environmental awareness of the household (that are included as soft factors as revealed by respondents and to which we can relate soft measures to change behaviour, potentially), and type of school. The reduction of variables related to personality analysis and environmental awareness was performed with Principal Component Analysis (PCA). The obtained scores were then cross tabled with the remaining descriptive variables and the willingness to shift to PT, in order to infer the corresponding impact. All the soft variables (psychology and environment types) were tested for reliability using the Cronbach´s alpha with a conventional value above 0.70 indicating satisfactory reliability as considered by Hair et al. (2006).

This regression model is based on the transformation of the binary dependent variable, i.e., it does not estimate the probability of an event but rather the logarithmic ratio between this probability and the probability that the event does not occur (Log-Odds), as considered by Long (1997), which can be expressed with the following formula:

$$\boldsymbol{L(pi) = \ln\left(\frac{pi}{1-pi}\right) = \alpha + \sum_{j=1}^{k} \beta j x} \qquad (1)$$

Where:

L(pi), represents the logarithm of the Odds-Ratio ratio;

p_i represents the probability of modal choice (affirmative WTC - 0, negative WTC - 1);

α, β_j represents calibration parameters of the utility function; and

x_j represents the independent variables collected from the survey.

If *α, βj* calibration parameters are negative, then the probability to shift to PT increases. Conversely, when α, βj are positive, then the probability of continuing to commute by car to school increases.

4.3.3. Results and discussion

The modelling approach presented above aims to understand the relative impact of "hard" (i.e., IF and OT), "soft" (UP and TB) and "context" factors on the willingness to shift to PT instead of using the private car. For the UP variables, a PCA was performed to the data collected regarding personality types revealing the existence of 5 personality factors. The respective results are presented in Table 4.5. As such, the initial 18 constructs gave rise to the following personality types: "Adventure seeker" (P1), "Organizer" (P2), "Bossy" (P3), "Loner" (P4) and "Peaceful" (P5).

Table 4.5 - PCA Personality types

Personality Constructs	Adventure Seeker P1	Organizer P2	Bossy P3	Loner P4	Peaceful P5
1-Optimist	0.485	0.154	0.211	-0.337	0.056
2-Adventurous	0.727	-0.132	0.068	-0.051	-0.074
4- Spontaneous	0.502	0.076	0.264	0.068	0.041
5- Like being outdoor	0.523	0.392	-0.181	0.015	-0.020
6- Risk taking	0.683	-0.100	0.129	0.109	-0.124
9- Variety seeking	0.513	0.249	0.041	0.219	-0.210
13- Creative	0.432	0.111	0.322	-0.126	0.263
8- Efficient	0.106	0.572	0.160	0.045	0.263
10- Punctual	-0.036	0.606	-0.081	-0.054	0.119
12- Independent	0.128	0.605	0.276	-0.084	-0.074
16- Like being in charge	0.081	0.042	0.761	0.120	-0.041
17- Participative	0.315	0.165	0.667	-0.113	0.102
11- Like to be alone	-0.011	0.336	-0.107	0.644	0.088
15- Anxious	0.080	-0.174	0.357	0.555	-0.004
18- Lazy	0.144	-0.396	-0.063	0.571	0.124
3-Like routines	-0,239	-0,004	0,060	0,025	0,678
7-Like to stay close to home	-0,036	0,170	0,042	0,180	0,640
14-Calm	0,295	0,098	-0,179	-0,372	0,490

Table 4.6 - PCA Environmental awareness

Environmental Constructs	Environmentally concerned E1	Environmentally relaxed E2	Environmentally awa E3
Environmt7	0,696	-0,195	-0,134
Environmt5	0,680	-0,159	0,247
Environmt15	0,624	-0,051	0,303
Environmt3	0,606	-0,078	0,192
Environmt9	0,568	-0,068	0,080
Environmt6	0,551	0,246	-0,405
Environmt13	0,551	-0,140	0,341
Environmt8	-0,190	0,715	-0,088
Environmt14	-0,069	0,690	-0,023
Environmt12	-0,311	0,682	0,187
Environmt10	-0,030	0,670	-0,170
Environmt2	-0,135	0,569	0,042
Environmt4	0,287	0,471	-0,038
Environmt1	0,130	0,016	0,723
Environmt11	0,267	-0,012	0,655

A similar approach was used for environment awareness (Table 4.6). Three attitudinal dimensions were discerned and labelled as “Environmentally concerned” (E1); “Environmentally relaxed” (E2); and “Environmentally aware” (E3).

In order to model the willingness to shift to PT when commuting to school, the initial model included all variables (hard and soft factors) and the *school level* the students attended. After running different models, the results from the final Logit model are presented in Table 4.7 and a number of factors revealed to be statistically significant: Hard Factors (*Number of Transfers, Security, Frequency, Schedule, Bus Suppression*); Soft Factors (*Users´ Profile 3 – “Bossy”, and Child Age*); and Context factors (*School*1 – Primary school, and *School2* – Intermediate school). The selected variables improved the quality of the model and avoided multicollinearity without reducing model-data fit (chi-square=99,346; df =15; p<0,001; McFadden Pseudo R-squared = 0,105).

As referred previously, decision to shift to PT was coded with “0”, while keep commuting by car was coded “1”. As such, negative parameters (and respective Odds Ratio (OR) lower than 1), indicate an increase in the probability of shifting to PT, while positive parameters (and respective OR bigger than 1), increase the propensity to keep on commuting by car. Table 4.7 includes two sets of factors: on the top, we include the factors that favour to remaining with the

car; while on bottom, we include the factors that favor shifting to PT. Each factor is organized according to being “hard”, “soft”, or “context” factors.

All factors that presented negative parameters are related to the identified barriers to shift to PT, by the respondents. Also, these are “Hard” factors as they are related to PT infrastructures or operations. As referred previously, if they are negative, this means that shifting to PT is preferred. This is consistent with the question asked, i.e., if they would shift to PT, provided that these barriers were dismissed. As such, *Frequency* and *Schedules* factors have the biggest impact on the willingness to shift to PT (i.e., the lowest OR), since they have the highest negative parameters. Interestingly, *Cost* has also a negative parameter, i.e., it impacts positively the propensity to shift to PT. This means that if PT cost is relieved (or minimized), then respondents are more prone to shift to PT. Still, the factor *Cost* has a lower impact than *Frequency* or *Schedule*. On the other end of the spectrum, the factor *Security* had the lowest impact on the propensity to shift to PT.

On the “Soft” side factors, we conclude that the Children Age (*Child Age*) has the biggest impact on keep on school commuting by car, i.e., younger children are more prone to be driven to school by their caregivers. Aligned with what was concluded by Haustein et al. (2018) and Yazdanpanah et al. (2017) some psychographic types were significant in determining future modal choice, as well as in our model. According to our results, Profile *P3* respondents (named after “Bossy”, as these revealed to be more prone to be in charge) prefer to remain with car than shifting to PT.

Finally, to compare the impact of both negative and positive parameters, we calculated the inverse of OR of the former (1/OR). We conclude that the impact of the four top “Hard” factors is bigger than the impact of “Soft” factors. This result suggests that intervening with “Hard” measures can potentially be more effective than “Soft” measures. Still, we believe that these should be implemented together.

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Table 4.7 - Logit model estimation model results

Variables	Type of factor	Symbol	Coefficient	Std. Error	z value	Pr(>|z|)	p-value	OR	1/OR
(Intercept)			-1.551	0.170	-9.109	0.000	***	0.211	4.718
								Remain with car	
Children´s age	Soft	ST_ChildAge2	1.156	0.476	2.425	0.015	*	3.178	0.314
Primary school	Context	s1	0.751	0.200	3.748	0.000	***	2.119	0.471
Owning a car	Soft	ST_Car1	0.709	0.650	1.090	0.275		2.032	0.492
Profile P3	Soft	SU_P3	0.629	0.230	2.726	0.006	**	1.876	0.532
Distance home/school/home	Soft	ST_HSHDist1	0.453	0.250	1.810	0.070	.	1.572	0.635
Intemediate school	Context	s2	0.356	0.252	1.413	0.157		1.428	0.700
								Shift to PT	
Frequency	Hard	HO_Freq1	-2.908	1.023	-2.843	0.004	**	0.054	18.322
Schedule	Hard	HO_Sch1	-1.841	0.614	-2.998	0.002	**	0.158	6.303
Transfers	Hard	HI_Transf1	-1.672	0.450	-3.710	0.000	***	0.187	5.326
Bus network	Hard	HO_BusNet1	-1.572	1.043	-1.506	0.131		0.207	4.818
Cost	Hard	HO_Cost1	-0.995	1.055	-0.943	0.345		0.369	2.705
Lack of buses connecting home/school	Hard	HO_LckBus1	-0.912	0.388	-2.351	0.018	*	0.401	2.491
Bus punctuality	Hard	HO_OnTim1	-0.840	0.768	-1.093	0.274		0.431	2.317
Bus network	Hard	HO_BusNet1	-1.572	1.043	-1.506	0.131		0.207	4.818
Security	Hard	HO_Sec1	-0.816	0.226	-3.605	0.000	***	0.442	2.261

4.3.4. Conclusions

These results should be a good indicator of the work that must be carried out in areas where the quality of PT supply is not satisfying, in order to make the public aware of the benefits of the PT modal choice or for a social awakening to their contribution to the sustainable mobility in the city. The most impactful variables on the willingness to shift to PT (i.e., *Frequency* and

Schedules) highlighted a latent concern, specifically related to the “operation services” (i.e., Hard factors). Children’s age is intimately linked to the school level, but also to the parent’s willingness to trust their children to travel alone in PT and trusting the operation/transport service. It is up to the PT operator to provide/offer solutions to mitigate this barrier, through direct control measures, i.e., transport tracking, elimination of modal transfers and ensuring security, not only inside the transport mode, but also in terms of the accessibility to transport modes. In the latter case, a good coordination with other entities such as the police, the school and the community in general, is essential. It is important to know their profiles to segment the target population, allowing for identifying the needs, barriers and willingness to shift and consequently influence mobility behaviour (Esztergár, 2019). For future research, the authors advocate that the focus should be placed on improving these hard factors and analyse *ex-post* the behaviour changes, so as to evaluate the effectiveness of the measures.

The following paragraphs attempt to answer the questions for this research:

Q1. *How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

In this analysis, we assessed the willingness to shift to PT (and leverage the PT option) by using the potential of hard and soft factors. “Hard” factors are related to interventions in Transport operation characteristics and “Soft” factors in the users´ behaviour (psychology type and environmental awareness). We added the school context (type: primary, intermediate and secondary school) considering that the age range is so comprehensive and involves levels of autonomy between students and the parents/guardians, these variables were added to the model, since it is related to the level of education of the school.

From the experiment, we concluded that on the “Hard” side, *Transfers*, *Frequency* and *Schedules* have the largest impact on the willingness to shift to PT. On the “Soft” side, “children age” has the largest impact on keep commuting to/from school by car. The “Bossy” profile was the only significant personality type in the model and prefers to commute by car.

Comparing the “Hard” and “Soft” factors, “Hard” ones have more impact on shifting to PT, than “Soft” ones.

Considering that the children´s age is intimately linked to the school level; primary and intermediate schools are more prone to use the car.

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

It is widely accepted that the transport service importance and satisfaction influence the modal choice. The closer the gap between the expected and the experienced service, the higher the satisfaction to PT users. Based on the results of the methods applied in the case study, the expansion of PT use should consider new transport solutions including transport *tracking,* elimination of modal *transfers* and, ensuring *security* (inside the bus and on the accessibility to transport modes), i.e. reinforce and improve “Hard” factors. Besides these improvements, it is crucial to establish closer relationships between the stakeholders involved and as mentioned in Figure 1.2 (Chapter 1).

4.4 Matching users´ expectations in school travel behaviour: where are we in public transport?

The following overall thesis research questions are addressed by the current section:

Q1. *How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

Q2: Which marketing mix is adequate to influence parents and children in their school commuting?

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

SQ2. *Which is the latent demand in PT?*

4.4.1 Introduction

In a society where in which younger people, who are expectably more prepared for the

digital era, have been losing their mobility autonomy that the research topic arises to understand the reasons for choosing the car as the main means of transports to schools disregarding existing public transport. Though children are not often considered the primary actor for transports planning and management, a better understanding of their travel behaviour provides important answers for future solutions in transports (Zwerts et al., 2010). Long-term travel behaviour of a citizen over his life can be significantly influenced by travel habits during childhood. (Long et al., 2019; Basington, 2008).

To our knowledge though, there is no literature sustaining such theory. This postulate will be analyzed with the literature review due to its important potential impact on urban mobility planning. In this competing scenario it is essential to develop capabilities for identifying latent needs, i.e., needs, desires, dreams, and solutions which commuters do not yet know they want.

So, we believe that the development of future solutions will have to be based on the identification of commuters' minimum requirements that drive their mobility habits. For that, the aim of the section is to analyze the factors that influence the decision to commute to and from school by car or bus, and the corresponding trade-offs, in order to pro-actively building future scenarios and necessary solutions. The factors included were "Travel Cost", "Travel time", "Bus following system for parents" and "Bus Timetable Flexibility", and "Socio-demographic variables of the households".

4.4.2 Methodology

In this section, parents/educators were asked to choose between hypothetical bus and car options from a binary choice set. This approach requires commuters to make trade-offs between the different attributes included in the utility functions of both modes (car and bus). In order to obtain effective responses for our modelling approach, we did an experimental design that aims to have a representative observation of the choices by parents regarding their children's commuting options to school, by manipulating the levels of a set of explanatory variables (Hensher et al., 2005). Before setting the possible levels of the attributes, we pre-tested several options with a smaller sample of respondents in a pilot survey.

The modal choice attributes and their levels are defined in Table 4.8.

Table 4.8 - Attributes, corresponding levels and values

Attributes	Variables	Levels	Corresponding values
CAR			
Morning duration trip	TMCAR	2	15 min;30 min
Afternoon duration trip	TTCAR	2	15 min ;30 min
Cost (month)	CCAR	2	25 euros; 60 euros
BUS			
Morning duration trip	TMBUS	2	20 min; 30 min
Afternoon duration trip	TTBUS	2	30 min; 60 min
Cost (month)	CBUS	2	20 euros; 40 euros
Tracking the trip	ACOMP	2	1: yes; 0: no
Flexible schedule	FLEX	2	1: yes; 0: no

The next stage in the Discrete Choice Experiment (DCE) was to elicit the choice sets to be presented to the commuters as studied by Arentze et al. (2013), among others.

For our design experimental, we used DCE macros in the statistical programme SPSS to generate an optimal orthogonal design with nine profiles. This method considers orthogonality, level balance and minimal overlap (Kuhfeld, 2010).

The profiles were combined to generate 27 choice sets, which is aligned with the literature and within an acceptable range for DCE studies.

The Table 3.2 (Chapter 3) portrays a choice set presented in the stated preference survey.

The response variable (mode choice) is assigned 1 if the car is chosen and 2 if the bus is chosen. The independent variables were divided into two categories: attributes of the mode of transport and sociodemographic characteristics as stated in Table 4.9.

Table 4.9 - Summary of the variables' descriptive statistics

Variable	Range	Description	Freq %
Dependent variable			
CHOICE	CAR	Modal choice to go to school	64
	BUS		36
Independent variables			
Attributes (CAR/BUS)			
TMCAR	15	Morning trip	34
	30		66
TTCAR	15	Afternoon trip	34
	30		66
CCAR	25	Cost (month)	34
	60		66

Variable	Range	Description	Freq %
TMBUS	20	Morning trip	34
	30		66
TTBUS	20	Afternoon trip	34
	30		66
CBUS	20	Cost (month)	34
	40		66
ACOMP	0	Tracking the trip	34
	1		66
FLEX	0	Flexible schedule	33
	1		67
Sociodemographics			
PARENT	Non Parents	Relationship to the students	9
	Parents		91
AGE	Class 1	≤ 20 years	1
	Class 2	20 – 24 years	0
	Class 3	25 – 34 years	8
	Class 4	35 – 44 years	53
	Class 5	45 – 54 years	36
	Class 6	55 – 64 years	2
	Class 7	≥ 65 years	0
FEM	No	Gender	30
	Yes		70
WRK	No work	Employment	16
	Work		84
STUD	Class 1	Primary	22
	Class 2	Secondary	34
	Class 3	grade level	44
INC	Class 0	Live-without restrictions	22
	Class 1	live moderately	64
	Class 2	Live with restrictions	14
NCAR	None	0	9
	0	1	42
	1	2	44
	2	3	4
	3	>3	1
CHILD	1	1	2
	2	2	25
	3	>=3	73
LEVEL	Class 1	Primary school	22
	Class 2	Intermediate school	34
	Class 3	Secondary school	44
MUN	1	Cascais	23
	2	Oeiras	56
	3	Sintra	21

The use of this tool (PCA) is related to the need to reduce substantially the initial variables used, allowing a better analysis and highlighting latent variables.

Principal component analysis is a statistical procedure that reduces the dimensionality of the data while holding most of the variation in the data set. It undertakes this reduction by identifying directions, entitled principal components, along which the variation in the data is maximal. PCA identifies new variables, unobserved ones, i.e., the principal components, which are linear combinations of the original variables.

Considering this tool, we aim to define profiles based on chosen hypothetical bus and car options from the binary choice set. Afterwards, the author believes this will facilitate to propose a marketing strategy to enable a modal shift from car to public transport.

4.4.3 Results and discussion

In order to answer the *a priori* questions, a PCA was started to reduce the number of variables, then a Discrete Model Choice was made based on the utility functions. All results are shown below:

Principal Component Analysis (PCA)

The dimensionality of transport priorities was examined in previous works (Nordfjærn et al, 2010; Şimşekoğlu et al., 2015, among others). This analysis used Principal Component Analysis (PCA) with iteration, Varimax Rotation and Kaiser Criterion. Six factors for transport segments were identified and are shown in Table 4.10.

PC1 are afternoon commuters who typically value fewer commuting times, and value positively the possibility to track their children while in public transport.
PC2 are afternoon commuters who value positively shorter commuting times and negatively longer commuting times.
PC3 are morning commuters who value shorter commuting in the morning.
PC4 relate to bus captive commuters who value lower commuting costs and value positively the flexibility of bus school transport flexibility.

PC 5 and **PC6** comprises respondents who prefer car over other modes. PC5 values a monthly cost of 60 euros and PC6 appreciates 30 minutes of travel time by car. The negative scores of these factors do not make sense in the present context, suggesting future deep investigation.

Table 4.10 - PCA Segment types

Segment / Variables	Aftern_comutter_Acomp (PC1)	Aftern_comutter (PC2)	Morn_comutter (PC3)	Bus_Captive (PC4)	Car_lover (PC5)	Multi-task (PC6)
TTBUS_60	**0,393**	**-0,359**	0,122	0,006	-0,002	-0,001
ACOMP	**0,298**	-0,106	-0,070	-0,003	0,022	0,025
TTBUS_30	-0,233	**0,640**	-0,010	0,052	0,007	0,010
TMBUS_20	-0,126	-0,082	**0,636**	0,019	-0,021	-0,019
TMBUS_30	0,291	0,254	**-0,404**	0,034	0,021	0,024
CBUS_20	-0,035	-0,037	-0,029	**0,628**	-0,028	-0,026
CBUS_40	0,223	0,223	0,139	**-0,490**	0,027	0,031
FLEX	-0,091	-0,004	0,270	**0,326**	0,068	0,070
CCAR_25	-0,078	-0,073	-0,040	-0,015	**-0,613**	-0,018
CCAR_60	-0,093	-0,096	-0,060	-0,029	**0,550**	0,010
TMCAR_15	-0,075	-0,070	-0,039	-0,015	-0,017	**-0,623**
TMCAR_30	-0,096	-0,099	-0,062	-0,029	0,012	**0,542**
% of respondents	*23%*	*15%*	*14%*	*13%*	*12%*	*12%*

Notes: Variables include possible scenarios of time and euros units, e.g., *TTBUS_60* means 60 minutes for travel time in afternoon. For full understanding of these coding, please see table 4.9.

Modelling

The first step was to run an unrestricted model with all the alternatives included. The second step was to run a model with more significant variables and finally with the significant variables, as we can confirm in Table 4.11.

The aim here is to understand the effects of the attributes of each alternative presented (Car or Bus) on the decision maker's choice. We included an alternative specific constant (ASC) to the reference alternative "Car" to try to capture the mean unknown component of utility (error term) which is not explained by the other variables. Utility in the model will be interpreted against the utility of choosing a private car.

As a result of this preliminary analysis and variable transformation, Table 4.11 presents the different models' specifications in our approach (variables acronyms are detailed in the previous *Table 4.9).*

Table 4.11 - Alternatives´ utility specifications

Models	Utility functions for the specification of model
Model 1 **Global**	U(CAR)= V1 = ASC_CAR + B_TIME1 * TMCAR + B_TIME2 * TTCAR + B_COST * CCAR + B_PARENT * PARENT + B_AGE * AGE + B_FEM * FEM + B_WRK * WRK + B_STUD * STUD + B_INC * INC + B_NCAR * NCAR + B_CHILD * CHILD + B_LEVEL * LEVEL + B_MUN * MUN **(REFERENCE ALTERNATIVE)** U(BUS)= ASC_BUS + B_TIME1 * TMBUS + B_TIME2 * TTBUS + B_COST * CBUS + B_ACOMP * ACOMP + B_FLEX * FLEX
Model 2 **Restricted**	U(CAR) = ASC_CAR + B_TIME1 * TMCAR + B_AGE * AGE + B_WRK * WRK + B_STUD * STUD + B_NCAR * NCAR + B_CHILD * CHILD **(REFERENCE ALTERNATIVE)** U(BUS) = ASC_BUS + B_TIME1 * TMBUS + B_ACOMP * ACOMP + B_FLEX * FLEX
Model 3 **Final**	U(CAR) = ASC_CAR + B_TIME1 * TMCAR + B_TIME2 * TTCAR + B_COST * CCAR + B_AGE * AGE + B_WRK * WRK + B_STUD * STUD + B_NCAR * NCAR + B_CHILD * CHILD **(REFERENCE ALTERNATIVE)** U(BUS) = ASC_BUS + B_TIME1 * TMBUS + B_TIME2 * TTBUS + B_COST * CBUS + B_ACOMP * ACOMP + B_FLEX * FLEX

The results in Table 4.12 show the results for Model 3. In this model, *ASC_Bus* is positive, which suggests that Buses are intrinsically preferred against the car by the respondents if no other attributes are considered. This is against expectations as, usually, the car is the preferred mode for all its normally perceived advantages over public transport (i.e., flexibility, availability, etc.). Here, there might be two causes for such results. Firstly, the population that attends the surveyed schools are of lower income. As such, being bus captive users, potentially, they are more constrained in their options to choose the car as the preferred option.

Table 4.12 - Model calibration results

Name	Value	*Std err*	*t-test*	*p-value*
ASC_BUS	1,52	*0,31*	*4,97*	*0,000*
B_ACOMP	-0,26	*0,07*	*-3,44*	*0,001*
B_AGE	0,02	*0,04*	*0,51*	*0,608*
B_CHILD	-0,17	*0,07*	*-2,30*	*0,021*
B_COST	-0,03	*0,00*	*-14,80*	*0,000*
B_FLEX	-0,28	*0,08*	*-3,77*	*0,000*
B_NCAR	0,21	*0,05*	*4,58*	*0,000*
B_STUD	0,29	*0,05*	*5,73*	*0,000*
B_TIME1	-0,03	*0,00*	*-6,32*	*0,000*
B_TIME2	-0,02	*0,00*	*-8,43*	*0,000*
B_WRK	0,30	*0,10*	*2,95*	*0,003*
Number of estimated parameters*	11			
Sample size	3910			
Init log likelihood	-2710.205			
Final log likelihood	-2304.011			
Likelihood ratio test for the init. Model	812.3898			
Rho-square (*McFadden*)	0.15			

Note: * Coefficient with the same names were calibrated together for both alternatives.

The variables related to cost (B_COST) and travel time present negative signs which corroborate with the corresponding disutility expectations. Interestingly, travel times in the morning (B_TIME1) and afternoon peak hours (B_TIME2) present very similar values, indicating that the afternoon peak hour is only slightly less penalized (-0,03) than the morning peak hour (-0,02).

Awkwardly, the possibility of tracking their children (B_ACOMP) while commuting to and from school autonomously was valued negatively (-0, 26), meaning that respondents do not like the idea of their children being tracked or also because she may have misunderstood the question. In the same vein, the greater flexibility (B_FLEX) of the bus schedules the lower the utility of the Bus option. Concerning flexibility, the negative coefficient could indicate that respondents could not understand the question, considering that usually, flexibility is something not related to PT. This means that there is some future work to do in this area, such as changing the management approaches of operators and decision-makers considering on-demand public transport. Additionally, the more children are present in a household ((B_CHILD), the less the car was preferred. This result is also surprising as we would expect that coordinating more children´s schedules would result in the disutility of the bus as a reference. On the other hand, more children

in the family might be understood as they group and support each other while commuting to school and up to 12 years they have free passes which enable families to save some money in their household budgets.

As expected, the more cars that household owns (B_NCAR), the more the household prefers cars over the bus for the children's school commuting, reinforcing the idea that the availability of cars leads to more car usage. Moreover, the higher ranks of work categories (B_WRK) or level of education (B_STUD), the higher the income is expected in the family. Apparently, higher income in the family would favour the option for driving children to school.

Strangely, we would expect higher environmental awareness from more educated families, which is not confirmed in this survey.

The calibration results show a reasonable goodness-of-fit of the model. The likelihood ratio chi-square of 812 with a p-value ~ 0.000 and a R^2 = 0, 15, tells us that the model can explain a significant portion of the variability of the choices made by respondents. All estimated coefficients significant at the 95% confidence level.

4.4.4 Conclusions

Our findings suggest that, to lower people´s car use, the operators should lower travel time and cost, as expected. The new monthly tariff for public transport in the Lisbon Metropolitan Area (30€/month within the municipalities; and 40€/month between any municipality of the 18 existing in the metro area) would certainly have an impact on the households' commuting choices.

Regarding the options of providing more flexible timetables of the buses or allowing for tracking children while in the bus, were either misunderstood or consciously penalized. An understanding of the latter is that the simple idea of tracking children was badly perceived. People do not want their children to be tracked. To the increased flexibility, respondents might not believe in the feasibility of such a possibility in public transport.

Also, the deep-rooted negative attitudes of non-bus users offer greater resistance to shift to buses. We believe that promoting school bus transport might be effective if the service characteristics meet the customers´ needs. If not, the leverage effect will be short-lived and will only lead to a new group of users, potentially, confirming the negative perceptions they had before.

This section provides new evidence of the typical choice between car and bus, for the case of 10 schools in the Lisbon Metropolitan Area peripheral municipalities. The focus was to test the potential attractiveness of new bus-related services to enable a further marketing mix to

leverage PT. We believe that the benefit of using a segmentation model is that it assists tailored approaches for specific groups. With this methodology, we can understand which groups are more sceptical about their behaviour shift or whether people are already actively seeking to influence their friends and family to move to a more environmentally friendly mode of transports as well as identifying opportunities issues and their implications, key factors, opportunities and risks.

We believe there is no single solution that will motivate a mainstream population to choose a greener mode of transport. It requires multiple, integrated interventions. These interventions should develop an intervention mix combining tools from policy and communications drives.

On the other hand, further developments of this study may be identified by considering the children´s participation in transport policy which has been neglected in the field of transport planning.

The following statements attempt to answer the questions for this research:

***Q1**. How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

An effort was made to segment the large group of parents in small groups and characterize them in order to design specific products to each segment.

Considering the sociodemographic aspect, we found that the more cars owned by households, the more families prefer cars over the bus for the school commuting. Moreover, when parents work and have a graduate education, the car is favoured.

Based on a Principal Component Analysis (PCA), we identified six parents´ segments based on the following drivers: “Travel cost”, “Travel time”, “Bus tracking system”, “Bus timetable flexibility”. These segments of parents have different needs to shift to PT. In this research, these groups of parents were labelled as:

i. “Afternoon commuters accompanied”;
ii. “Afternoon commuters”, who value tracking their children and having a short time when their children commute;
iii. the “Morning commuters” for whom is important to have short time commuting;
iv. the “Bus captive” who value the cost and the flexibility and;

v. the “Car-lover” and “Multi-task” who prefer the car instead of PT and the main attributes for them is money and time consumption.

With this methodology we identified the “Car-lover” and “Multi-task” groups as more skeptical about behaviour shifting. The segments “Car-lover” and “Multi-task” and from the possible choice sets, preferred a monthly cost of 60 euros and with a pattern of a 30 minute trip duration.

Afternoon commuters value their children's tracking, which means that this feature (PT tracking) would be enhanced by the operators so that parents would allow their children to return home from PT. Probably, children returning home is not compatible with the parents´ working time (i.e., it is not possible to leave work to pick them up at school) and on the other hand they have more time off to get home than in the morning to get school.

In order to allow this feature in the PT it would be required the following procedures:

- Coordinate school departure times and bus schedules (School-> Operators);
- Assess whether there is a reliable and confidential mechanism in place to ensure that children are tracked when travelling by bus and if there is authorisation for this functionality from the parties involved;
- To operationalize this feature, it would be necessary to inform the school community about this system so that the parties involved have the correct perception of this added value and their confidentiality implications.

As far as the *Bus captive* segment is concerned and because they usually have no other alternatives to move around, cost will always be the differentiating factor in the product/service (PT). For frequent confident users it is necessary to increase loyalty by assuring them the commitment to maintain/increase service quality levels and balanced by the mobility cost they can afford.

The *Morning commuters* always prevail the trip duration, in face of the pressure that they have in the work entry hours (parents/carers) and/or the class start time in the schools (children).

Those who are *Car lovers* and who have many activities (*Multitask*) throughout the day admit being available to pay 60 euros per month and for travel of 60 minutes on average.

Considering this segment, the most difficult to capt to PT it has to be made a continuous effort so that they change their perception about PT. Information campaign with complimentary bus tickets (tailor-made pricing and communication) for specific non users (particularly after the launch of new services) and combining with leisure activities (that they probably have) could be a path to take.

For all these segments of users and non-users, the operator should make all the customers and citizens aware about any improvement in terms of quality and quantity of the service provided. Another driver could be providing public transport to main events in order to increase ridership among non-users, particularly in this segment of the research: families with pre-university students.

Considering the transport price (Price, one of the 4Ps), it is important to mention this survey was made before the new (2019) monthly tariff for public transport in the LMA was implemented (30 euros month within the municipalities and 40 euros between any municipalities of the 18 existing in the metropolitan area). A choice assessment after this LMA tariffs' change would certainly reveal an impact on the households´ commuting choices. Considering the choice sets available to choose in the surveys, the results related to costs suggest a need for a future deeper investigation to design more adequate mobility packages.

Q2: Which marketing mix is adequate to influence parents and children in their school commuting?

From the Choice set submitted to commuters, and considering the Marketing mix, the favourite packages were related to Product and Price.

Product: Travel time in the morning and in the afternoon was 30 minutes by car. Using PT it was assumed that the afternoon travel time could be 60 minutes.

Price: The Car willingness to pay (monthly) was 60 euros and PT was 40 euros.

These preferences will enable operators to develop future public transport packages incorporating the resulted features (Product and Price).

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

Somewhat unexpectedly, after running the model the possibility of *Tracking* children was valued negatively, possibly because parents do not like the idea that operators can track their children (digital means, i.e., digital information) or may have misunderstood the question on the survey.

Concerning the *Flexibility,* the negative coefficient seems to indicate that respondents could not understand the question, probably because they consider it unfeasible, as they do not know it or experienced it before and how it can work in daily commuting.

It is suggested that in order to achieve a modal shift towards public transport, we should focus on improving *Flexibility, Tracking* the trip and trip *Duration time.*

In Marketing Mix, we should focus on Product/service: morning supply, *Flexibility* and *Tracking.* The price considered was a monthly cost of 40 Euros and under the conditions that the trip duration can be 60 minutes.

It is necessary to remove these physical barriers to increase ridership by reassuring frequency and reliability of the service, i.e., by product (service) development. Educating new users on how to use the bus, or re-educating people who have not used the used for a long time.

Another issue related to status perception consists in changing the attitude that the bus is only for people who cannot afford a car. In the segment we are studying, one solution would be to make a partnership with young ambassadors of Public Transport (influenzers or opinion makers that young people follow in social networks) to commute in public transport and change this social paradigm.

SQ2. *Which is the latent demand in PT?*

The identification, classification and understanding of (potential) customers is essential to be able to develop a marketing strategy and set specific target groups.

Considering the Principal Component Analysis (PCA), we could identify six segments of parents: (1) “Afternoon commuters accompanied”, (2) “Afternoon commuters”, (3) “Morning commuters” for whom is important to have short time commuting; the (4) “Bus captive” who value the cost and the flexibility, and the last ones the (5) “Car-lover” and (6) “Multi-task”. Through this identification, we can develop PT attributes which are perceived as important to the modal shift.

4.5 On the importance of parents' decision to escort children to school with private cars: a structural equation model analysis

Designing interventions to change school travel behavior requires a thorough understanding of the main factors involved in the modal choice when commuting to and from school and, in particular, the parents' decision to escort or not their children. This section identifies and analyzes the latent (e.g., *Norms and Attitudes*, and *Public Transport Satisfaction)* and the observable (e.g., *Stage of School* of the children and the *'home-school-home' Distance)*, determinant factors influencing the escort parental decision.

The following overall thesis research questions are addressed by the current section:

***Q1**. How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

SQ2. *Which is the latent demand in PT?*

SQ4. *How can a targeted marketing mix be developed to leverage public transport systems and make it more attractive to school commuting?*

4.5.1 Introduction

Public Transport (PT) is crucial for the quality of life, environmental sustainability, and economic competitiveness of cities. Sustainable mobility assessment reports and recommendations by prominent international organizations, including OECD (Organization for Economic Co-operation and Development), WHO (World Health Organization), and the EU (European Union) highlight the numerous environmental and climate change impacts and challenges related to transports. Despite the investment made over the years in PT infrastructures and services by cities, the unsustainable trend of urban mobility remains unsolved in many cities, including regarding the relatively short home-school trips.

As part of the problem, school commuting with private cars is still frequent, as opposed to more sustainable options like PT and active modes. For instance, more than 80% of school trips

in the Lisbon metropolitan area are performed with private cars, until high school (IMob, 2017). Besides being relevant in the overall urban mobility context, school travel is highly dependent on home and school location decisions by the parents, i.e., how mobility and land use interact (Schlossberg et al., 2006; Fyhri and Hjorthol, R., 2011; Mori and Willcox, 2012; Mitra, 2014). Also, home-school trips overlap with other household routines (frequently during morning and afternoon peak hours) by involving several actors, including the students, parents, other relatives, friends, neighbors, teachers, employees of the school, or other involved in the daily logistics. Such intricacies in the household mobility planning also influence the household´s quality of life by adding trips or limiting the work schedule or job opportunities (Novaco and Gonzalez, 2009).

Furthermore, teenagers and children that are car-reliant, when growing up, become less responsive to policies that encourage car use reduction, making it important to understand youth´s intentions when they decide to commute by car (Davison, Werder, and Lawson, 2007).

Previous research suggests that modal choice in adulthood is formed in part by experiences and influences of the childhood (Long et al., 2019; Basington, 2008). Moreover, direct childhood experiences and parental influences get internalized and replicated in adulthood, such as parents´ values and practices (Grusec, 2012). As such, a child who is driven everywhere is expected to become an adult who will prefer the car to other modes and will also drive his/her offspring more often, thus perpetuating this travel behaviour cycle (Morris et al., 1998, Cairns, 2000; Macket, 2001; Davison et al., 2007).

Considering that many children are still escorted to school on a daily basis, until later ages, and believing that children tend to mimic parents' behaviour, designing interventions to change school travel behaviour of children requires a thorough understanding of the main factors involved in the modal choice decision-making and, in the first place, the decision by parents to escort or not to escort children to school. As such, this section aims to analyze which are the determinant factors that influence the decision of parents to escort or not their children to school. The decision-making process by parents involve complex relationships between several dimensions such as households' characteristics, urban environment, and mobility options. We used Structural Equation Modelling (SEM) to model these relationships. Based on this understanding, we also suggest an intervention framework for promoting the active use of PT by younger citizens.

Theoretical background and hypotheses

Concerning school travel behaviour, Mitra (2013) proposed a conceptual framework called "Behavioral Model of School Transportation" (BMST), based on a comprehensive literature review. BMST is a holistic approach to the school travel behaviour of children and youth, involving five levels of observable influencing factors: external influences, urban environment, household, characteristics of a child/youth, and travel.

- **External influences** are factors that can affect commuting and that are beyond the control of individuals. These external factors can be natural (natural environment) and policy related (policy, social political context) (Panter et al., 2008; Zwerts et al., 2010; Wilson et al., 2010; Trapp et al., 2011);
- **Urban environment** involves factors related to the spatial structure (regional distribution of residences, employment, and other urban facilities), the built environment (extent and quality of land-use mix; transport network and urban design features) and the social environment (neighbors and friends) (Larsen et al., 2012; Panter et al., 2008);
- **Household** factors are grouped into three dimensions: sociodemographic, mobility, and attitudes, beliefs and social norms (McAlister et al., 2008; Mitra et al., 2010);
- **Child/Youth** includes factors such as travel and self-efficacy (i.e., physical, and cognitive capabilities and gender) that influence the parents' perception of their children's maturity (Robertson-Wilson et al., 2008; Timperio et al., 2004); and
- **Travel** of the children to school involved two factors: independent vs. escorted trip; and school travel mode (Faulkner et al., 2010; Lang et al., 2011).

The remaining literature reviewed suggests that parents are the final decision-makers and planners of the children's mobility options, independently of the focus of the study. The final decision of parents on the travel mode for school commuting varies with the children age, depending on their varying levels of maturity and mobility independence. The literature suggests that parents behave as "protectors" of children's travel behaviours and manage their children's travel mode decision (Carver et al., 2013; Pont et al., 2011; Panter et al., 2008). For example, in his framework, Mitra (2013) includes the parents´ perception of their children's autonomy as a key factor for their mobility planning. In the same vein, Faulkner et al. (2010) argue that the parents decide firstly on whether they will escort their children to school or not, and after they decide on the travel mode to school.

Based on the assumption that parents are focal in the final decision, it becomes necessary to deepen their characteristics, norms, and attitudes towards the children's school travel behaviour, if marketing solutions design is expected to become more effective in the end. Moreover, the present work argues that transitions from primary to intermediate education can become lifetime “game-changing” events that implicate structural modifications in the children’s life, which may facilitate changes in mode choices towards more sustainable options (Cooper et al., 2012).

Norms and Attitudes

Attitude towards behaviour is a positive or negative emotion to do or not to do something (Ajken, 1985, 1991). Attitudes are psychological constructs according to the Travel Planned Behaviour (TPB) for travel mode choice and can be summarized as a travelers’ option towards a particular travel mode. Subjective norm is an indication of perceived social pressure where reference people (parents, wife/husband, and friends) motivate an individual to undertake or reject a behaviour (Moutinho, 1987).

In this section, we intend to analyze how the norms and attitudes and the PT Satisfaction influence escorting choice when travelling to/from school. As such, we propose two 2nd order constructs: (1) *Normative and Attitudinal Constructs* (NormATT) and (2) *Public Transport Satisfaction*. The *NormAtt* captures two first order constructs: *Personality type* and *Environmental Awareness*.

Personality type

Personality type refers to the psychological grouping of different types of individuals (Van Liere and Dunlap, 1978; Dunlap et al., 2000). It enables us to understand and differentiate the individuals and potentially better predict decisions of different types of individuals. There is extensive literature on the topic of classifying the various types of human personality and on personality traits or domains. Furthermore, there are studies concerning its influence on modal choices. Aligned with what was concluded by Haustein et al. (2018) and Yazdanpanah et al. (2017), some psychographic types were significant in determining the future modal choice. Redmond (1996) proposed a methodology to cluster survey respondents by attitudes, personality,

and lifestyles to enable insights from travel behaviour theory and not just the traditional sociodemographic approach that we used in our study and in which respondents were asked to rate their personality according to eighteen personality traits.

Environmental awareness

The rapid growth of environmental issues in recent decades requires a better-informed society and awareness of the impacts that daily decisions may have on the environment. There is also evidence in the literature that *Environmental Awareness* is determinant in an individual´s choices of PT in daily commuting (Doran and Larsen, 2016; Nordlund and Garvill, 2003, DEFRA, 2008).

It is necessary to understand the attitudes and environmental knowledge to promote pro-environmental travel behaviour by reducing private car driving and less escorting by parents. With this identification, we can entice the pro-environmental behaviours of households to shift to PT. The purpose of the statements was to measure a person´s knowledge about the interactions of humans and their environment, environmental issues, and the connection in the ecological systems.

PT Satisfaction

It is widely accepted that the transport service importance and satisfaction influence the modal choice (Mouwen, 2015; Del Castillo and Benitez, 2012; Dell´Ollio, 2011; Eboli and Mazzula, 2009). The smaller the gap between the expected and the experienced service, the higher the satisfaction of PT users. Other studies confirm that PT satisfaction is positively related with the behavioural criteria of intention and actual behaviour (Wen et al. 2005; Fornell et al. 1996). Some scholars analyzed measures of behavioural tendency (e.g., PT frequency, transfer time, trip duration), which confirmed the relation between satisfaction and intention.

The most relevant PT attributes that characterize users' satisfaction are known. For instance, Mouwen (2015) examined 15 service attributes on 180.000 questionnaires and concluded that on-time performance, travel speed, and service frequency were the most important factors to evaluate satisfaction. On the other hand, Dell´Ollio (2011) found the users´ perception and waiting time, in-vehicle comfort, and cleanliness as the most important features.

School commuting context and escorting decisions

There is a worldwide perception that children have lost their mobility autonomy in the last decades, as evidenced in the large-scale comparative study that was conducted in 16 countries (Shaw et al., 2015). In this study, Portugal ranks 10th in the independent children´s mobility ranking. The top positions are occupied by Finland, Japan, and the lowest by Sri Lanka and Italy.

In recent years there has been extensive multidisciplinary research to identify factors that may limit the development of young people's autonomy and independence, namely the **distance** between home and school locations (Nelson et al., 2008; Mitra, 2014; Wilson et al., 2010; Fyhri and Hjorthol, 2009). Furthermore, Queiroz et al. (2019a) conducted and experiment with the same schools analyzed in the present paper and found that the higher the distance the school is from the students' residence, the more dependent they are on the car.

On the other hand, children's life cycle stage is directly linked to the **school stage** and to the parent's willingness to trust their children to travel alone in PT (Valentine, 1997; Carver et al., 2014). Children's lifecycle stage has an impact on the mode they use to commute to and from school and the younger the children are, the more they are prone to be driven to school by their caregivers (Hillman et al.; 1990; Fyhri and Hjorthol, R.; 2009; Cordovil et al., 2015; Al-Mosaind, M., 2019).

In this section, we intend to analyze if the observable variables (**Distance to and from school** and **school stage**) influence the escorting decisions of parents in their children's school commuting.

Proposed conceptual model for analyzing school commuting behaviour

Based on the review of the literature, and the objective to keep the model specification as parsimonious as possible, the current section proposes the conceptual model shown in Figure 4.2. The variables and constructs are explained in the forthcoming paragraphs.

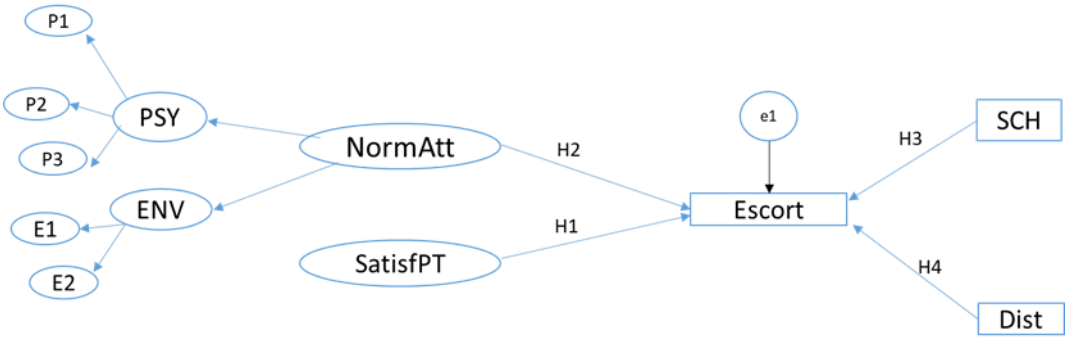

Figure 4.2 - The study Conceptual model

Legend: PSY=Personality latent factor; P1=Adventurer and Seeker; P2 = The Organizer; P3 = The Loner; ENV = Environmental Awareness; E1 = Environmental concerned; E2 = Environmental relaxed; NormAtt = Norms and Attitudes; SatisfPT = Perceived PT service satisfaction; SCH = school stage (primary, intermediate or secondary); DIST = distance between home and school locations; Escort = Parents/Caregivers escorting decision on children's commuting to and from school.

The hypotheses tested in our study are stated as follows:

Table 4.13 - Hypotheses considered in this study

H1	Perceived PT service satisfaction negatively influences the decision to escorting children to and from school
H2	The Norms and Attitudes negatively influence the decision to escorting children to and from school
H3	The increase of school stage negatively influences the decision to escorting children to and from school
H4	The increase of distance between school and home positively influences the decision to escorting children to and from school

Aligned with the Mitra´s (2013) framework and to measure the features we considered the distance (urban environment), parents´ personality and environmental awareness profiles, Norms and attitudes, and also their perception of PT Service Satisfaction. Related with the children and youth, we considered the stage of school since parents´ attitudes towards independent school travel also change with child´s maturity, as perceived by the parents (Johansson, 2006; Marzoughi, 2011; Timperio et al., 2004).

As for the dependent variable related to travel decisions, we opted for using the decision to escort or not to escort children to and from school, since that is the end objective of the present research.

4.5.2 Methodology

Structural Equation Models (SEM)

The Structural Equation Model (SEM) was created with the lavaan package (Rosseel, 2012) for the R statistical system (Team RC, 2013). The model features two exogenous observed variables: School (SCH), Distance (DIST), three first-order exogenous constructs (SatisfPT, PSY, ENV), one second-order construct (NormAtt) and one endogenous criterion variable (Escort). SEM and invariance analyses were carried out using robust maximum likelihood estimation (MLR) implemented in lavaan (Rosseel, 2012). This method accounts for deviations from the normal distribution of the items on the estimation of the parameters' standard-errors and model fit indices.

Even so, we used measures of shape, namely skewness and kurtosis, to evaluate the normality assumption. When items have five or more points and a distribution that is not severely non-normal (absolute skewness and kurtosis values below 7 and 3, respectively), maximum likelihood estimation methods produce reliable estimates (Marôco, 2014; Bentler, 1988).

Measurement errors of items belonging to the same factor were correlated when their modification indices were greater than 11 ($p < .001$) (Marôco, 2014), and a theoretical association could be defended. The following goodness-of-fit indices for both confirmatory factor analysis and structural equation modeling were used: CFI (Confirmatory Fit Index Scaled), TLI (Tucker-Lewis Index Scaled), RMSEA (Root Mean Square Error of Approximation Scaled) and SRMR (Standardized Root Mean Square Residual Scaled). Because robust maximum likelihood estimation was used, the presented indices are scaled. Model fit was considered adequate if scaled CFI and TLI values were above 0.90 and RMSEA and SRMR values were below 0.05 and 0.08, respectively (Marôco, 2014; Hu, 1999). The composite reliability was used to evaluate the construct reliability, with recommended minimum values of 0.70; while the Average Variance Extracted (AVE) was used as indicative of convergent validity of the constructs. Values do AVE larger than 0.5 are indicative of good convergent validity (Anderson and Gerbin, 1988; Fornel and Larcker, 1984).

Measurement instruments

We did a survey to collect empirical data on ten elementary, middle, and high schools (6-18 years), which is detailed in section 3.1.1.

Questions related to Public Transport satisfaction

The following PT attributes were assessed to evaluate the public transport satisfaction, aligned with similar studies (Eboli and Mazzula, 2009; Papaioannou, 2017): 1- Frequency, 2- Schedule Reliability, 3- Access to destinations, 4- Without or low number of transfers, 5- Transfer time, 6- Trip duration, 7- Ticket/Pass cost, 8- Seating, 9- Easiness in acquiring tickets/Passes, 10- Way of payment (on the bus. on the internet), 11- Good PT stop condition, 12- No crowdedness, 13- Safe, comfortable and calm trip, 14- Information availability, 15- PT stop proximity, 16- Aesthetics (inside/outside bus), 17- Drivers´ attitude and appearance.

The attributes' satisfaction was graded on a 1-7 Likert Scale (7 is the best mark).

Questions related to Personality type

Regarding the personality type, respondents were asked to rate their personality according to the following eighteen personality traits, according to the scale proposed by Redmond (1996): 1- optimist, 2- adventurous, 3- like routines,4- spontaneous, 5- like being outdoor, 6- risk-taking, 7- like to stay close to home, 8- efficient, 9- variety seeking, 10- punctual, 11- like to be alone, 12- independent, 13- creative, 14- calm, 15- anxious, 16- like being in charge, 17- participative, 18- lazy.

These traits were placed on a three-factor scale: "Yes, that is me", "Somewhat", "No, not all", following previous studies (John and Srivastava, 1999; Redmond, 1996; Haustein et al. 2018).

Likewise, to previous researches (Queiroz et al., 2019b; Redmond, 1996), a Principal Component Analysis (PCA) was performed to this data and regarding personality types, revealing the existence of personality factors (Queiroz et al., 2019b).

The three factors obtained for these 18 characteristics are: Adventure Seeker (P1), Organizer (P2) and Loner (P3) personalities. For the P1, we hypothesize that people with a high score on this factor enjoy adventure, risk taking, like being outdoor, etc. Regarding the P2, the personality traits that most strongly load on this factor are "efficient", "on time" and "like a routine", indicating someone who likes everything to have organized and who likes punctuality The Loner (P3), quite simply, likes to be alone and who is lazy and anxious. Loners may want to avoid meeting other people.

Questions related to Environmental awareness

In designing the survey, indicators of various specific dimensions were constructed to assess how individuals perceives the environmental concerns (Collins and Chambers, 2005). The environmental awareness evaluation contained 15 statements related to environmental concerns that respondents rated on a five-level Likert psychometric scale, from “1- Completely disagree” up to “5- Completely agree” (Van Liere and Dunlap, 1978; Dunalp et al., 2000; Onwezen et al. 2013):

Table 4.14 - Environmental statements (15 dimensions)

1- We are getting close to the limit of the population on earth
2- Human beings can modify the environment when they need
3- The interference of human beings in nature frequently results in disasters
4- Human skills will prevent the earth to become uninhabitable
5- Humans are using excessively environmental resources
6- Earth has many natural resources as far as we learn how to exploit them
7- Plants and animals have the same right to exist as human beings
8- Nature equilibrium is strong enough to cope with the impacts of modern industrial societies

9- Despite our special skills, human beings are vulnerable to laws of nature

10- The “ecologic crisis” our humanity faces have been exaggerated

11- Earth has limited space and resources

12- Human beings should dominate the rest of nature

13- Nature equilibrium is delicate and easily disturbed

14- Human beings will learn enough about how nature works to control it

15- If current behavioural and consumption patterns remain as until today, an ecologic catastrophe will occur

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A similar PCA was used for environment awareness (Queiroz et al., 2019b; Redmond, 1996). Two attitudinal dimensions were discerned and labelled as “Environmentally concerned” (E1); “Environmentally relaxed” (E2). For the E1, we hypothesized that people with a high score on this factor are concerned with the interference of human beings in the environment and with the nature equilibrium. Regarding the E2, we hypothesized that people with a high score on this factor, believe that human beings should dominate, and that nature equilibrium is strong enough.

Questions related to other attributes

Respondents were asked to indicate the student´s zip code to calculate the *Home-School Distance*, using the Google Maps Geocoding API. In addition, *School stage* was divided into Primary, Intermediate, and Secondary levels and identified the level which student is enrolled in the school at the moment the survey was responded. Concerning the endogenous variable *Escort*, i.e., escorting to and from school, respondents were asked to respond yes or no (binary variable, where “yes” = 1; “no” = 0).

The survey data

The data was collected in the survey detailed in section 3.1.1. After the data cleaning and removal of invalid observations (e.g., with missing values on key variables), we validated 874 responses. To analyze the factors determining somehow the parents’ decision to escort children to school, we filtered down the sample to select the 444 responses from households that answered positively to the question related to their perceived satisfaction regarding the number,

quality and location of bus stops close to their home location. This subsample represents approximately 50% of the total survey respondents. The objective of filtering these respondents was to make sure that they had access to PT and therefore, commuting to school by bus would be an option.

The demographic profile of the respondents was the following: 52% of the respondents were aged between 35-44 years, while 34% ranged between 45 and 54 years and, the majority (68.5%) were women. The majority of respondents (70.9%) had a full-time job, and 7.4% were unemployed. Concerning the level of education, 38.4% had a graduate level of education and 36.8% a secondary grade. About half (55%) of the parents escort their children by car, 30% of the children use PT to go to school, while 15% walk.

4.5.3 Results and discussion

Regarding the hypothesis tests, described in section 2.4 and Figure 1, all structural path estimates were statistically significant ($p<0.01$). Table 1 summarizes the outcomes for the four tested hypotheses by comparing hypothesized relations in Figure 4.2 and results in Figure 4.3.

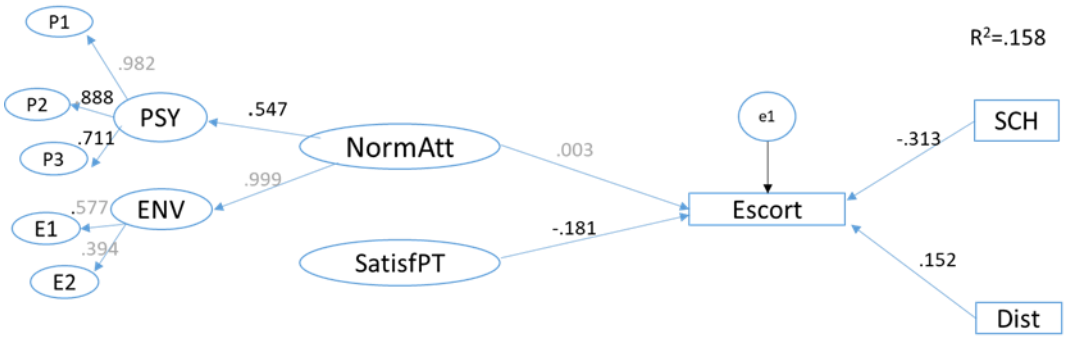

Figure 4.3 - The estimated model

Legend: PSY = Personality; P1 = Adventurer and Seeker; P2 = The Organizer; P3 = The Loner; ENV = Environmental Awareness; E1 = Environmental concerned; E2 = Environmental relaxed; NormAtt = Norms and Attitudes; SatisfPT = Perceived PT service satisfaction; SCH= school stage (primary, intermediate or secondary); Dist = distance between school and home; Escort = Parents/Caregivers' decision to escort children to and from school. Standardized values **black**: significant at $p<0.05$); **grey**: not significant at $p< 0.05$).

Table 4.15 - Summarization of the outcomes for the hypotheses

Nº	Hypothesis	Outcome
H1	Perceived PT service satisfaction negatively influences the decision to escorting children to and from school	Confirmed
H2	The Norms and Attitudes negatively influence the decision to escorting children to and from school	Not confirmed
H3	The increase of school stage negatively influences the decision to escorting children to and from school	Confirmed
H4	The increase of distance between school and home positively influences the decision to escorting children to and from school	Confirmed

Table 4.16 summarizes the outputs for the 4 tested hypotheses by comparing hypothesized relations in Figure 4.2 and results in Figure 4.3

Table 4.16 - Results of CFA (Confirmatory factor analysis)

Construct	Construct Designation	Items	Variables Designation	Standardized loading	t value	Composite reliability	AVE
SatisfPT	PTservice satisfaction					0.91	0.52
		S_Frq	Satisfaction Frequency	0.780	18.929		
		S_Ttr	Satisfaction Transfer time	0.692	15.963		
		S_Dur	Satisfaction Trip duration	0.750	17.871		
		S_PTP	Satisfaction Ticket/Pass cost	0.689	15.940		
		S_WYP	Satisfaction Way of payment	0.669	15.324		
		S_Inf	Satisfaction Information availability	0.782	18.993		
		S_Near	Satisfaction PT stop proximity	0.733	17.348		
		S_Look	Satisfaction Aesthetics	0.695	16.067		
		S_Driv	Satisfaction Drivers´ attitude	0.687	15.836		
EnvirAwar	Environmental awareness						
E1	Environment Concerned					0.88	
		Elimit	"…limit of population.."	0.403	7.016		
		ECons	"…The interference of human beings.."	0.759	10.381		
		EUse	"...using excessively resources.."	0.751	10.328		

		ERes	"…Earth has many natural resources…"	0.605	9.222		
		EPlAn	"….Plants and animals have the same right…"	0.687	9.889		
		EVuln	"….human beings are vulnerable…"	0.656	9.725		
		EEart	"…Earth has limited space and resources…"	0.656	9.645		
		ENat	"…Nature equilibrium is delicate…"	0.693	9.933		
		ECatas	"…an ecologic catastrophe will occur.."	0.806	10.660		
		EHuman	"….Humans are using excessively…"	0.401	7.256		
E2	Environment Relaxed					0.78	
		EMod	"….Human beings can modify…"	0.471	9.091		
		EEquil	"…Nature equilibrium is strong enough.."	0.738	14.434		
		ECris	"…"ecologic crisis" has been exaggerated…"	0.676	13.227		
		EDom	"….Human beings should dominate…"	0.630	12.295		
		ELearn	"….Human beings will learn enough…"	0.675	13.211		
		EHuman	"….Human skills will prevent…"	0.410	8.636		
Personality							
P1	Adventurer and Seeker					0.83	0.37
		POpt	optimist	0.596	1.095		
		PAdv	adventurous	0.606	1.095		
		POut	like being outdoor	0.548	1.095		
		PRisk	risk taking	0.582	1.095		
		PVar	variety seeking	0.621	1.095		
		PCreat	creative	0.648	1.096		
		PCharg	like being in charge	0.581	1.094		
		PPartic	participative	0.663	1.096		
P2	Organizer	PRout	like routines	0.397	5.137	0.71	0.27
		PClose	like to stay close to home	0.519	5.739		
		PEff	efficient	0.669	6.121		
		PPunc	punctual	0.508	5.708		
		PIndep	independent	0.569	5.966		
		PCalm	calm	0.546	5.839		
P3	Loner	PAlone	like to be alone	0.620	10.708	0.70	0.45
		PAnx	anxious	0.693	11.305		
		PLazy	lazy	0.695	11.326		
Personality	P1		Adventurer and Seeker	0.982	1.043		
	P2		Organizer	0.888	4.177		0.75
	P3		Loner	0.711	5.234		
EnvironAwar	E1		Environment Concerned	0.577	0.003		0.24
	E2		Environment Relaxed	0.394	0.003		
NormAtt	Personality		Personality	0.547	1.930		0.81
	EnvironAwar		Environment Awareness	0.999	0.003		

4.5.4 Conclusions

To the best of our knowledge, this is the first work to investigate parents' decision to escort children when commuting to school by constructing a comprehensive modal considering Norms and Attitudes and PT Satisfaction constructs and observable variables Home-School Distance and School stage. This section harmonized the Mitra´s BMST model with the latent factors of households' school commuting.

The outputs of the relationships between these constructs in the context of students´ families suggest important implications for school commuting:

Impact 1- PT Satisfaction on the decision of parents to escorting children to and from school.

Impact 2- Factors such as school stage and distance, on the decision of parents to escorting children to and from school.

By revealing that PT Satisfaction is a statistically significant predictor in escorting choice, we were able to pinpoint the service attributes that explain this construct: Frequency, Transfer Time, Trip duration, Ticket/Pass cost, Way of payment, Information availability, PT stop proximity, Aesthetics (inside and outside the bus) and Drivers' attitude and appearance. These findings are consistent with previous research (Mouwen, 2015; Del Castillo and Benitez, 2012; Dell´Ollio, 2011; Eboli and Mazzula, 2009), indicating that if users are satisfied with PT they are more prone to choose PT instead of the car. These results can provide useful information for the PT operators in its effort to prioritize the critical service attributes and ensure its service quality meets or exceeds passenger expectations (Impact 1). For example, Hypothesis 1, which relates to the effects of the overall perceived satisfaction, is well supported and proved.

The effects of observable variables on the Escort choice, such as School stage and Distance, confirming the Hypotheses 3 and 4, are largely consistent with published literature (Carver et al. 2013; Shaw et al., 2015) (Impact 2).

On the other hand, the impact of Norms and Attitudes on the escorting decision was not supported in our study, which is contrary to the literature (Wen et al. 2005; Fornell et al. 1996), not confirming the Hypothesis 2.

From a previous PT marketing field-intervention (Queiroz et al., 2020) we proposed a market approach which is supported in the Stakeholders´ triangle (parents/schools/operators) (Figure 1.2), which is the essence of the research.

Considering the importance of these stakeholders, in the present study we highlight the parents' role in the decision-making regarding escorting or not escorting children in school commuting.

Beyond the importance of parents, PT operators need to be more market-oriented and competitive, which requires an improvement in service quality by understanding the current and potential users' needs and expectations and developing a closer relationship with parents and schools.

Despite the promising relevance of our findings to providing a useful tool for changing model choice, they should be interpreted with some caution for two primary reasons. First, despite the lack of a variable clearly capturing the habit of using PT in the model, it does not necessarily mean that we should ignore it. A variety of studies argue that travel behaviour is strongly influenced by travel habits (Gärling and Axhausen 2003; Verplanken and Aarts 1999).

Secondly, and considering the Theory of Repeated behaviour (TRB) (Ronis et al. 1989), which refers that *Stimuli* and life changes can end in conscious decision-making and possible shift from habitual behaviour, we can develop future studies to test the influence of field *Stimuli*. Though interactions between these other variables and mobility shifts can offer additional insights they were not tested to keep the model specification as parsimonious as possible.

Promoting the use of PT is critical and involves multidisciplinary research topics and the simultaneous combination of field measures. We argue that the future in the field, particularly for those pursuing practical solutions to the PT overall adoption by users, should encompass further research on the use of marketing solutions. It was found that PT attributes (*Frequency, Transfer time, Trip duration, Ticket/Pass cost, Way of payment, Information availability, PT stop proximity, Aesthetics and Drivers´ attitude and appearance)* are good predictors of PT choice. Thus, we advocate that the identification of the presence of these variables in the PT service would improve the formation of perceived value to the PT choice.

According to the literature the *NormAtt* determine the modal choice. However, our model shows that this is not the case. There are several reasons for this. In the transport of children to school, the modal choice does not concern only the individual himself and is limited by endogenous and exogenous factors to the household. On the one hand, it depends on the characteristics and number of children and young people to be transported (Susilo and Liu, 2015; Shokoohi et al., 2012). The complexity increases with the number of children, age groups involved (the *SCH* variable may indicate this), timetables (identical or differentiated) and extra-curricular

activities. Moreover, younger children have a much lower speed of travel than adults. This compromises travel to/from PT stops (again, in the model the *SCH* variable may indicate this aspect). Students carry backpacks, which can prevent walking over certain distances and greatly limits the mobility of younger children (the *SCH* and *DIST* variables point in this direction) (Kotoula et al., 2017; Queiroz et al., 2019b). On the other hand, it depends on the characteristics of the parents and their working environment, particularly in terms of flexible working hours. Mother or father will have to make at least two trips in PT instead of one (home/school and school/work). The importance of transfers for total travel time and, consequently, modal choice is known. Regardless of the flexibility of parents, students have fixed hours.

Thus, the quality, reliability and punctuality of the PT service influences very significantly the choice of mode (the variable *SatisfPT* points in this direction). Thus, our study shows that, given the existing constraints in the analyzed universe, the *NormAtt* are not significant for the decision to take children to school by car.

Moreover, we strongly believe that younger citizens should be approached at key moments in their lives when they change habits to facilitate non-escort choice. Taking into account that increasing the school stage encourages the students´ autonomy in their school commuting, we propose that the best possible timing for PT stimulations can be when children upgrade their school level (Primary-> Intermediate school->Secondary school).

To implement the previously proposed interventions, marketers can use observed and latent variables in the structural model developed in this research as criteria for effectively targeting potential PT users.

The following statements attempt to answer the questions for this research:

Q1. *How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

Data from the present section illustrate the potential importance of the identification of latent demand and useful implications for transport marketing strategies targeting an increase of both current users' fidelity and new users. We show that *Stage of school distance and level of Public Transport satisfaction* are the most important variables promoting a non-escorting to school by parents. We also suggest key moments of the students´ lives to facilitate mode choice, such as when children upgrade their school level.

SQ2. *Which is the latent demand in PT?*

We explored the potential of the Structural Equation Modelling tool in a novel context, by evaluating the impact of latent variables (*Norms and Attitudes, and Public Transport Satisfaction*) and other observable variables (*Stage of School, Distance home-school-home*) in the *Escorting choice* when commuting to and from school.

The determinant factors that influence the decision of parents to Escort or not their children to school by the Structural Equation Modelling (SEM) are the following factors that include latent factors, e.g., *Norms and Attitudes, and Public Transport Satisfaction*, and observable variables like *Stage of School* of the children and the 'home-school-home' *Distance*.

The quality, reliability and punctuality of the PT service, influences very significantly the choice of mode (the variable SatisfPT points in this direction). Thus, our study shows that, given the existing constraints in the analyzed universe, the *NormAtt* are not significant for the decision to take children to school by car.

To implement the previously proposed interventions, marketers can use observed and latent variables in the structural model developed in this research as criteria for effectively targeting potential PT users.

We also suggest key moments of the students´ lives to facilitate mode choice. Taking into account that increasing the school stage encourages the students´ autonomy in their school commuting, we propose that the best possible timing for PT stimulations can be when children upgrade their school level (Primary-> Intermediate school->Secondary school).

SQ4. *How can a targeted marketing mix be developed to leverage public transport systems and make it more attractive to school commuting?*

Our results enabled to concentrate efforts on the quality of the *Product/Service*. In this study, it is necessary that operators invest in the users´ perception of quality of PT service, as this factor makes the difference when parents have to decide whether or not their children to escorting their children when travelling to school.

We can infer that if the service does not offer the basic features for which they exist, it makes no sense to differentiate the product by types of customer segments (Personality type and

environmental awareness), because the strategy must start be guaranteeing the basic features and afterwards differentiate its characteristics for the various segments.

5. What to expect from marketing mix strategies´ impact in school travel behaviour

5.1 Introduction

This chapter describes part of the presentation and publications achieved during the thesis research. They relate to Survey 2, are referred in 3.1.1 and match with the research questions and sub-questions (mentioned in 1.2).

To develop the marketing strategies, field interventions and their impact were assessed using Hazard-based duration models (QUEIROZ, M.M., ROQUE, C. MOURA, F., 2020. Shifting from Private to Public Transport using a Duration-Based Modeling of a School-Based Intervention. Transportation Research Record (TRR) 2674(7):540-554. doi: 10.1177/0361198120923666).

Also, to improve communication with current and future PT users and conconmitantly design better marketing campaigns to attract more users, their expectations of the PT service were followed-up using the LDA technique (QUEIROZ, M.M., ROQUE, C.A., MOURA, F., MARÔCO, J.P.. Understanding the expectations of parents regarding their children´s school commuting using Latent Dirichlet Allocation method, was submitted to *Transportation Journal*, and it is under review).

5.2 Shifting from Private to Public Transport using a Duration-Based Modeling of a School-Based Intervention

The following overall thesis research questions are addressed by the current section:

Q1. *How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

***Q2**: Which marketing mix is adequate to influence parents and children in their school commuting?*

***Q3**: What is the time delay for behavioural and modal choice changes to occur*

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

SQ3. *What positive effect can gamification have on the behavioural and modal choice changes?*

SQ4. *How can a targeted marketing mix be developed to leverage public transport systems and make it more attractive to school commuting?*

SQ5. *Which is the delay time for each factor of the marketing mix?*

SQ6. *Which marketing Stimuli has more impact to shift to PT?*

5.2.1 Introduction

The age at which children are considered to be able to travel independently has increased in recent years, which has led to a dramatic decrease in children´s autonomy, as well as an increase in car travel and less independence (Hillman et al., 1990). Generically, children are not often considered the primary actor in transport management. Therefore, a better understanding of their travel behaviour may provide essential answers for future solutions in transports systems (Zwerts et al., 2010).

As we seek to influence particular segments and not society as a whole, our goal is to impact younger generations that could potentially promote a change in how PT is perceived in the future. Furthermore, Westman et al. (2017), concluded, through a tailor-made Satisfaction Travel Scale for children, that children's satisfaction, temper, and mental performance is better when commuting to school by bus, walking, or cycling than by car. There is a correlation between these

modes of transport and the positive feelings of children. These effects should be taken into consideration by the parents, but also by the stakeholders involved in school commuting, i.e., teachers and PT operators.

However, it is not easy to change habits without conquering the willingness-to-change of travelers, mainly because they are empowered and control their journeys' planning. The idea of controlling passenger travel plans, and decisions is an illusion (Lemon and Verhoef, 2016). Nevertheless, there is a research potential around customer experience by exploring marketing methodologies and strategies applied to PT. It is also widely recognized that having a capable PT system and a strategic approach is very important.

The overall goal of this section is to develop a tailor-made integrated marketing approach to increase the attractiveness of PT for school commuting. For that, we explore the duration between marketing actions (whether this focus on Product, Place, Price or Promotion) and mobility behaviour changes of the communities involved, i.e., modal shift to PT. Our research explored the impact of a set of marketing events on the duration to shift to PT by children when commuting to school, with a Hazard-Based Duration Model (HBDM).

5.2.2 Methodology

The methodological approach was based on the following the stakeholders´ triangle for action for PT leveraging in school commuting (Figure 3.5 in Chapter 3), which is the essence of the present research.

A critical component of the research was to define marketing events related to the classical 4 Ps marketing mix approach that Table 5.1 summarizes and is aligned with Table 1.1 (Chapter 1).

Table 5.1 - Marketing mix variables

Mix variable	Expectations
Product	What do we expect from the product? What does it look like? What attributes do we need? Which is the Brand image? How can we get a mobility package: integration with others?
Price	Which are the possible transport tickets? Which are the possible combinations for integrated mobility: physical and/or online sales?
Promotion	Which are the campaigns? Which targets? Segments? Which are the means of communication?
Place	How can we assess the product? Which is the network? How can we know the possible alternatives and interfaces with other modes?

Case Study and Description of Marketing Mix Interventions

This study was conducted in Portuguese primary and secondary schools, in three municipalities of the Lisbon Metropolitan Area (LMA), in Portugal: Cascais, Oeiras, and Sintra. The sample was composed of 1760 households (including responses by parents and students), and a total of 445 primary (1st - 4th grade), 990 intemediate (5th – 9th grade), and 325 secondary (10th-12th grade) students were included in this study. These participants belonged to ten public schools from three municipalities.

The intervention, based on action research (Lucas, 2013; Tripp, 2005), aimed to assess travel behaviour potential of shifting to PT of these students when commuting to and from school. The intervention lasted two school terms, from February to June 2018 and from September 2018 to June 2019. Children and some parents participated in 7 marketing events within the intervention program during school hours.

The groundwork included several activities that are summarized in Table 4.14. These activities were carried out in the school and its neighborhood, within the same municipality.

Table 5.2 - Marketing events - action research process

Field experiment (Code)	Objective	Technique	Marketing Mix (Table 1.1)	Date	Participants	Stakeholders	Relevant studies
P1 - Public Debate (PD)	Involve children´s stakeholders in the design of PT solutions	Workshops	Product	Fev.2018	175	Students, parents, teachers, school employees	Checkoway, 2011; Barker and Weller, 2005
P2 - Bus Paper (BP)	Improve intermodality, mobility literacy, urban mobility, develop PT habits	PT experience / observation / gamification	Product	Ap.2018 May 2019*	154	Operators, Students, Teachers	Klementschitz and Roider, 2015; Braun-Latour et al., 2007; Duhigg, 2014)
P3 - Free Pass (FP)	Experience PT	Prize/ PT experience	Price	Jul. 2018	25	Sponsor Operators, students	Molander et al., 2005; Tomanek, 2007
P4 - Traffic Snake Game (TSG)	Gamification of sustainable ridership.	Gamification	Place	Ap.2018	282	Teachers, Students, parents, ACA-M**	TSG, 2017; Moura et al., 2019
P5 - Think Tanks (TT)	Involve children´s stakeholders in the design of PT solutions	Meeting, video, PT campaign	Place	Oct.2018	9	Teachers, Students, parents	Barker and Weller, 2005; Schmitt, 2011; Haryanto et al., 2017)

Field experiment (Code)	Objective	Technique	Marketing Mix (Table 1.1)	Date	Participants	Stakeholders	Relevant studies
P6 - Stands (ST)	Operators' market orientation: Improve information communication; Interchange information between students, parents, and operators	Informative stands	Product	Sep.2018	+400	Operators, Parents, children, School boards and employees, teachers.	Schmitt, 2011; Keengwe and Schnellert, 2012; Civitas, 2019
P7 - Transports APP (APP)	Digital literacy: Improve information and how to organize a trip chain; Know how to check different operator schedules	Informative workshops/ merchandising	Promotion	Jan.2019	695	APP Developer, Students, teachers, parents.	Keengwe and Schnellert, 2012; Baran, 2014; Allan and Grudziecki, 2006

Notes: * in Cascais; **ACA-M – Non-profit NGO to raise public awareness for more sustainable urban mobility in Portugal.

The timeline of these marketing field interventions of the study is presented in Figure 3.5 (Chapter 3).

Stakeholders involved in the current marketing interventions framework had a significant effect on the success of events' implementation (Civitas, 2019) and are summarized in Table 5.3.

Table 5.3 - Stakeholders' participation in the study

Sector	Stakeholder	Role in the study	Present or were aware of the events
Transports	Local transport operators	Enabling the BP, FP, ST	BP, FP, ST
School	Boards, Students, Teachers, Employees	Decision, organization enabler, participation/acknowledgment in/of events. The link between parents and students. Increase PT. Dissemination and response to the survey. Outreach	PD, BP, TSG, TT, ST, APP, Survey
Parents / Caregivers	Households	Participation/acknowledgement in/of events, students' authorization, responding to survey. Increase PT.	PD, TSG, ST, APP, Surveys
Community	Retail shops, Media, Transport App´s, Media, ACA-M, Social Media, NGO´s	Sponsoring of events, gamification, kits for methodologies, merchandising	BP, TSG, ST, APP

Note: For acronyms, refer to Table 5.2.

A survey was launched after the implementation of marketing activities and was completed in May 2019 and it is described in section 3.1.1.

Variables

The response variable (*CShift_Kickoff_pos*) is the time (measured in days) between the first field intervention (16/02/2018) and the self-reported date when the child changed her/his mobility behaviour and began commuting to school by PT. Respondents who already commuted to school with PT before the first intervention, the response variable was valued 0 days. After the data cleaning, we validated and used 347 responses of the case study, which included only the respondents who did shift to PT, after being exposed to any marketing intervention, until the date of our survey. Further studies will be developed that will include the responses of those who had not shifted to PT until the survey, as right-censored data in HBDM.

The independent variables are divided into 5 categories: (1) Sociodemographic characteristics (SD), (2) Mobility, (3) Selected drivers to shift to PT, (4) PT improvements' evaluation (5) Presence in *Stimuli* events, as presented in Table 5.4.

The "Selected drivers to the shift to PT" (3) were organized according to the following categories:

- Better/worse service offered;
- Lower/higher prices;
- More/less information about products or packages;
- Adequate/inadequate promotions;
- Convenience (e.g., does not drive); and
- Others

PT improvements' evaluation (4) were grouped into the categories "PT vehicles" (e.g. buses, trains, etc.) and "PT systems".The former resulted from a question in the survey where respondents were asked whether there "*Was any improvement on the following attributes: comfort, security, cleanliness, information inside the bus?*"(Yes/No). The latter resulted from a question in the survey where respondents were asked whether there "*Was any improvement on the following public transport services: cost changes of monthly pass (2019's New pass for the Lisbon Metro Area; more buses per hour; punctuality (arriving on time); Bus stop (e.g. more comfort); stops´ location; ?*"(Yes/No)

Table 5.4 - Summary of the categorical independent variables and descriptive statistics

Variable	Description	Percentage	Frequency
(1) Sociodemographics			
Age of respondent			
A35_44_S	(35 - 44)-Secondary School	10	35
A55_64_S	(55 - 64)-Secondary School	2,6	9
Household number of cars			
Car2	2 cars	34,6	120
(2) Mobility			
Previous mode before shifting to PT			
Cwalk	Walk	34,3	119
Previous mode before shifting to PT			
Pcar	Car	24,8	86
(3) Drivers to shift to PT	**(response by Students)**		
CDriver1Shift_P	Better Transport service- Primary School	0,9	3
CDriver3Shift_I	Lower prices- Intermediate School	10,4	36
CDriver3Shift_S	Lower prices-Secondary School	4,6	16
CDriver9Shift_I	Convenience-Intermediate School	18,4	64
CDriver9Shift_S	Convenience-Secondary School	17,3	60
CDriver10Shift_P	Others-Primary School	0,9	3
CDriver10Shift_S	Others-Secondary School	1,7	6
(4) PT improvements' evaluation (response by Parents)			
Psystemspunct_I	Transports systems – Punctuality in Intermediate School (i.e. "arriving on time")	10,7	37

Variable	Description	Percentage	Frequency
Psystemslocal_P	Transports systems – Stops localization - Primary school (i.e., “more comfort”)	5,5	19
Psystemslocal_I	Transports systems – Stops localization - Intermediate School (i.e., “more comfort”)	13,5	47
(5) Presence in *Stimuli* events (response by Parents)			
PAPromo	Promotion- Traffic Snake Game, Think Tanks	2,6	10

Table 5.5 - Summary of the categorical independent variables and descriptive statistics

Variable	Description	Mean	SD	Min	Max
CShift_Kickoff_pos	Days between the first intervention on the field (16/02/2018) and the shift date.	211	147,705	0	576

We used Hazard-based duration models (HBDM) to study the conditional probability of a time duration ending at time t, given that the duration continued until time *t* (Washington et al., 2011).

By using hazard-based duration models, it is possible to model the time until students shifted towards PT and away from private cars throughout a period where several marketing events were implemented. With this approach, additional insights can be obtained regarding essential survival effects, such as how the probability of a student shifting to PT may change over time. For this purpose, "survivor" refers to any student who continues to use a private car to commute to-and-from school. The characteristics of children and parents, spatial characteristics, PT improvements, and the presence of *Stimuli* (i.e., marketing events) may influence the duration until shifting. According to Washington et al. (2011), probabilities that change with time are ideally suited to hazard-function analyses. To determine the event duration (time until shifting), hazard-based models consider the probability that a duration *T* is greater than or equal to some specified time *t*, with the survival function, *S(t)*, written as follows:

$$S(t) = \Pr(\mathrm{T} > t) = 1 - Pr(\mathrm{T} \leq t) = 1 - F(\delta t) \quad (4)$$

where *F(t)* is the cumulative distribution function of durations until students' shift towards PT. The hazard function, *h(t*), is defined as the conditional probability of a shifting occurring at some time t, given that a student has not shifted until time *t*, and is written as follows:

$$\mathrm{h(t)} = \frac{\mathrm{f(t)}}{1-\mathrm{F(t)}} = \frac{\mathrm{f(t)}}{\mathrm{S(t)}} \quad (5)$$

where *f(t)* is the density function of durations until students' shift towards PT.

In this case, it gives the rate at which event durations are ending at time t, given that they have lasted to time t. If the hazard function is upward sloping over the event duration (*dh(t)/dt > 0),* then the longer the event lasts, the higher is the probability that the student shifts sooner to PT. Conversely, if the hazard function is downward sloping over the event duration *(dh(t)/dt < 0),* then the longer the event lasts, the lower is the probability that the student shifts sooner to PT.

Moreover, if the hazard function is constant over the event duration (*dh(t)/dt = 0*), then the probability that a student will shift is independent of this duration.

We used the Kaplan–Meier estimator to measure the event duration until students' shift towards PT. Also, this duration is affected by several factors. The primary objective of this study is to accommodate the effects of the explanatory variables on the event duration. The impact of these variables can be considered using a proportional hazards approach. In this case, the explanatory variables act multiplicatively on the baseline hazard function (Washington et al., 2011; Vadeby et al., 2010) as follows:

$$h_i(t) = h_0(t)\exp(\beta X_i) \quad (6)$$

where $h_0(t)$ is the baseline hazard denoting the hazard that occurs when all elements of the explanatory variables vector are zero, X_i is a vector containing the p explanatory variables, which may depend on time *t*, and β is a $p\times 1$ vector of the estimable coefficients.

The individual hazard function $h_i(t)$ is semi-parametric and consists of two parts: a non-parametric part, $h_0(t)$, and a parametric part, $exp(\beta X_i)$. In a nonparametric proportional hazard-based duration model, the baseline hazard function $h_0(t)$ follows a discrete distribution, and observations are grouped into duration intervals rather than exact times to the observed shift (Sharman et al., 2012). This model predicts the hazard (or the probability) of an observed shifting in each interval. In this approach, the baseline hazard, $h_0(t)$, is equal for all students. Therefore, individual differences are not considered when the model is making an estimate but are considered later when changes in risk are investigated by the hazard function (Vadeby et al., 2010).

In the Cox proportional-hazards model, the hazard ratio (HR) is a measure of the relative importance of the explanatory variables concerning hazard, while controlling for distance. The HR is often used to interpret results predicted by the Cox proportional-hazards model (Van den Berg et al., 2012) and can be obtained by the exponentiation of each regression coefficient. Specifically, HR indicates the time rate of stopping at any distance during the study period, compared to that of the reference category. If HR = 1, then the

explanatory variable in the model does not affect and does not change the baseline hazard, $h_0(t)$. If HR < 1, then the time rate of stopping is decreased throughout the study period. Conversely, if HR > 1, then the time rate of stopping is increased throughout the referred period (Roque and Jalayer, 2018).

In this section, we use likelihood ratio statistics to calculate the goodness-of-fit of the models. We performed all statistical analyses using R Version 3.4.2 (R Development Core Team, 2011) and the survival package (Therneau, 2015).

5.2.3 Results and discussion

Figure 5.2 shows estimates derived by the nonparametric method to measure the duration before shifting to PT over our experiment. This figure also shows the estimated probability that students continue without shifting to PT after the school intervention – designated as survival probability. Survival probability can be divided into two parts, depending on the gradient. Day 1 corresponds to the kickoff event, while Day 0 in the graph corresponds to the number of participants who already had commuted to school by PT, i.e., about 30% of respondents.

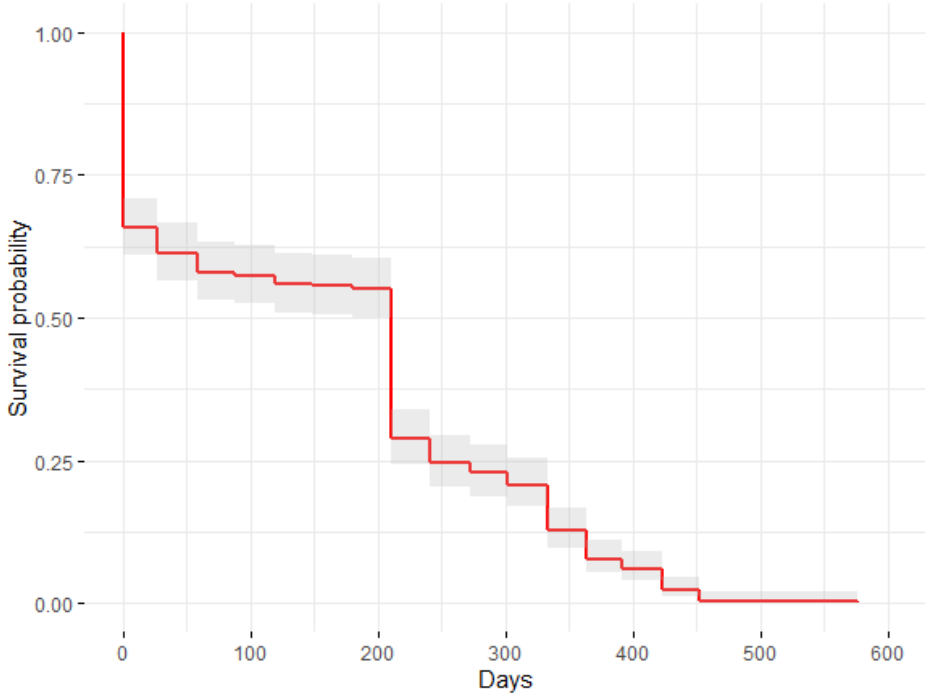

Figure 5.1 - Kaplan–Meier estimate of the time duration between the modal shift and the field kick-off event (left to day 210) or other marketing mix interventions over the experiment (right to day 210)

Based on the graph, we can divide the evolution of shifting to PT in three periods, separated by two significant moments over the experiment: day 210 and day 330. Until day

210, period 1 includes a cumulative shift to PT by 13% of respondents. Then, there is the 1st sudden shift of 25%, about seven months (210 days) after the kick-off event, when a Product-related marketing event P6 was implemented (Table 5.2). In this marketing event, PT operators went to schools to present their products and services and clarify any doubts that parents, caregivers, students, schoolteachers, and staff may have had on how PT could serve their daily commuting requirements to and from schools.

During period 2 (from day 201 until day 330), there is a 10% cumulative shift of respondents to PT, after which another sudden drop (10%) occurs, ten months after the kick-off event. A Promotion-related marketing event P7 (Table 5.2) was implemented, when students participated in a Bus Paper where they took a bus and had to accomplish several challenges, quizzes, and, eventually, receive rewards. After this second drop, the cumulative shifting to PT is progressively 12,5%, until the date of the survey and end of our experiment.

As previously described, the Cox proportional hazards modeling method was applied to a sample of 347 respondents to explore the causes of duration before shifting to PT by respondents. In this analysis, 16 variables relating to students and their families were selected and used to identify their potential impact on time-to-shifting to PT.

Table 5.6. presents the estimation results of the Cox mixed-effects regression model in which the response variable is the number of days between the first marketing intervention and the reported modal shift to PT.

Table 5.6 - Cox model estimation results of the time gap between kick-off intervention and shift to PT

Variables type	Description	Variable code	Respondent	coefficient estimate	p-value	Hazard ratio
Sociodemographic	Respondent's age btw 35 and 44 + Completed secondary school	*A35_44_S*	Parents	-0.3121	0.149	0.732
	Respondent's age btw 55 and 64 + Completed secondary school	*A55_64_S*	Parents	1.0114	0.008	2.750
	Two cars in the household	*Car2*	Parents	-0.2924	0.021	0.747
Mobility	Walked to school before shifting to PT	*Cwalk*	Children	-0.3645	0.005	0.695
	Commuted to school by car before shifting to PT	*Pcar*	Parents	-0.3694	0.008	0.691
Drivers to shift PT	Acknowledge better PT services + Attends Primary school	*CDriver1Shift_P*	Children	1.3003	0.029	3.670
	Acknowledge lower PT price + Attends Intermediate School	*CDriver3Shift_I*	Children	-0.2569	0.165	0.773

	Acknowledge lower PT price + Attends Secondary School	*CDriver3Shift_S*	Children	-0.4704	0.126	0.625
	Acknowledge the convenience of PT services + Attends Intermediate School	*CDriver9Shift_I*	Children	0.2962	0.049	1.345
	Acknowledge the convenience of PT services + Attends Secondary School	*CDriver9Shift_S*	Children	0.4274	0.015	1.533
	Others + Attends Primary School	*CDriver10Shift_P*	Children	1.3859	0.020	3.999
	Others + Attends Secondary School	*CDriver10Shift_S*	Children	0.8366	0.063	2.308
PT satisfaction	Acknowledge the punctuality of PT services + Attends Intermediate school	*Psystemspunct_I*	Parents	-0.5102	0.015	0.600
	Acknowledge the Stops localization + Attends Primary School	*Psystemslocal_P*	Parents	0.5367	0.032	1.710
	Acknowledge the Stops localization + Attends Intermediate School	Psystemslocal_I	Parents	0.4107	0.030	1.508
4Ps *Stimuli* event	Experienced the four P's of marketing events	*PAPromo*	Parents	0.3888	0.112	1.475

Concordance	= 0.624	(S.E. = 0.022)
Likelihood ratio test	= 64.46	on 16 df, p=9e-08
Wald test	= 64.7	on 16 df, p=8e-08
Score (logrank) test	= 67.32	on 16 df, p=3e-08
Sample size	=347	

The positive sign of the variables indicates a positive impact on the dependent variable, i.e., an acceleration of the time to shifting to PT. Those variables are:

- Sociodemographic: A55_64_S;
- Drivers to shift to PT reported by respondents: CDriver1Shift_P, CDriver9Shift_I, CDriver9Shift_S, CDriver10Shift_P, CDrivver10Shift_S; and
- Indicators of satisfaction with PT: Psystemslocal_P, Psystemslocal_I.

Conversely, the variables with a negative coefficient indicate a delay of the time to shifting to PT, and those were:

- Sociodemographic: A35_44_S;
- Mobility: Car2, Cwalk, Pcar;
- Drivers to shift to PT reported by respondents: CDriver3Shift_I, CDriver3Shift_S, Psystemspunct_I.

Interestingly, mobility habits reported by the respondents are negatively related to the time to shift to PT, which suggests that there is some resistance to change, to the extent of the sample collected in the survey. Also, we strike out that being exposed to events related to

all 4 Ps of the marketing mix is positively associated with anticipating the shift to PT. This finding confirms our *a priori* hypothesis that acting through marketing events can have an impact on travel behaviour change of school commuting.

The hazard ratio (HR) is obtained by calculating the exponential of the parameter and is an indication of the relative impact of each variable when compared to the remaining variables. Importantly, variables related to the respondents' perception of Drivers to shift to PT (e.g., “CDriver10Shift_S” or “CDriver1Shift_P”) had the higher acceleration impact on the time to shift to PT (HR of 3,9985 or 3,6704, respectively). We can conclude that there is a direct relationship between the marketing mix intervention and behaviour change of students. Sociodemographics variable “A55_64_S” was also impactful (HR = 2,7494), indicating that older parents tend to accept that their children shift more easily to PT to commute to school. Such a result might be correlated with the fact these parents have older children and therefore are more risk-taking.

Finally, the variable “PAPromo” related to the Promotion-related field intervention was also relevantly accelerating the time to shifting to PT (HR = 1,4751), our comment in the previous paragraph.

As shown in Table 5.6, we found that the most statistically significant variables are parent's perceived drivers for potentially shifting to PT, i.e., better transport services (“CDriver1Shift_P”) and other reasons (“CDriver10Shift_P”), mainly in Primary schools. Specifically, better transport services have 3,7 times higher probabilities of anticipating a shift to PT. These findings are reasonable as the need for safety and control of all variables by parents and relating to young children's mobility is stronger than when they are grown up, confirming our previous comment.

Parents often chose "Other Drivers" that would make them decide to shift to PT for their children's school commuting. These Drivers have a higher probability (3, 9) of being associated with potentially shifting to PT, although they are unspecified. Somehow these other drivers are not related to transport services (i.e., quality of service, price, information, promotion, and impossibility to drive) but probably other households´ reasons.

Data from these results illustrate that the importance of better services for primary school students is more significant to shift to PT than for other school levels (intermediate and secondary). These results are consistent with studies reported in the literature and that support an association between child´s age and the modal choice (Babey et al, 2009; Bere et al., 2008; Johansson et al., 2011; McDonald, 2008a; McDonald, 2008b; Robertson et al., 2008). On the other hand, the present work argues that transitions from primary to intermediate education

can be prime timings facilitating changes in mode choices towards more sustainable options (Cooper et al., 2012).

These empirical results show that PT has to improve its fundamental operational indicators, such as punctuality. Moreover, operators have to improve the quality of the waiting environment at the bus stops to improve the overall service and become more attractive to users and potential users. Our result is in line with other studies for which on-time performance (i.e., punctuality), travel speed, and service frequency were the most important (Dell´Olio et al., 2010, Mouwen, 2015).

We found that secondary-school children with older parents (aged 55 to 64) would shift to PT more rapidly if transport services were improved, i.e., PT convenience and bus stop relocation. On the other hand, having two cars in the household would delay the change to PT.

Related with socio-demographics perspective, the variables statistically significant are the parents' age and the car ownership in the household. The variable related to car ownership influences the choice of the car when traveling to school, and this result is consistent with studies reported in the literature (McMillan, 2003; Chillón et al., 2014; Mehdizadeh et al., 2016). On the other hand, the parents' age is associated with children´s age and, consequently, with their autonomy as younger children are more prone to be driven to school by their caregivers (Queiroz et al., 2019b), as already mentioned.

Moreover, if children walked to school before being exposed to the marketing events (variable “Cwalk”), they would take longer before shifting to PT. This finding may be explained by the fact that they most probably live closer to school, and it is less attractive to use the PT. On the other hand, parents who travel by car (variable “Pcar”) also delay their children’s shift to PT.

Our results suggest that any intervention to promote more autonomous mobility in school commuting requires a detailed a priori knowledge of the children involved and their families to target the marketing events better. The information to be collected includes sociodemographic characteristics, mobility habits, and drivers to shift to PT.

From the transport system perspective, it is fundamental to improve the level of service of PT, including vehicles' quality, to positively influence and attract potential users. Finally, we emphasize that the community reacted positively to field-intervention stimuli (for instance, Promotion - related marketing events).

Although we implemented field *stimuli* related to all 4 Ps of the Marketing mix (i.e., Product, Place, Price, Promotion), only the Promotion-related action turned out to be relevant

in the final model. Such a result might be explained by the small sample of students and parents exposed to some of the events. We believe that if these other actions had the formal involvement of all the transport players and not just the transport operators as sponsors of this research, these measures could have had more impactful results.

The Promotion-related event (variable “PAPromo”) consisted of presenting an existing PT route planner APP to the students and teach them how to find PT routes between an origin and a destination. The stakeholders involved considered that this simple action was innovative in the marketing approach to school commuting by PT. More effective measures can be proposed hereon. Traditionally, PT is less proactive in the use of marketing approaches, and it is necessary to incentivize the change to make these marketing events more common in future interventions and have continuity.

On the other hand, we would like to highlight the integrated approach of our implementation of the Marketing Mix. We believe that it was more impactful than implementing just one P. To the best of our knowledge, no previous research addressed the potential user acceptance of integrated marketing activities organized according to the 4 Ps, and more specifically, for school commuting.

5.2.4 Conclusions

In this section, we presented the results of an HBDM that analyzed the time between behaviour change (i.e., shift to PT) after being exposed to PT marketing field-intervention. We collected and analyzed data from an initial sample of 1760 families, from which we selected 347 respondents, who are the respondents that shifted to PT during the experiment.

We used a nonparametric method to estimate the time between the moment the intervention began until the moment the children changed their commuting to PT. The first contribution of this empirical research is that sociodemographic characteristics of respondents influence the time-to-shift to PT, such as the self-reported drivers to shift to PT by respondents, their evaluation of the quality of PT services, and the 4 Ps integrated-marketing events.

The results of this section also confirm that the Cox proportional-hazards model is an appropriate method for evaluating the time delay in shifting to PT, in the specific case of school commuting. We expect that these results provide guidance to define marketing strategies to promote the shift of children's school commuting to PT and a better understanding of the timeline necessary to change travel behaviour.

The following statements attempt to answer the questions for this research:

***Q1**. How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

Theories of behavior change, and modal choice explored in the literature review chapter, contribute to understanding how the marketing events influence the decision to change behaviour. This section helps to answer this question, by taking into account not only the previous marketing experiments but also the implemented innovative ones (Bus Papers, Stands, Think Tanks) in schools. To explain the shift, we assessed sociodemographic; mobility (previous mode); drivers to shift (quality of service, tariffs, information, promotions, convenience, others); PT improvements (PT vehicles and PT systems) and also the presence in Marketing events.

In the PT improvements, we have to point out the more statistically significant category: better transport services mainly in Primary schools and other reasons related to households´ reasons which exclude PT service. These empirical results show that PT has to improve essential features such as punctuality, and the bus_stops, in order to improve the overall service (on-time performance, travel speed and service frequency), lading to the desired PT leverage.

***Q2**: Which marketing mix is adequate to influence parents and children in their school commuting?*

Although field *Stimuli* were implemented, involving the Marketing 4 Ps (i.e., Product, Price, Promotion and Place), only Promotion-related action turned out to be relevant in the final model. We believe if these actions had the formal involvement of all transport players and not just the sponsors´ operators and the researcher, these measures could have more impactful results. It would be important the number of students participating in ***Bus Papers*** to be expanded so that their impacts are greater. The fact that the request of Bus Papers to operators arose from the researcher and not by entities that patornship transport and on the other hand it is an activity that entails costs (with the availability of buses and drivers) did not allow the number of BPs to be expanded.

Similarly, the presence of operators in the **Stands** also required the transfer of human resources to the schools, and we consider that if it had had the endorsement of the responsibles for transport management in the metropolitan area, the presence in the schools would have been more intensified and consequently the results would have been impactful.

The presence of students in the ***Think Tanks*** also could have been more intensified if it had not taken place during the classes' period, which required a great effort to coordinate

parental authorization and justifications for absences to some classes in order to make these strategic reflection meetings on future transport solutions possible. Regarding the presence of parents, it was even more difficult because it was during working hours. The parents who were present were unemployed or working in the schools where the meetings took place.

Traditionally, PT is less proactive in the use of marketing approaches, and it is necessary to incentivize the change in order to make these marketing events more common in future interventions and promote their continuity.

Q3: *What is the time delay for behavioural and modal choice changes to occur?*

Based on the results of the methods applied in this study, the evolution of shifting to PT was separated by two significant moments over the experiment: on the day 210- Event P6- (shift of 25%) after the kick-off and when operators presented their products and services and had the chance to clarify doubts about transport services and routes. During the period 2 – Event P7- (between day 201 and day 330) there was a 10% shift to PT. This event consisted of presenting an existing PT route planner APP to students and teach them how to find routes between an origin and a destination. The stakeholders involved considered that these simple actions were innovative in the marketing approach in PT and can be proposed hereon.

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

It is suggested that PT improvements should focus on the overall service (on-time performance, travel speed and service frequency). Theories of PT users´ satisfaction concluded that modal choice is influenced by the basic attributes of transport service (reliability and frequency, among others).In this case study, the most important transport services were punctuality, quality of bus_stops, travel speed and service frequency.

SQ3. *What positive effect can gamification have on the behavioural and modal choice changes?*

The implementation of marketing events related to gamification - Traffic Snake Game and Bus Papers - was not statistically significant. Potentially, a larger student sample is required to effectively capture the underlying data structure in the model. Somehow there was a positive feedback about this initiative by word of mouth and also in the open-ended questions of the surveys. To overcome these barriers and have greater results in the models, we

consider **Bus Papers** have to expand the number of participants and even consider intermodality with other PT modes beyond bus. On the other hand, **Traffic Snake Game** should evolve to a more digital format to make it more appealing to the more grown up students, who considered collage on the serpent a more childlike activity.

Despite these weaknesses, the perception of the teachers and the researcher in the various moments of sharing was that these gamification activities were valued by young people and should be continued in future school years.

SQ4. *How can a targeted marketing mix be developed to leverage public transport systems and make it more attractive to school commuting?*

Our findings revealed that Promotion was the most impactful drive out of the marketing mix, in particular the need for "word of mouth" regarding the available products and services and the ways of accessing them (physically and digitally).

Despite the initial perception for of the need to change the paradigm, i.e. from a reactive to a proactive attitude, this study confirmed that the attitude of transport players makes a difference and that the time reaction is crucial for the change in mobility.

The change of habits involves many variables in families, but operators should act at critical moments for the families (e.g. changing jobs, school, house, etc.), which enables a greater willingness to change their travel behaviour.

Marketing mix in itself is not enough, it is necessary to act at specific moments and to have a coherent and coordinated policy in order to achieve the desired objectives of sustainable mobility.

SQ5. *Which is the delay time for each factor of the marketing mix?*

Based on the results of the methods applied in this study, we were only able to assess *the delay time* of Promo events, as the other events were not statistically significant in the model. The evolution of shifting to PT was separated by two significant moments over the experiment: on the day 210- Event P6- (shift of 25%) after the kick-off, and when operators presented their products and services and had the chance to clarify doubt about transport services and routes.

During the period 2 – Event P7- (between day 201 and day 330) there was a 10% shift to PT. From this analysis we can infer that the minimum reaction time to *Stimuli* (marketing events) was 210 days

This finding confirms that the results of these promotional investments in PT take time to have a return and on the other hand require continuity and consistency with all other policies related to PT.

This intervention on the ground lasted two school years and after these conclusions these events should continue in these schools and be extended to others in these councils and even others to assess their spread.

SQ6. *Which marketing Stimuli has more impact to shift to PT?*

Although field *Stimuli* were implemented, involving the Marketing 4 Ps (i.e., Product, Price, Promotion and Place), only Promotion-related action turned out to be relevant in the final model. It should be noted that the remaining three Ps, Product, Price and Place, are dependent of the authorization of the Transport Authority, the Government/Municipality and also the operators' feasibility in operational terms.

We must point out that Promotion (in the Marketing mix) is likely the most feasible P to change. However, we believe that if we simultaneously changed these 4 Ps, it would be more impactful on the final result.

5.3 Understanding the expectations of parents regarding their children´s school commuting using Latent Dirichlet Allocation

The following overall thesis research questions are addressed by the current section:

Q1. How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

SQ2. *Which is the latent demand in PT?*

5.3.1 Introduction

Open-ended questions in surveys may be used to explore deeper information and expectations in PT. Based on surveys of 1760 households whose children attend primary,

middle and high Portuguese schools, we carried out an analysis of the open-end questions and gathered two surveys during two school years (2017-2018 and 2018-2019). The analysis was undertaken using a Latent Dirichlet Allocation, to evaluate the topics which are the main concerns or suggestions in order to improve the transport service. Results suggest that in order to achieve a modal shift towards PT, we should focus on improving the PT operation (frequency, compliance and cleanliness) and the waiting environment i.e., the bus-stops in order to improve the overall service.

This section presents empirical evidence that the LDA an alternative method to collect users´ feedback related to PT expectations. The findings may also encourage policy makers and operators to develop these recommendations for PT.

The interest of deepening the expectations about PT is due to the fact that the literature indicates that the choice of this mode is strongly dependent on the degree of satisfaction and especially in relation to punctuality and comfort (Papaionnou, 2017; Mouwen, 2015; Del Castillo and Benitez, 2012; Dell´Ollio, 2011; Eboli and Mazzula, 2009, among others)

Exploring the open-ended questions give the researchers a direct window of what concerns respondents and explore deeper information they have about the subject.

Usually, it is suggested to avoid open-ended questions, since it is difficult to treat and harmonize the language. Despite this handicap, it is still one of the ways to gather the information that would not be included in the pre-selected close-ended questions by the researchers. Also, it does neither limit nor influence the respondents and may enrich the analysis (Fowler, 1995).

A method to mine information from the original digital data collection is the so-called topic models. They analyze data entities which can be documents (Blei et al, 2003), images (Iwata et al., 2007) or videos (Wang et al., 2007).

In this section, the following terms are used, as defined by Blei et al. (2003):

- A *Word* or *Term* is the basic unit of discrete data, defined to be an item from a vocabulary indexed by {1, …., V};
- A *Document* is a sequence of N *words* denoted by F = (w_1, w_2, …w_n), where w_n is the n^{th} word in the sequence;
- A *Corpus* is a collection of M *documents* denoted by D = (F_1, F_2, ….F_N);
- A Topic is a unique distribution over a vocabulary of words that respondents use to identify PT reviews.

Topic models are “probabilistic latent variable models of documents that exploit correlations among the words and latent semantic themes” (Blei and Lafferty, 2007). The

“topic” means the unknown variable relations that link words in documents. A document is seen as a mix of topics.

This section aims to describe how topic modelling can be effectively used to identify patterns of suggestions related to PT, as described in open-ended questions of the collected surveys.

This research applies latent Dirichlet allocation (LDA) (Blei et al., 2003), a particularly common method for fitting a topic model, to open-ended questions in the framework of two surveys to collect information from school commuting. LDA was applied to a dataset collected from surveys of 1760 households whose children attend primary, middle and high schools in three municipalities of the Lisbon Metropolitan Area (LMA).

5.3.2 Methodology

We used a Latent Dirichlet Allocation (LDA) which has been thoroughly explained in the original paper by Blei et al. (2003), Griffiths and Steyvers (2004), Heinrich (2005), Beli and Lafferty (2009), Berry and Kogan (2010), Blei (2011), among others. LDA has become one of the most popular probabilistic text modelling techniques in machine learning (Wi and Croft, 2007) and it is fully detailed in section 3.1.2.4.

Surveys

Two surveys were conducted to collect empirical data for this study on ten elementary, middle and high schools (6-18 years) of three municipalities of the LMA, in Portugal. The surveys are detailed in section 3.1.1.

The first survey included an open-ended question in the end. The second survey also included an open-ended question at the end of the survey.

The reviews resulted from the two surveys, 103 (23%) from the first and 345 (77%) from the second one. The original reviews were in Portuguese and the researcher responsible for the design, collection and treatment of the surveys translated them, in order to enable consistency in the overall process.

The open-ended questions were not mandatory. 448 responses were received from 1760 participants (25%).

Data

The open-ended responses consist of respondents´ reviews related to PT when commuting to school.

A description of the socio-demographics of the respondents in the two surveys is shown in Table 5.7 46% of the respondents of the survey are aged between 35-44 years, while 39% range between 45 and 54 years. 68.5% of the respondents are women. The majority of respondents (70.9%) have a full-time job. With regard to the level of education, 40% have a graduate level of education and 38% a secondary grade level. Of the total number of surveys, 18%, 42% and 40%, are from primary (6-10 years), intermediate (11-12 years) and secondary (13-18 years) schools, respectively.

Table 5.7 - Summary description of socio-demographics of the open-ended questions respondents

Variable	Classes/Options	Description	Freq (%)
Sociodemographics			
PARENT	Non Parents	Relationship with the students	10
	Parents		90
AGE	Class 1	≤ 20 years	1
	Class 2	20 – 24 years	1
	Class 3	25 – 34 years	6
	Class 4	35 – 44 years	46
	Class 5	45 – 54 years	39
	Class 6	55 – 64 years	6
	Class 7	≥ 65 years	1
FEM (Female)	No	Gender	33
	Yes		67
WRK (Work occupation)	No work	Employment	18
	Work		82
STUD (Level of education of the respondent – parents only)	Class 1	primary	22
	Class 2	secondary	38
	Class 3	grade level	40
INC (Income)	Class 0	Live without financial restrictions	30
	Class 1	live modestely	56
	Class 2	Live with financial restrictions	14
NUM_CAR(Number of cars)	None	0	10
	0	1	40
	1	2	42
	2	3	5
	3	>3	3
LEVEL (School level)	Class 1	Primary school	18
	Class 2	Intermediate school	42
	Class 3	Secondary school	40
MUN (Municipality of the school)	1	Cascais	22
	2	Oeiras	61
	3	Sintra	17

Topic analysis is based on the spreadsheet containing the reviews of the respondents. To create a document-term matrix that can be processed via topic modelling some data information was reorganized, and some assumptions for pre-processing choices were made.

The document-term matrix works is an input to the LDA topic modelling to get the most relevant topics (Biel et al., 2003).

The process of text pre-processing in this study included tokenization, converting words to lower-case, removing punctuation and removing stop words.
In the case of words that appear in the following way: "bus" "417", "bus" "408", we made the concatenate in the following way: "bus417", "bus408" to avoid that the words appear separated and the purpose was understandable, i.e., to which buses they were referring to.

The Figure 5.2 shows the word cloud of reviews from respondents. A word cloud represents the word frequency in a given text with words of higher frequency in a given text and the size of each word is in proportion to its probability.
The more precise words are used, the bigger they appear in the word cloud. This is a visual method of obtaining tangible insights from qualitative data. Studies have shown that a word cloud is a simple but effective illustration of data.

In this section, the word cloud clearly shows four prominent themes related to PT: school, safety, comfort, increase, school_bus_schedules.

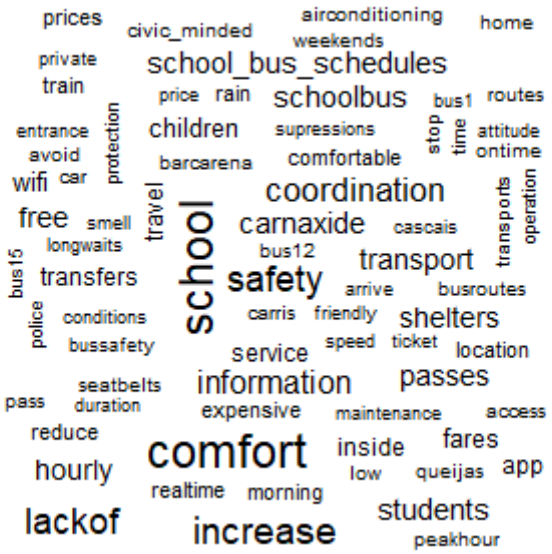

Figure 5.2 - Word cloud of reviews of the record set

5.3.3 Results and discussion

Relationship between words

Figure 5.3 plots the combination of connected words for the recordset. The relationships are directional (ticked with an arrow). There are some words, such as ”bus_stops“, “improve“ and “drivers” that form common centers of nodes. We also see pairs

and triplets that form common phrases related to PT issues, on the one hand, a problem (e.g., “lack of PT”), but, on the other, some solutions: “compliance schedules”, “coordination school_bus_schedules”, “free passes”, “lower fares”, “increase supply”. The word “information” is preceded by “app” and followed by “bus_stops” and then by “location” and “shelters”. The word “comfort” is preceded by “improve” and followed by “safety”. The word “bus” is preceded by “improve” and followed by “inside” and “per hour”. And also, the sequence “passengers”, “protection”, “rain” and “cold”.

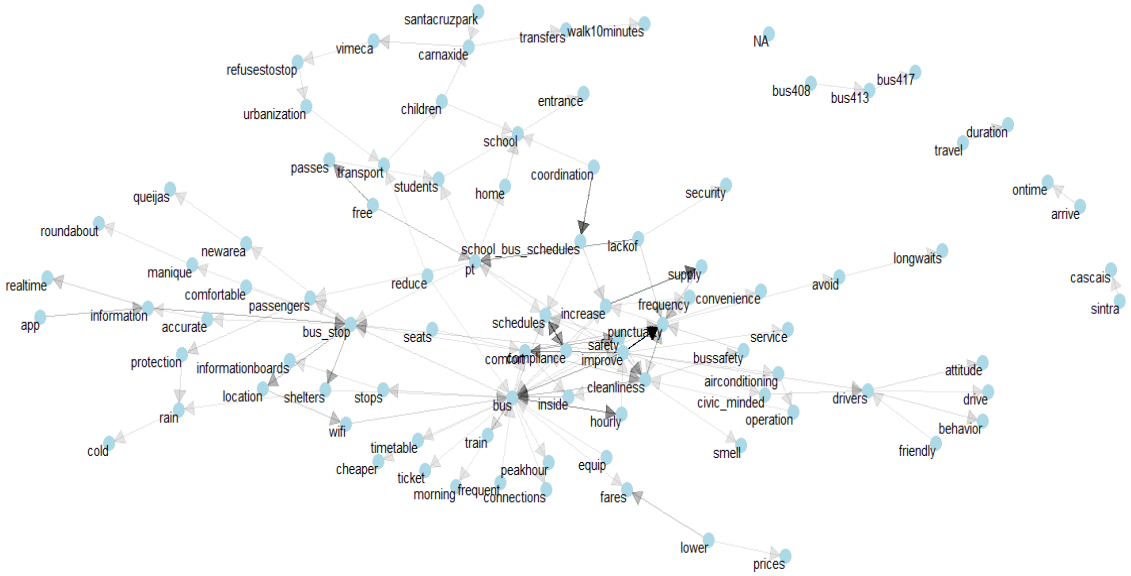

Figure 5.3 - Directed graph of common bigrams in the record set

In Figure 5.4, the words most correlated with “bus”, “bus_stop”, ”improve”, “pt”(Public Transport) are presented for the *reviews* record. These correlations point out issues regarding the necessary improvements in PT. Examining words correlated with the word “improve”, it is possible to identify issues as basic attributes of the PT, such as “punctuality”, ”cleanliness”, ”comfort”, “safety”, ”smell”, “maintenance”, and “attitude”, which covers topics of reliability, aesthetics and human resources management. Related to the “bus_stop”, the focus is the waiting environment and its design, which includes thermal comfort, rain protection, and information availability.

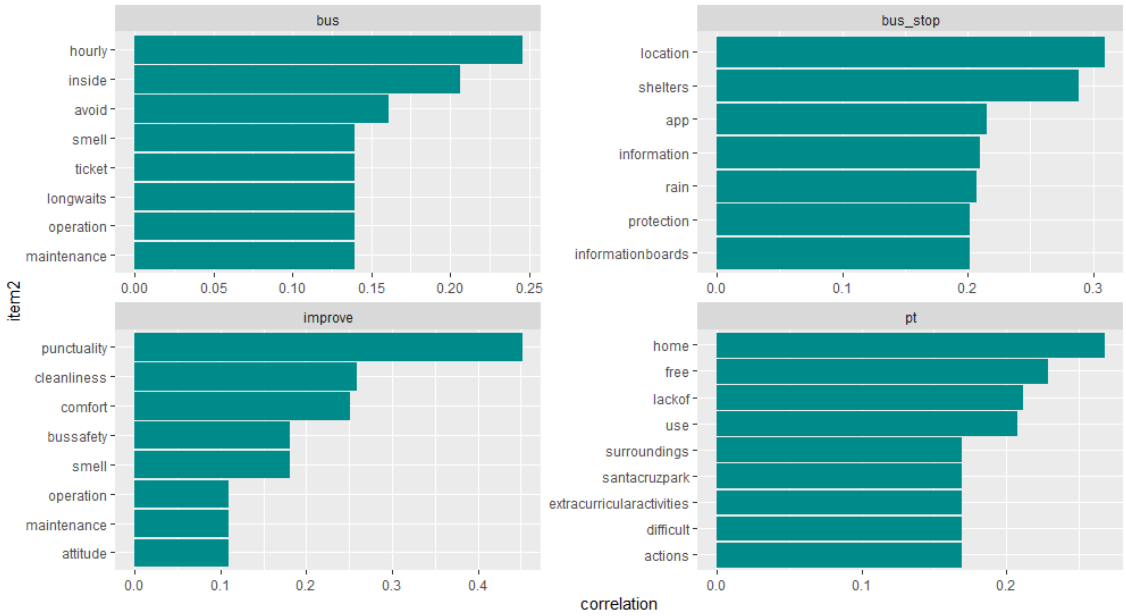

Figure 5.4 - Words associated with "bus", "bus_stop", "improve" and "pt" in the reviews PT record

Models and interpretation

The LDA implementation was applied to the PT reviews, collected on the two surveys in schools researched (section 3.1.1). Punctuation, whitespace, and stop words were first removed from the *corpus.*

The first problem when applying LDA involves identifying the number of topics. The R package "ldatuning" (Nikita, 2016) was used to fix the optimal k.

In addition, the topic number selection was led by the model´s capability to identify a number of meaningful topics. In fact, the increase in fit is sometimes interpreted due to overfitting (Dyer et al., 2017). Increasing the number of topics, producing detailed partitions can result in a less suitable model because it becomes impossible for humans to differentiate between numerous topics (Chang et al., 2009). Ultimately, the choice of models must be determined by the questions being researched. DiMaggio et al. (2013) suggest that the process is empirically controlled, in that, if the data are unsuitable for answering the analysts´ questions, no topic model will produce a useful extraction of the data.

There is no clear correct number of topics in the data (Roque et al., 2019), but as shown in Figure 5.5, a LDA model was estimated by setting a different number of topics K, ranging from two to 25. The expectation maximization metrics limit the number of topics by 25. From the plots of the two methods, we can conclude that the optimal number of topics is

in range 12-18. We ran different models considering this interval of topics and the LDA model with 12 topics gave the most efficient clustering of the dataset.

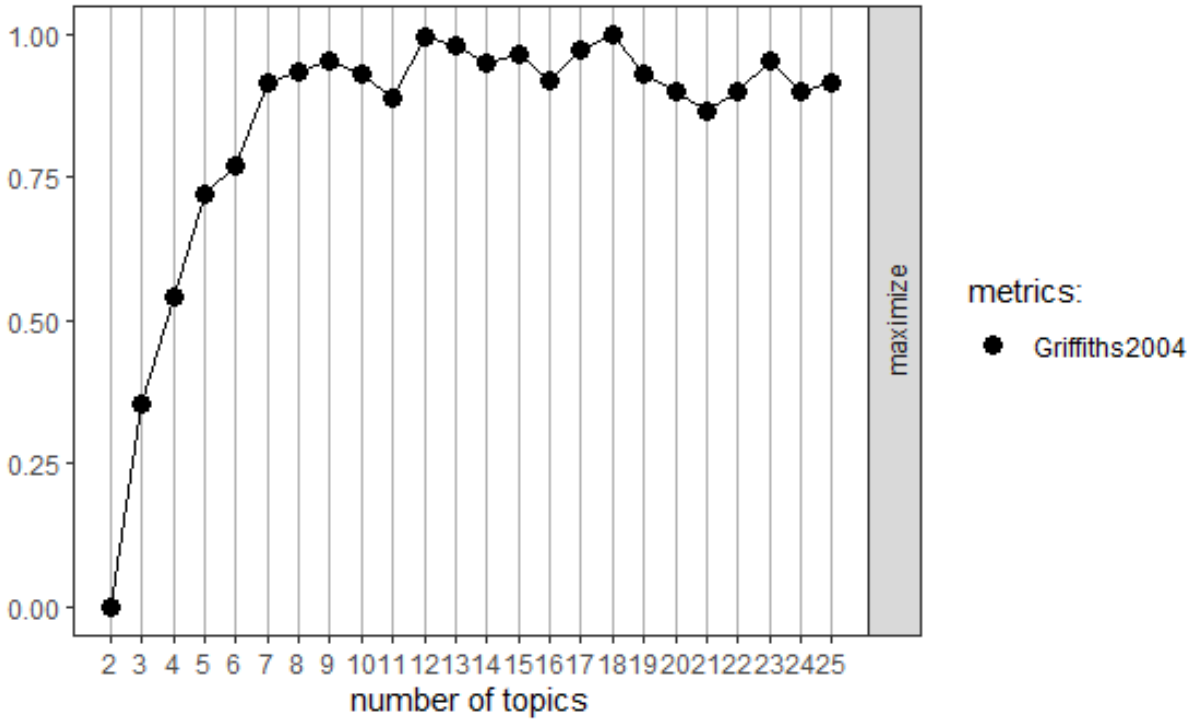

Figure 5.5 - Determining the number of latent topics (K) for the reviews' PT record set

LDA´s latent variables estimation used the Gibbs sampling algorithm since it overcomes the problem of obtaining samples from complex probability distributions by using random numbers (Mackay, 2005). The sampling is done successively and continues until the tested values approximate the target distribution (Steyvers and Griffiths, 2007).

Table 5.8 shows the 12 extracted latent topics for the *reviews PT* record set. Each topic contains all words in the *corpus*, though with different probabilities. The top 8 terms for each record set are listed in Table 5.8.

Table 5.8 - Extracted Latent Topics with keywords (reviews record set)

Topic 1	*Topic 2*	*Topic 3*	*Topic 4*	*Topic 5*	*Topic 6*
Hourly punctuality	**Bus_stop Comfort**	**Lower fares**	**More Supply+ cleanliness**	**Increase**	**Bus punctuality**
punctuality	Busstop	transport	supply	busstop	punctuality
schedules	Compliance	fares	lackof	increase	bus
school	comfort	lower	cleanliness	schedules	free
hourly	coordination	inside	service	school buscshedules	vimeca
frequency	Drivers	shelters	comfort	transfers	wifi
travel	busroutes	expensive	passes	compliance	children
location	reduce	rain	drivers	comfort	more
train	vimeca	passes	more	vimeca	travel
Topic 7	*Topic 8*	*Topic 9*	*Topic 10*	*Topic 11*	*Topic 12*
More safety	**Improve supply**	**Bus information**	**More comfort**	**Bus Students**	**More punctuality**
safety	improve	bus	more	bus	more
passengers	Supply	information	comfort	students	punctuality
schoolbus	school	carnaxide	busstop	coordination	drivers
cleanliness	Routes	frequency	children	school	schedules
school	prices	app	prices	train	delays
drivers	travel	stops	comfortable	shelters	comfort
ontime	passes	realtime	vimeca	compliance	seats
more	improve	bus	more	bus	more

To provide a better understanding of the LDA's latent topics, Figure 5.6 presents some examples of the topic-specific words probabilities (β) for the 12 topics of the suggestions record set. For instance, the word "cleanliness" has more than 20% probability of being generated from Topic 1, though "busroutes" has less than 10% probability of being created from the same topic.

There are same words that stand out in different topics, for example "more" (topics 4,10,12), "punctuality" (topics 1, 6, 12), "bus" (topic 6,9 and 11), "improve" (topic 8), "bus_stop" (topics 2 and 5).

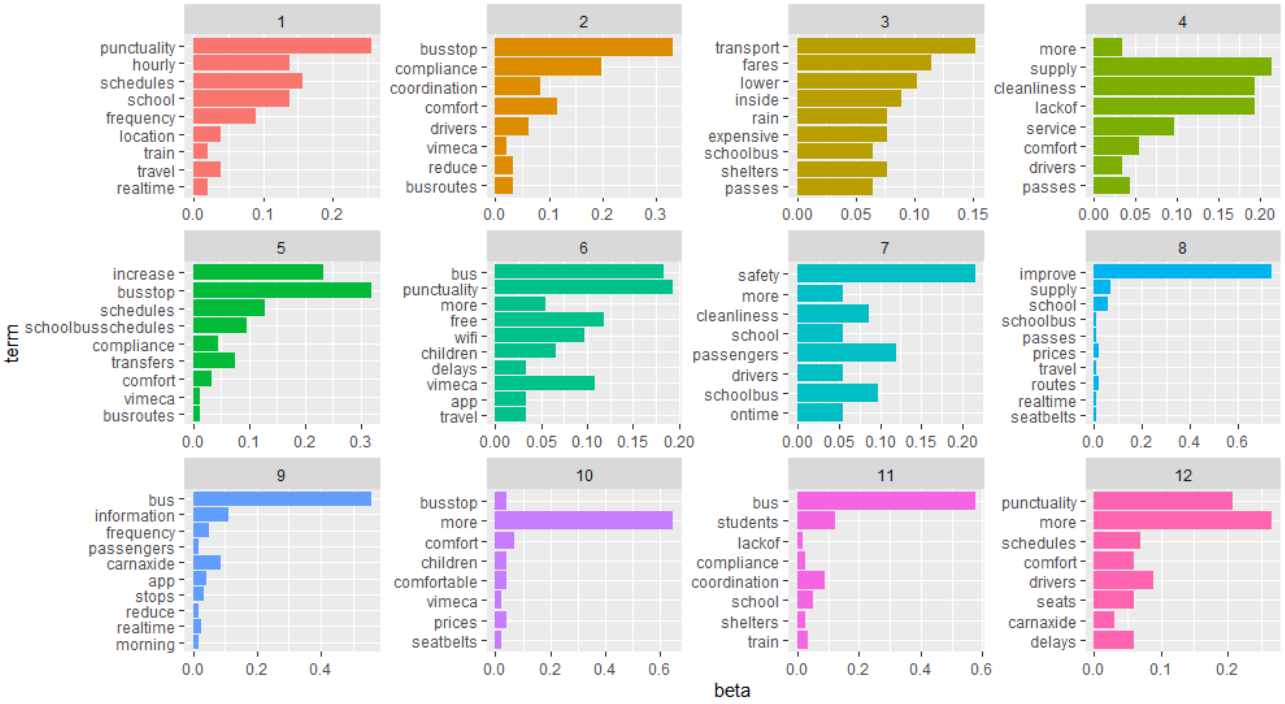

Figure 5.6 - Topic-specific word probabilities for the suggestions record set

As demonstrated by Table 5.8, the extracted 12 topics obtained from the record set match the reviews to improve PT reasonably well. It is also worthwhile to stress that common words such as “more” and “lack of”, which are not typically related to PT, appears in several topics. The frequency of topics related to operations service (frequency, punctuality, supply, safety, delays, cleanliness, compliance) are higher than those related to potential identified solutions (school_bus; shelters, improve, app, free).

We can recognize that each topic based on the main focus were labelled, as we can confirm in Table 5.8, e.g. topic 1 ”Hourly punctuality”, topic 2 “Bus_stop comfort”, etc.

5.3.4 Conclusions

The combination of text mining and topic modelling enables the PT suggestions to be extracted and evaluated and help to determine the extent improvement that is necessary in PT. The results of this section provide evidence that the LDA is appropriate for identifying the reviews related to PT. This method complements other data analysis, such as exploratory and confirmatory data analysis.

Explore open-ended questions help the researchers to understand the survey respondents´ perspective instead of stock responses. In parallel when we collect responses, we can view trends automatically or even spot information that stands out with word clouds and graphs.

With this alternative method to collect qualitative data, we can simplify the analysis of the open-ended question by understanding the traveler's behaviour in terms of interpretability and contextually.

This section provided a useful tool to explore the logical prevalence and relevant trends in the fields of PT when commuting to school and resulted from mining information behind reviews and evaluating the main concerns about PT aiming to aid transport planning ranging from a strategic, tactical and operational level.

However, the literature supports that usually users state negative reviews instead of positive ones (Salazar, 1990), the negative comments enables to understand deeper emotions, compliment closed-ended questions and overcome questions content limitations.

Our results support our theory that PT expectations make the difference in PT choice when commuting, similarly to these studies (Papaionnou, 2017; Mouwen, 2015; Del Castillo and Benitez, 2012; Dell´Ollio, 2011; Eboli and Mazzula, 2009, among others).

After taking the results into consideration and previous research in this topic we confirm the transport service has to improve mainly in frequency and schedules (Queiroz et al., 2019a; Queiroz et al., 2019b; Queiroz et al., 2020).

Unlike to what was expected respondents did not refer any necessary improvement on bus flexibility and tracking, as found in previous study (Queiroz et al., 2020)

This technique is a powerful one and confirms the expectation to explore open-ended questions. These results suggest it is likely that we can use words to build messages in marketing claims and campaigns in order to leverage the PT. The word "more" conveys a stronger one, mainly associated with "punctuality", coordination between "school and bus schedules".

The findings of this section may also encourage policy makers to make the necessary efforts to develop recommendations for PT. The results of this study confirm the potential of LDA in analysing the PT issues.

These empirical results showed that PT has to improve basic requirements (frequency, compliance and cleanliness) as well as the waiting environment i.e., the bus-stops in order to improve the overall service and become more attractive to users and potential users.

For future work, it would be of interest to apply other modelling approaches, such as structural topic models (Roberts et al., 2014, 2016), which allow topics to correlate when estimating the model and graph topic models (Xuan et al., 2015; Zhang et al., 2019).

The following statements attempt to answer the questions for this research:

Q1. How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?

Open-ended questions in surveys may be used to explore deeper information and expectations in PT by understanding the travellers´ behaviour in terms of interpretability and contextually. Using the LDA, we evaluated the topics reflecting the travellers' main concerns or suggestions in order to improve the transport service. Results suggest that in order to achieve a modal shift towards PT, we should focus on improving PT operation: frequency, compliance, cleanliness and the waiting environment (the bus_stops). Unlike to what was expected, respondents did not refer to any necessary improvement on bus flexibility and tracking.

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

From the results, the focus should be on improving PT operation: *Frequency, Compliance*, *Cleanliness* and the waiting environment: the bus_stops. It become clear from the study the importance of psychological and physical barriers. By identifying and gradually removing these barriers, ridership can be increased. Thus, increasing the modal share of PT, and of buses in particular, should on the agenda of most PT players.

To operationalize these improvements, it is necessary service providers adapt the supply and focus on key aspects of the journey (frequency, reliability and cleanliness). Simultaneously altering perceptions through communications and messages, this last one frequently forgotten by the operators. Another Critical Success Factor (CSF) is that staff at all levels, especially the front-line staff who have day to day customer contact, understand the company's 'message'. These investment decisions on the service requires customer communications is a two-way path: let users know what operators are doing and that they are being heard.

SQ2. *Which is the latent demand in PT?*

Throughout the users´ reviews, we can acknowledge suggestions and more in-depth insights that affect parents´ perceptions of PT service.

Considering that the respondents who write in the open questions are the most dissatisfied and that after the whole survey is completed there are still comments on PT, these segments should be analysed with some care.

These reviews enable to gather information that were not included in the pre-selected closed-ended questions by the research and allows to enrich the overall analysis.

Every review has a personal story, and behind that review is an experience that matters.

By sharing experiences, we can provide recommendations on the design of existent or future products. These respondents (potential users of PT) expect improvements on PT basic operational requirements which include frequency, compliance and cleanliness and comfort of bus_stops. This is in line with previous studies in this research regarding drivers of service improvements.

6. Conclusions and further work

6.1. Integrating transport modelling tools and marketing guidelines for more effective marketing strategies

The results from the previous mentioned models covered the 4 Ps framework (Table 1.1), however **Price** had fewer results. It is understandable considering that price is determined by the government/municipality and cannot be modified by whoever is developing the marketing actions.

After the implementation of marketing events in the field, the **Promotion** was the most statistically significant, namely the stands (event P6 in the intervention) and the app presentation (event P7 in the intervention).

With this research it is possible to identify the weight of the Product and Promotion components at the level of the Marketing approach.

Furthermore, with this research we have learned about users´ requirements, expectations, perceptions and the level of satisfaction due to PT. The marketing plan should outline these marketing research findings as well as the previous state of art and state of practice to improve PT when commuting to school.

We further argue that to achieve consolidated results it is necessary a Marketing Strategy but in order to succeed we must sustain it in the stakeholders´ triangle (Figure 1.2). Hence, in the Marketing strategy we have to define the Mission, the marketing and financial objectives, and the needs we have to satisfy in the market as well as its operators positioning in the mobility. On the other hand, marketing tactics outlines the marketing activities that will be undertaken to execute the marketing strategy: Key product attributes, Price definition, Place (channels distribution), promotion and communication, i.e., define the 4 Ps. At last, define the controlling, which outlines the controls, for monitoring and adjusting implementation of the plan

6.2. Main contributions of this research

This research succeeded in developing a 4 Ps framework to increase PT usage in pre-university school commuting supported by the stakeholders´ triangle.

Such findings represent fill an important gap in the the urban mobility management to leverage PT and is characterized by 4 Ps: Product, Price, Promotion and Place.

The model, called *Grow with Mobility* (Figure 6.1), is the representation of the 4Ps perspective. A set of 4Ps proposed in this thesis to better relate them to the Market approach. The stakeholders´approach is the second characteristic important of the proposed approach by changing the traditional relashionships between the parties involved.

Figure 0.1 - Logo Grow with Mobility

Another feature of this research is the following innovative marketing events implemented in the schools: Bus Papers, Operators´ stands and an APP demonstration in schools and also Think Tanks in which were conceived a Transport campaign with claims and a design adjusted to the young people.

Moreover, multiple analytical techniques (Discrete Choice Models, Structural Equation Models, Latent Dirichlet Allocation and Hazard-Based Duration Models) were required to fully respond to the complexity of the problem studied.

Next are presented the conclusions to each research question.

***Q1**. How can public transport systems be leveraged to gain attractiveness in school-related mobility in urban and suburban environments?*

From the results of the various experiments and different methodologies in this research it became evident that the basic requirements of PT service such as frequency, reliability, cleanliness and as well as the comfort of the bus_stops, are crucial to attract new PT users.

In addition to this need to improve the service, the exit of the operators from the comfort zone was greatly appreciated, going to schools to publicize their products/packages and clarify some doubts about mobility. This more proactive attitude of the operators and more customer focus going to the sites to try to capture more market had impact on families and students, because traditionally the PT is a more closed sector and more reactive to demand.

Despite the growing share of digital applications and tools in the PT environment, we found that current and potential users were still unaware that these digital media exist and on the other hand the human factor is still highly valued, namely the staff engagement on the service, such as the drivers´attitude and the help desk attendance, i.e., the human factor playing an important role in the service.

SQ1. *Which attributes of the PT system affect school commuting mode choice of households and how?*

The main attributes related to the Product features valued by the PT users are *frequency, schedules, punctuality, transfers, security* and *trip duration*.

From the data mining developed on the open-ended question of the survey, some suggestions of improvement in PT were presented: "*punctuality", "cleanliness", "comfort", "safety", "smell (inside the bus)", "maintenance" and " drivers' attitude".*

SQ2. *Which is the latent demand in PT?*

Whereas the study aimed to identify latent demand in PT to and from school and based on 27 choice sets of car/ bus attributes it was possible to identify 6 different profiles of parents: (1) "Afternoon commuters accompanied", (2) "Afternoon commuters", (3) "Morning commuters" for whom is important to have short time commuting; the (4) "Bus captive" who value the cost and the flexibility, and the last ones the (5) "Car-lover" and (6) "Multi-task" . This analysis enables a product segmentation and to develop a customer-centered orientation.

Moreover, and through a structural equation modelling tool it was possible to identify Personality and Environment Profiles: P1 (Adventurer and Seeker), P2 (Organizers), P3 (Lone), E1 (Environmental concerned) and E2 (Environmental relaxed). Based on these common characteristics of the population in study, transport players can market to each group effectively and appropriately.

Q2*: Which marketing mix is adequate to influence parents and children in their school commuting?*

In terms of the **Product,** we can conclude that it is necessary to develop transport products adequate to children whose parents work in full time and who live far from the school. Flexible schedules and the possibility to track the children´s trip must be better understood to explain to parents the possibilities to mitigate insecurity and consequently encourage shifting to PT. A possible solution is to develop a Travel Plan in the schools.

As for the **Price**, families assume a willingness to pay 40 euros per month to travel by bus and for a 30 minute trip duration. The Bus Papers´ Prize which was a free month Pass was positively evaluated and could be expanded in further experiments.

In the **Promotion**, the most impactful aspect was the identification of the segments requiring a dedicated task force to shift to PT, namely the parents who work, have a graduate education and more than two cars in the households.

Additionally, the most impactful marketing events were those in which operators went to school and showcased their products and clarified possible doubts about routes, i.e., a proactive and innovative attitude in the market.

As the **Place**, it was relevant to experience the possible routes (through Bus Papers experiences). Through Bus Papers which was like “Learning Public Transport Rallys”, it was required that students visit different locations and consult information about schedules and bus_stops location to move in their municipalities. On the other hand, by the open-ended questions of the surveys we found the importance of the necessary comfort of the bus-stops in the overall transport system.

SQ3. *What positive effect can gamification have on the behavioural and modal choice changes?*

Despite exploring real feedback via field experiment development, namely the Bus Papers and the Traffic Snake Game, these events were not statistically relevant in the modal shift.

A possible explanation for these results is that the number of students was limited in both and hance hampered the detection of an underlying effect pattern. However, the number of participating students in the Bus Papers was experimentally limited by reduced availability of drivers to drive these buses.

Considering that the Traffic Snake Game is designed for Primary schools it was possible to adapt to the grown-up student. Maybe in further experiments, a digital version may

be developed and by enlarging the number the participants in these two events, the results could be more impactful.

SQ4. *How can a targeted marketing mix be developed to leverage public transport systems and make it more attractive to school commuting?*

The Targeted Marketing mix requires a triangle stakeholders' relationship (parents/school/operators) and its development should have the sponsorship of the Municipality and Transports Authority to overcome resource limitations (Buses, drivers, etc).

In developing the marketing strategy, we have to consider the 4 drives: *Product, Price, Promotion* and *Place.* Considering that *Price* is the most difficult to change by operators, since in most countries these are regulated by the Governments, we have the other vectors left to adapt to our objectives.

On the assumption that one size does not fit all, the variables: *Product*, the *Promotion* and *Place* should be analysed together and adapted to the various segments.

Q3*: What is the time delay for behavioural and modal choice changes to occur?*

By implementing *Stimuli* associated with the 4 Ps of Marketing (Product, Price, Place and Promotion), we evaluated the impact of the decision to shift to PT on respondents. The marketing events included Public Debates, Bus Papers, Stands (Product), Free Passes (Price), Traffic Snake Game, Think Tanks (Place) and Transports app (Promotion).

In this impact assessment, the presence/knowledge of parents and children was measured in marketing events, as well as the moment they shifted to PT. The analysis was undertaken using a Hazard Based Duration Model (HBDM), to evaluate the time taken to make their shift to PT. The preliminary studies revealed that to a modal shift towards PT to occur, we should focus on the previous modes before shifting, improving PT system and vehicles, the sociodemographic and also consider *stimuli* related to marketing approach.

Furthermore, the innovative *Transports app* and the *Stands* triggered the most impactful modal shift to PT.

Based on the literature review, it is uncommon for researchers to implement marketing events and evaluate the modal choices changes through a Hazard-based duration model.

There is even less research in school commuting and involving children in the events´ implementation.

Based on our experience, we strongly argue, that the necessary planning to change travel behavior to shift to PT should include marketing techniques as these were proven useful and effective in this regard.

SQ5. *Which is the delay time for each factor of the marketing mix?*

Based on the implementation of Marketing events, there were 210 days to react to a stand of the Operators in an Open Day at the beginning of the School year and 330 days to react to the presentation of a transports´ app.

SQ6. *Which marketing Stimuli has more impact to shift to PT?*

Despite being tested in the field intervention, the reaction to 4 Ps was only significant for the Promotion. No clear results were obtained for the others, but it is clear that modifications in the Product, Price and Place require the involvement of Transport authority, government/Municipality and Operators authorizations and Operations changes. These modifications are beyond a simple intervention as it would be necessary to have the government permission enabling the possible changes.

Although the market is dynamic and the price policy is intervened by the Government or the municipality, we believe that what is proposed here allows being replicated in any municipality, because it consists in the identification of the most relevant TP features (e.g., frequency, reliability, cleanliness, among others) and of how important is the integrated management of the stakeholders involved and the roadmap of activities to be developed to reach the objectives defined for commuting by PT.

Considering the above discussed contributions, it is believed that the final product of this thesis establishes a valuable contribution to the mobility management field through the marketing approach. By leveraging the role of Marketing in PT it becomes easier for PT players to know when and how to stimulate the use of PT.

Besides, the alignment of the methods considered through the assessment of problems and the application of the modelling techniques confer a more robust way of addressing the Marketing issues in PT.

Moreover, the results of the application in three municipalities and different stages of schools (primary, intermediate and secondary) allowed to demonstrate the usefulness of different contexts of the Lisbon Metropolitan Area.

6.3 Transport Policy recommendation

Public transport is in a turning point, where it must find a way to lead the transition from a traditional service moving masses of people to a customized service, i.e., from collective transport to shared mobility. Urban leaders need to make the change from seeing citizens (including the youth segment) as passive users of public services and generators of data on consumption patterns to active participants in shaping the mobility solutions. This behavioural change will certainly create more empowered urban stakeholders.

Another change required in Public operators and transport authorities is to become an urban lifestyle planner and not just a transport service provider. This shift will need leadership to gather the stakeholders in round tables discussions and develop new mobility solutions which respond to public interests, contrary to the traditional policy development and planning which is still carried out in closed environments.

Improving the basic attributes of the mobility journey is a must-have standard to provide a satisfying experience. To tackle this challenge, it is necessary to embody this cultural change within the operators´ company.

Public education represents an important tool to achieve behaviour change. If young people can learn in school and through the media and outreach campaigns about the benefits of sustainable transport, they will be more likely to make sustainable choices in the future. Raising awareness can help translate this awareness into decision making.

From the various moments that the researcher experienced, namely in public debates, Bus Papers and Think Tanks, some insights were gathered that will contribute to the success of its implementation. Therefore, we suggest next pragmatic measures that will reinforce the strategy and the tactics to leverage PT:

- **Detailed information about children and youth**
    - Develop an annual School and leisure commuting Census
- **Communication:**

- Establish a **travel information Centre** which includes self-service information kiosks throughout the city and also an e-mail information service;
- Distribution of redesigned **timetables and maps targeted for youngsters** and other segments);
- Citizens should be approached at key moments in their lives when they change habits to facilitate the modal choice. For example, when they buy a house, kids grow up and in the moment of upgrading in the school level (Primary-> Intermediate school), loss of driving license for infringement, etc.). **These life events enable change in mobility habits** and operators should take advantage of this and define a strategy which included these opportunities to shift to PT.

- **Mobility Plans:**
  - Develop **School Travel Plans** aligned with a global strategy to this segment and enable a coherent vision of sustainable mobility;
  - Develop **Workplace Travel Plans coordinated with School Travel Plans** to encourage more employees (parents) to engage their children to use PT.

- **Authorities´ and Operators´ management:**
  - Reshape mobility jobs by creating the role of **Mobility managers (**working in operators and schools). The mission should be to provide individual travel advice and design tailor-made plans. The suggested disruptive changes to business will have a profound impact on the employment and this role would enable to anticipate future requirements;
  - Citizens should be approached at **key moments** in their lives (buy a house, stage of school change, loss of driving license for infringement, etc.), as it enables to change their mobility habits;
  - Create moments to make **closer and robust relationships between mobility actors** and target solving their daily problems (as considered in this field study);
  - Mobility services by ***SMS*** or ***Whatsapp messages***, as for example when there are disruptions on the service, other **public announcements about traffic, offering timely information** to drivers and PT users (closer relationship with PT users);
  - Organise **training courses for the schools´ mobility manager**;
  - Implementing a **real-time passenger information system** to increase the level of satisfaction;

- Various and **continuous marketing and publicity campaigns** encouraging the public to opt for less polluting and cleaner forms of transport;
- Strength the image of PT through some **unconventional marketing** activities (e.g., musicians, a mobile birthday party when celebrating PT anniversary with the chance to win PT tickets, etc.);
- Mobility services by **SMS**, for example when there are disruptions on the service, other public announcements about traffic, offering timely information to drivers and PT users (closer relationship with PT users);
- Events: developing **innovative products and services** to make people aware of sustainable modes and trigger behaviour change. Examples of events: PT hackathon, parades, shows, the "PT Fridays" campaign (combined tickets "Event+Transport");
- To promote the use of multimodal PT realise the **Eco-point programme** (e.g. loyalty schemes, privileges for holders of an annual transport pass – e.g., CITYPOINTS Cascais[12]);
- Develop games to build interactive traffic training for children (gamification).

- **Schools´ management:**
  - Include sustainable mobility concepts throughout the school **educational and curricular system**;
  - **Partnerships with other institutions** to plant sustainable thinking related to mobility (e.g., Lego, Games´ companies, etc.);
  - Promote **school mobility projects** (in partnership with operators);
  - Create a **youth information mobility centre**.

The research presented in this dissertation also suggests that the urban PT services available in this study should be managed under a common administration to capture and optimize the synergies of the mission of each different transport modes available in the LMA.

All the elements discussed above should be carefully addressed in the case of moving forward with the implementation of the Marketing approach. This may require a **simultaneous creation of conditions to enable successful implementation and be integrated into the transport strategic plan** for the LMA.

[12] https://www.cascais.pt/citypoints

6.4 Future work

Any research about a multidisciplinary subject as complex as this and involving so many players is never complete and there is always room for additional study and discussion. The subject of this dissertation has been on the focus of many researchers in the last decades, with a wide range of backgrounds and different approaches. Despite the efforts to tackle the problem, it is still a challenging issue and prone to further improvements and involvement of schools/operators/families (parents and children).

The dissertation contributed with novel information for the available body of knowledge by analyzing in-depth the school commuting, by addressing mitigation opportunities to the actual unsustainable mobility and by considering the necessary relationship between the stakeholders.

This research encompassed the development of several mathematical tools enlarging their field of application onto the transport analysis research.

The dissertation was built on the available data of the schools from three LMA municipalities involved in the study, which can be perceived as limited in the overall context. This fact can restrict the results reached, due to the possible different realities and contexts between the other municipalities of the country. Yet, we consider that there is no special bias linked to these three municipalities and that the results could be adopted and further tested to any other municipality.

Additional data for different time frames would be an experimental improvement since these interventions and evaluations should be done on longitudinal studies considering that changing habits involves a path that does not conclude in two school years.

Nevertheless, the novel framework developed here can be further used in the future, with the use of more comprehensive datasets, to estimate reliable impacts of the implementation of this innovative marketing approach on the school commuting or even in Mobility in general. This study should be used as a support instrument, empowering operators to have a broader approach to the different possibilities available to gain benefits from applying marketing strategies.

The evaluation of the marketing approach did not include the possible impact on the operator and other context indicators (overall metropolitan mobility) during the intervention, but it could be carried out in future research.

The future in the field, particularly for those pursuing pratical solutions to the PT overall adoption by users, should encompass further research on the use of marketing solutions, considered both from the user and provider points of view. Only such an integrated approach will effectively provide the baseline conditions for a game-changing shift conducive of generalised PT usage.

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Annexes

Annex 1- Survey 1, in Portuguese

Observation: Overall, the nine surveys share the same structure and whereby the only difference between them is “Question no. 16”.

O Transporte público nas Escolas dos Concelhos de Oeiras, Cascais e Sintra da Área Metropolitana de Lisboa

Inquérito

O objetivo deste inquérito é caraterizar as escolhas de mobilidade e transportes dos alunos do 1º, 2º e 3º ciclo e ensino secundário dos Concelhos de Cascais, Oeiras e Sintra. Pretende-se compreender as barreiras e motivações da utilização do transporte público, para melhorar o desenho de políticas de mobilidade.

O inquérito está dividido em 2 seções (1ª para os encarregados de educação; e 2ª para os educandos) com 4 grupos de perguntas:

- Características sociodemográficas;
- Padrões de mobilidade atuais;
- Grau de Satisfação com o Transporte Público; e
- Expetativas futuras quanto à mobilidade.

Este inquérito é realizado no âmbito de uma tese de doutoramento em Sistemas de Transportes, do Departamento de Engenharia Civil e Arquitetura do Instituto Superior Técnico (Universidade de Lisboa).

As respostas são anónimas e os resultados poderão ser divulgados em Conferências, publicações em livros e revistas, e nos meios de comunicação na esfera académica.

A duração estimada para preenchimento do formulário: 15 a 20 minutos.

Para dúvidas ou questões relacionadas com este questionário, envie email para: info.inquerito.escolasOCS@gmail.com

Concordo em participar voluntariamente neste inquérito. Estou ciente do objetivo desta investigação e de que os resultados poderão ser difundidos nos meios de comunicação académicos e de que este questionário é anónimo, não permitindo a identificação dos (as) participantes (não existindo qualquer tratamento de dados pessoais). Se concorda em participar neste inquérito e consente que os seus educandos participem no mesmo, coloque a primeira letra das palavras “Transporte” e “Público” na caixa seguinte:

Nome da Escola

Seção 1ª

1. Para iniciar o inquérito, indique a sua relação com o(s) educando(s), colocando uma X na opção certa:

☐ Mãe/Pai ☐ Encarregada(o) de educação ☐ Avó/Avô ☐Tia/Tio

Outra:

2. Indique por favor a sua idade:

☐ 20 anos ou menos ☐ 20 a 24 anos ☐ 25 a 34 anos

☐ 35 a 44 anos

☐ 45 a 54 anos ☐ 55 a 64 anos ☐ mais 65 anos

3. Género: ☐ Feminino ☐ Masculino

4. Situação laboral:

☐ Trabalhador part-time ☐ Trabalhador full-time ☐ Estudante

☐ Trabalhador /Estudante ☐ Pensionista/Reformado ☐ Doméstico/apoio Familiar

☐ Desempregado ☐ Profissão Liberal

5. Formação:

☐ Ensino básico (até ao 9º ano) ☐ Ensino secundário (até ao 12º ano) ☐ Ensino superior

6. Sobre os seus rendimentos:

☐ Os meus rendimentos permitem-me viver sem dificuldades

☐ Os meus rendimentos permitem-me viver com moderada facilidade

☐ Vivo com dificuldades financeiras

7. Quantos automóveis existem no agregado familiar? ☐ Nenhum

☐ 1 ☐2 ☐3 ☐Mais de 3

8. Código postal da sua residência:

				-			

Caso não saiba o código postal da sua residência indique um ponto de referência

(por exemplo, Centro Comercial das Palmeiras, Oeiras)**:**

9. Filhos: Idade? Género? Ensino Especial?

Filho	Idade (anos)	Género (F/M)	Ensino Especial (S/N)
1			
2			
3			
4			

10. Se respondeu à questão anterior, costuma levar os seus filhos à escola?

☐ Sim ☐ Não

Se respondeu **não** nesta pergunta, ignore as perguntas que se referem às atividades extracurriculares daqui em diante.

11. Costuma levá-los à escola ou às atividades extracurriculares?

Escola: ☐ Sim ☐ Não

Atividades extracurriculares: ☐ Sim ☐ Não

12. Se respondeu sim no transporte à escola, qual o modo que usa regularmente?

☐ Automóvel conduzido por si ☐ Automóvel conduzido por outro

☐ Transporte público ☐ A pé

☐ Outro: _____

13. Se respondeu não, quem os leva?

☐ Vão sozinhos ☐ Pai/mãe ☐ Outro familiar

☐ Pais de colegas ☐ Vizinho(a)

☐ Outro. Quem?

_____

14. Se respondeu sim no transporte às atividades extracurriculares, qual o modo que usa regularmente?

☐ Automóvel conduzido por si ☐ Automóvel conduzido por outro

☐ Transporte público ☐ A pé

☐ Outro: _____

15. Se respondeu não, quem os leva?

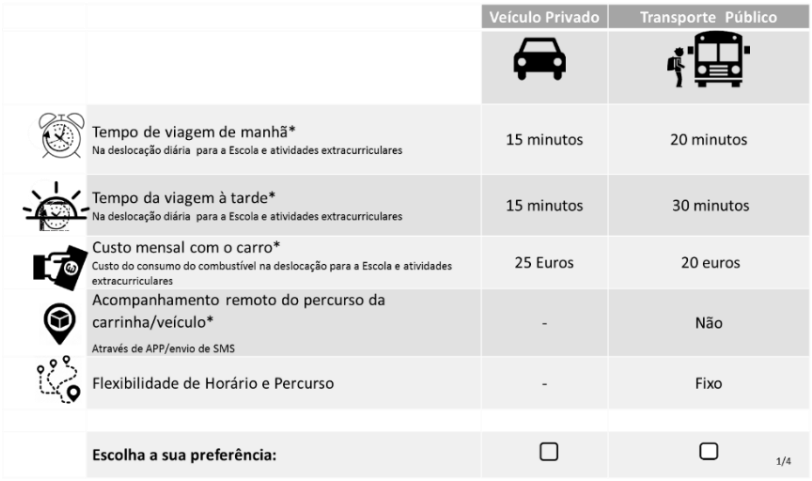
☐ Vão sozinhos ☐ Pai/mãe ☐ Outro familiar

☐ Pais de colegas ☐ Vizinho(a)

☐ Outro:_____

16. Qual das 2 opções das tabelas seguintes escolheria para levar os seus educandos à escola, considerando a rotina semanal e que:

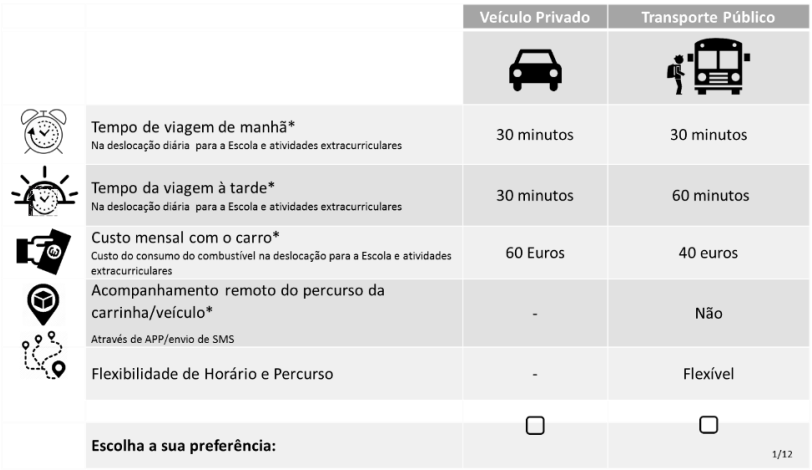
- Os serviços de transporte público podem ter mais flexibilidade de horários e percursos dos autocarros (transporte a pedido);
- Os serviços de transporte público podem ter um sistema de acompanhamento remoto dos veículos enquanto os educandos viajam (nomeadamente, através de APP em *smartphone* ou envio de SMS).



	Veículo Privado	Transporte Público
Tempo de viagem de manhã* Na deslocação diária para a Escola e atividades extracurriculares	15 minutos	20 minutos
Tempo da viagem à tarde* Na deslocação diária para a Escola e atividades extracurriculares	15 minutos	30 minutos
Custo mensal com o carro* Custo do consumo do combustível na deslocação para a Escola e atividades extracurriculares	25 Euros	20 euros
Acompanhamento remoto do percurso da carrinha/veículo* Através de APP/envio de SMS	-	Não
Flexibilidade de Horário e Percurso	-	Fixo
Escolha a sua preferência:	☐	☐

1/4

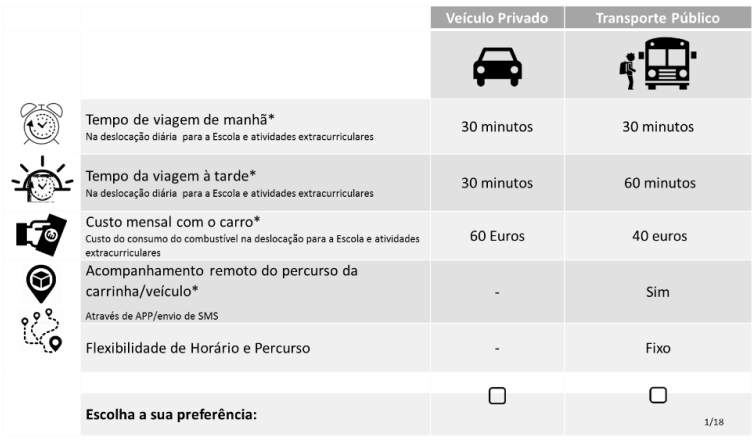
e entre estas duas, qual escolheria ?



	Veículo Privado	Transporte Público
Tempo de viagem de manhã* Na deslocação diária para a Escola e atividades extracurriculares	30 minutos	30 minutos
Tempo da viagem à tarde* Na deslocação diária para a Escola e atividades extracurriculares	30 minutos	60 minutos
Custo mensal com o carro* Custo do consumo do combustível na deslocação para a Escola e atividades extracurriculares	60 Euros	40 euros
Acompanhamento remoto do percurso da carrinha/veículo* Através de APP/envio de SMS	-	Não
Flexibilidade de Horário e Percurso	-	Flexível
Escolha a sua preferência:	☐	☐

1/12

e entre as seguintes, qual escolheria



	Veículo Privado	Transporte Público
Tempo de viagem de manhã* Na deslocação diária para a Escola e atividades extracurriculares	30 minutos	30 minutos
Tempo da viagem à tarde* Na deslocação diária para a Escola e atividades extracurriculares	30 minutos	60 minutos
Custo mensal com o carro* Custo do consumo do combustível na deslocação para a Escola e atividades extracurriculares	60 Euros	40 euros
Acompanhamento remoto do percurso da carrinha/veículo* Através de APP/envio de SMS	-	Sim
Flexibilidade de Horário e Percurso	-	Fixo
Escolha a sua preferência:	☐	☐

1/18

17. Avalie o quão importantes são as seguintes características dos Transportes Públicos, numa escala que varia de 1 a 7, sendo que <u>1 representa "nada importante" e 7 "muito importante"</u> (responda a todos os itens por favor).

	1	2	3	4	5	6	7
1. Frequência	☐	☐	☐	☐	☐	☐	☐
2.Cumprimento Horário	☐	☐	☐	☐	☐	☐	☐
3.Transporte Público deixa-me junto dos locais que quero	☐	☐	☐	☐	☐	☐	☐
4. Sem transbordos ou número reduzido transbordos	☐	☐	☐	☐	☐	☐	☐
5.Tempo de transbordo	☐	☐	☐	☐	☐	☐	☐
6. Duração da viagem no Transporte Público	☐	☐	☐	☐	☐	☐	☐
7. Preço do Bilhete/Passe Mensal	☐	☐	☐	☐	☐	☐	☐
8. Ter lugar sentado	☐	☐	☐	☐	☐	☐	☐
9. Título de transporte (bilhete simples, bilhete recarregável, passe mensal, bilhete em APP no smartphone)	☐	☐	☐	☐	☐	☐	☐
10. Forma de pagamento (no autocarro, no quiosque, através de APP/internet)	☐	☐	☐	☐	☐	☐	☐
11. Boas condições da paragem do Transporte Público	☐	☐	☐	☐	☐	☐	☐
12. Transporte Público não estar lotado	☐	☐	☐	☐	☐	☐	☐
13. Viagem segura, confortável e suave	☐	☐	☐	☐	☐	☐	☐
14. Informação disponível	☐	☐	☐	☐	☐	☐	☐
15.As paragens estão junto a casa/escola	☐	☐	☐	☐	☐	☐	☐
16. Aspeto do autocarro por fora e por dentro	☐	☐	☐	☐	☐	☐	☐
17. Apresentação e interação do motorista com os utentes	☐	☐	☐	☐	☐	☐	☐

18. Ainda relativamente ao Transporte Público, diga qual é o seu nível de satisfação no que respeita a estas características, numa escala que varia de 1 a 7, <u>sendo que 1</u>

representa "nada satisfeito(a)" e 7 representa "muito satisfeito(a)" (responda a todos os itens por favor).

	1	2	3	4	5	6	7
1. Frequência	☐	☐	☐	☐	☐	☐	☐
2.Cumprimento Horário	☐	☐	☐	☐	☐	☐	☐
3.Transporte Público deixa-me junto dos locais que quero	☐	☐	☐	☐	☐	☐	☐
4. Sem transbordos ou número reduzido transbordos	☐	☐	☐	☐	☐	☐	☐
5.Tempo de transbordo	☐	☐	☐	☐	☐	☐	☐
6. Duração da viagem no Transporte Público	☐	☐	☐	☐	☐	☐	☐
7. Preço do Bilhete/Passe Mensal	☐	☐	☐	☐	☐	☐	☐
8. Ter lugar sentado	☐	☐	☐	☐	☐	☐	☐
9. Título de transporte (bilhete simples, bilhete recarregável, passe mensal, bilhete em APP no smartphone)	☐	☐	☐	☐	☐	☐	☐
10. Forma de pagamento (no autocarro, no quiosque, através de APP/internet)	☐	☐	☐	☐	☐	☐	☐
11. Boas condições da paragem do Transporte Público	☐	☐	☐	☐	☐	☐	☐
12. Transporte Público não estar lotado	☐	☐	☐	☐	☐	☐	☐
13. Viagem segura, confortável e suave	☐	☐	☐	☐	☐	☐	☐
14. Informação disponível	☐	☐	☐	☐	☐	☐	☐
15.As paragens estão junto a casa/escola	☐	☐	☐	☐	☐	☐	☐
16. Aspeto do autocarro por fora e por dentro	☐	☐	☐	☐	☐	☐	☐
17. Apresentação e interação do motorista com os utentes	☐	☐	☐	☐	☐	☐	☐

19. Quais são as barreiras que existem para os seus filhos não utilizarem o transporte público? (Indique até 3 razões por ordem decrescente de importância) (Por exemplo: "Não existe transporte público perto de casa ou perto da escola"; "Tenho receio pelos meus filhos"; "O trajeto para a paragem é pouco seguro")

1. _____

2. _____

3. _____

20. Estaria disponível para que os seus filhos fossem para a Escola de transporte público, se algumas das barreiras que enunciou fossem eliminadas? ☐ Sim ☐ Não

21. O modo de pagamento deveria ser diferente do atual?

☐Sim ☐Não ☐Não sei, pois não uso Transporte Público, nem o(s) meu(s) educando(s)

22. Se respondeu sim na questão anterior, que modo de pagamento alternativo proporia?_____

23. As paragens do Transporte Público são suficientes:

Junto a casa?☐Sim ☐Não **Junto à escola?** ☐Sim ☐Não

24. Está satisfeito com as paragens que utiliza?

Qualidade genérica das paragens? **Localização das paragens e inserção no espaço urbano?**

☐Sim ☐Não ☐Sim ☐Não

25. Se respondeu <u>não à questão anterior aplicável</u>, assinale as razões que melhor justificariam a sua resposta da lista seguinte:

Qualidade genérica das paragens: **Localização das paragens e inserção no espaço urbano:**

☐ Falta de iluminação ☐ Sem passeio para aceder à paragem em segurança

☐ Falta de abrigo para chuva, sol, etc. ☐ Demasiado perto da estrada e do tráfego automóvel

☐ Falta de bancos para sentar (demasiada exposição ao risco) ☐ Tráfego a circular com velocidade excessiva

☐ Falta de informação do operador TP na proximidade de paragem ☐ Sem local de atravessamento em segurança

☐ Falta de manutenção ☐ Isolada (por exemplo, longe de cafés, lojas, zonas de lazer, etc.)

☐ Outra. Qual?_____ ☐ Outra. Qual?_____

26. Que paragens de Transporte Público é que estão em falta na sua opinião?
Indique um ponto de referência (por exemplo, "junto à Escola Secundária de Carnide" ou no "Bairro das Torres, perto de casa")

_____
_____

27. Os transportes públicos que usa têm ligações com outros modos de transporte público? ☐Sim ☐Não

28. Costuma estar a par de campanhas relacionadas com Transportes Públicos?

☐Sim ☐Não

29. <u>Se respondeu sim</u> na pergunta anterior, qual (is)?_____

30. Qual o modo de transporte preferido para levar os seus filhos/educandos <u>à Escola</u>? Escolha <u>até 3</u> e ordene por ordem de preferência (em que "1" é o modo mais preferido e "3" é o modo menos preferido).

☐ Automóvel conduzido por si ☐ Automóvel conduzido por outros

☐ Comboio ☐ Autocarro de Transporte Publico

☐ Autocarro da Escola ☐ Autocarro privado e contratado

☐ Bicicleta ☐ Motorizada

☐ A pé ☐ Outro.
Qual?_____

31. Qual o modo de transporte preferido para levar os seus filhos/educandos a atividades extracurriculares? Escolha até 3 e ordene por ordem de preferência.

"1"- o modo mais preferido e "3" o modo menos preferido.

☐ Automóvel conduzido por si ☐ Automóvel conduzido por outros

☐ Comboio ☐ Autocarro de Transporte Publico

☐ Autocarro da Escola ☐ Autocarro privado e contratado

☐ Bicicleta ☐ Motorizada

☐ A pé ☐ Outro.
Qual?_____

32. Que fatores o(a) levariam a mudar de modo atual de transporte? Indique os 3 mais relevantes.

☐ 1. Alteração de rendimento ☐ 6. Alteração de local de residência

☐ 2. Alteração de local de emprego ☐ 7. Os filhos serem autónomos nas suas deslocações para as escolas

☐ 3. Existir mais oferta de Transporte Público ☐ 8. Maior divulgação de oferta de Transporte Público

☐ 4. Mais segurança nos acessos

aos transportes públicos ☐ 9. Não ter estacionamento gratuito no local de trabalho

☐ 5. Não haver estacionamento

junto a transportes públicos

☐ Outro. Qual?_____

33. Ordene as suas escolhas por ordem decrescente de importância: _____

34. Pergunta aos seus filhos/educandos como é que gostariam de ir para escola ou atividades extracurriculares? ☐Sim ☐Não

35. Se respondeu sim na pergunta anterior, a preferência deles alterou a decisão em relação ao modo de transportes para a escola ou atividades extracurriculares?

Para a **escola**: ☐Sim ☐Não

Para as atividades **extracurriculares:** ☐Sim ☐Não

36. O seu círculo de amigos influencia-a(o) nas suas opções do transporte?

Para a **escola:** ☐Sim ☐Não

Para as atividades **extracurriculares:** ☐Sim ☐Não

37. Por favor indique em que medida cada item da tabela seguinte corresponde à sua personalidade, assinalando com uma cruz:

Itens	Sim, sou eu	Um pouco	Não, de todo
Otimista	☐	☐	☐
Aventureiro/a	☐	☐	☐
Gosto de rotinas	☐	☐	☐
Espontâneo/a	☐	☐	☐
Gosto de estar ao ar livre	☐	☐	☐
Gosto de arriscar	☐	☐	☐
Gosto de estar próximo de casa	☐	☐	☐
Eficiente	☐	☐	☐
Gosto de variedade	☐	☐	☐
Pontual	☐	☐	☐
Gosto de estar sozinho/a	☐	☐	☐
Independente	☐	☐	☐
Criativo/a	☐	☐	☐
Paciente	☐	☐	☐
Inquieto/a	☐	☐	☐
Gosto de liderar	☐	☐	☐
Participativo/a	☐	☐	☐
Preguiçoso/a	☐	☐	☐

38. Os problemas ambientais e a sustentabilidade do planeta Terra são uma preocupação presente nas sociedades modernas. Avalie o seu grau de concordância relativamente às seguintes afirmações, numa escala que varia de 1 a 5, sendo que <u>1 representa "Discordo completamente" e 5 representa "Concordo completamente"</u> (responda a todos os itens por favor).

	1	2	3	4	5
1. Estamos a aproximar-nos do **limite do número de pessoas** que a **Terra** pode suportar	☐	☐	☐	☐	☐
2. Os seres humanos têm o **direito de modificar o ambiente natural** de acordo com as suas necessidades	☐	☐	☐	☐	☐
	1	2	3	4	5
3. A interferência **dos seres humanos com a natureza produz frequente consequências desastrosas**	☐	☐	☐	☐	☐

4. O engenho humano assegurará que **não tornamos a terra inabitável**	☐	☐	☐	☐	☐
5. Os seres humanos estão a **usar excessivamente** os recursos ambientais	☐	☐	☐	☐	☐
6. A Terra possui muitos **recursos naturais** na condição de aprendemos a desenvolvê-los	☐	☐	☐	☐	☐
7. As plantas e os animais têm o mesmo direito a existir que os seres humanos	☐	☐	☐	☐	☐
8. O equilíbrio da natureza é suficientemente forte para lidar com os impactos das nações industriais modernas	☐	☐	☐	☐	☐
9. Apesar das nossas competências especiais, os **seres humanos** ainda estão **vulneráveis** às leis da natureza	☐	☐	☐	☐	☐
10. A chamada **"crise ecológica"** que enfrenta a humanidade tem sido muito exagerada	☐	☐	☐	☐	☐
11. A **Terra** é como uma nave espacial com espaço e recursos muito **limitados**	☐	☐	☐	☐	☐
12. Os seres humanos deveriam **dominar** o resto da natureza	☐	☐	☐	☐	☐
13. O **equilíbrio da natureza** é muito delicado e facilmente perturbado	☐	☐	☐	☐	☐
14. Os seres humanos aprenderão o suficiente **sobre como a natureza funciona** para poder controlá-la	☐	☐	☐	☐	☐
15. Se as coisas continuarem o seu curso atual, em breve, acontecerá uma grande **catástrofe ecológica**	☐	☐	☐	☐	☐

39. A utilização de veículos motorizados (combustíveis fósseis) tem impactes ambientais, em particular nas cidades onde a população está mais expostas a estas agressões. Avalie o seu grau de concordância relativamente às seguintes afirmações, numa escala que varia de 1 a 5, <u>sendo que 1 representa "Discordo completamente" e 5 representa "Concordo completamente"</u>:

	1	**2**	**3**	**4**	**5**
1. Reduzir a poluição requer que eu use o carro o menos possível	☐	☐	☐	☐	☐
2. Eu mudo o meu comportamento quando tomo conhecimento do impacto que tem no ambiente	☐	☐	☐	☐	☐
3. Manter a **biodiversidade** significa manter o número e a variedade dos seres vivos	☐	☐	☐	☐	☐
4. Os **meus hábitos** de mobilidade influenciam os hábitos de mobilidade do futuro	☐	☐	☐	☐	☐

40. Pensa nos aspetos de segurança pessoal quando decide a opção de transporte dos seus educandos? ☐Sim ☐Não

Seção 2ª - Cada filho (a)/educando (a) deverá preencher cada uma das colunas seguintes:

	Educando 1	Educando 2	Educando 3	Educando 4	Educando 5
Idade (Anos)					
Género (F/M)					
Ciclo que estudas					
Como te deslocas para a Escola? **1.** Autocarro **2.** Automóvel **3.** Comboio **4.** A pé **5.** Bicicleta **6.** Motorizada **7.** Outro	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐
Gostas de usar Transportes públicos?	☐Sim ☐Não ☐Indiferente	☐Sim ☐Não ☐Indiferente	☐Sim ☐Não ☐Indiferente	☐Sim ☐Não ☐Indiferente	☐Sim ☐Não ☐ Indiferente
Se pudesses mudar de modo de transporte, qual preferias? Se não quiseres mudar, responde nenhum.					
Quando escolhes o transporte para Escola e atividades extracurriculares pensas na poluição/ambiente?	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não
Alguma vez tiveste medo de ir em Transporte Público?	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não
Se tiveste medo. Escolhe a causa: **1.** Enquanto esperava na paragem **2.** Dentro do modo de transporte **3.** No caminho para a paragem próximo de casa ou na paragem próxima da Escola	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
Usa o Transporte Público para as atividades extracurriculares?	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não
A tua opinião conta na escolha do modo de transporte que usas para ir para a Escola?	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não
A tua opinião conta na escolha do modo de transporte que usas para ir para as atividades fora da Escola?	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não

No Transporte Público o que dás mais importância ? (escolhe até 3 pontos): **1.** Autocarro chegar a horas (ser pontual) **2.** Conforto **3.** Segurança **4.** Rapidez nas viagens **5.** Paragens do transporte **6.** Passeios da estrada e acessos às paragens **7.** Funcionários simpáticos **8.** Existir informação na internet e plataformas digitais	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐
Costumas saber de campanhas dos Transportes Públicos?	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não
Gostarias de participar em Jogos, Concursos promovidos pelas empresas de Transportes Públicos?	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não	☐Sim ☐Não
Escreve a primeira letra das palavras "Transportes" e "Público""					

41. Se respondeu sim à pergunta anterior, assinale qual ou quais das circunstâncias seguintes, em que se sentiu inseguro(a)?

☐ No caminho até às paragens ou na espera nas paragens ☐No interior do transporte público

☐Acidente num transporte público ☐Sensação de claustrofobia num modo de transporte

☐Outra experiência passada. Quais (roubos, ataques, acidentes, …)_____

E com que idade ocorreu essa experiência? _____

42. Se faz parte de algum grupo ou participa em algum evento regular, assinale nas opções seguintes:

☐Associação / Organização/Federação

☐Rede social na internet

☐Lista eletrónica de discussão / Fórum online ☐Evento regular

☐Nenhum dos acima mencionados

Fim do Inquérito dos encarregados de educação. Muito obrigada pelo seu contributo e disponibilidade!Se desejar deixar um comentário, por favor utilize a caixa de texto em baixo:

_____

Fim do Inquérito dos educandos. Muito obrigada pelo teu contributo e disponibilidade!

Annex 2- Survey 2, in Portuguese

O transporte público nas Escolas dos Concelhos de Oeiras, Cascais e Sintra da Área Metropolitana de Lisboa

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Inquérito

O objetivo deste inquérito é avaliar que tipo de estímulos podem incentivar os alunos do 1º,2º e 3º ciclo e ensino secundário dos Concelhos de Cascais, Oeiras e Sintra, a recorrer ao Transporte Público. O inquérito está dividido em **2 secções** (**1ª** para os pais/encarregados de educação e **2ª** para os educandos) com **2 grupos de perguntas**:

- Avaliação de eventuais alterações no modo de transporte; e
- Avaliação de eventuais alterações no modo de transporte por reação às acções de *marketing* desenvolvidas com os alunos da escola.

Este inquérito é realizado no âmbito de uma tese de doutoramento em Sistemas de Transportes, do Departamento de Engenharia Civil e Arquitetura do Instituto Superior Técnico (Universidade de Lisboa).

As respostas são anónimas e os resultados poderão ser divulgados em conferências, publicações em livros e revistas científicas, e nos meios de comunicação na esfera académica. Duração estimada para preenchimento do formulário: 10 minutos.

Para dúvidas ou questões relacionadas com este questionário, envie *email* para: info.inquerito.escolasOCS@gmail.com

Concordo em participar voluntariamente neste inquérito. Estou ciente do objetivo desta investigação e de que os resultados poderão ser difundidos nos meios de comunicação académicos e de que este questionário é anónimo, não permitindo a identificação dos (as) participantes (não existindo qualquer tratamento de dados pessoais). Se concorda em participar neste inquérito e consente que os seus educandos participem no mesmo, coloque a primeira letra das palavras "Transporte" e "Público" na caixa seguinte: ☐

Nome da Escola _____

1ª secção: Dirigido aos pais/encarregados de educação

1. Para iniciar o inquérito, indique a sua relação com o(s) educando(s), colocando uma X na opção certa:

☐ Mãe/Pai ☐ Encarregada(o) de educação ☐ Avó/Avô ☐ Tia/Tio ☐ Outra

2. Indique por favor a sua idade:

☐ 20 anos ou menos ☐ 20 a 24 anos ☐ 25 a 34 anos ☐ 35 a 44 anos

☐ 45 a 54 anos ☐ 55 a 64 anos ☐ mais 65 anos

3. Género: ☐ Feminino ☐ Masculino

4. Situação laboral:

☐ Trabalhador *part-time*

☐ Trabalhador *full-time*

☐ Estudante

☐ Trabalhador /Estudante

☐ Pensionista/Reformado

☐ Doméstico/apoio Familiar

☐ Desempregado

☐ Profissão Liberal

5. Formação:

☐ Ensino básico (até ao 9º ano)

☐ Ensino secundário (até ao 12º ano)

☐ Ensino superior

6. Sobre os seus rendimentos:

☐ Os meus rendimentos permitem-me viver sem dificuldades

☐ Os meus rendimentos permitem-me viver com moderada facilidade

☐ Vivo com dificuldades financeiras

7. Quantos automóveis existem no agregado familiar? ☐ Nenhum ☐ 1 ☐2 ☐3

☐Mais de 3

8. Código postal da sua residência (7 dígitos):

<table>
<tr><td>9. Leva os educandos à escola?</td><td colspan="2">Sim ☐ Não ☐</td></tr>
<tr><td rowspan="4">10. Passou a andar de Transportes Públicos, durante os últimos 2 anos letivos dos seus educandos: 2017/2018 ou 2018/2019?</td><td rowspan="4">Sim, em 2017
Sim, em 2018
Sim, em 2019
Não ☐</td><td>Se sim, escolha a opção mais adequada:
Menos de uma vez por semana ☐
1 vez por semana ☐
2 vezes por semana ☐
+ de 3 vezes por semana ☐</td></tr>
<tr><td>Se sim, em que mês fez a alteração?
_____</td></tr>
<tr><td>Causa (s) – Indique apenas as que a(o) fizeram mudar:
<table>
<tr><td>Melhor serviço oferecido☐</td><td>Pior serviço oferecido☐</td></tr>
<tr><td>Preço mais baixo☐</td><td>Preço mais alto☐</td></tr>
<tr><td>Mais divulgação dos serviços oferecidos☐</td><td>Menos divulgação dos serviços oferecidos☐</td></tr>
<tr><td>Campanhas/promoções adequadas☐</td><td>Campanhas/ promoções desadequadas☐</td></tr>
</table></td></tr>
<tr><td>Necessidade
(p.ex., impossibilidade de conduzir ☐</td></tr>
</table>

<table>
<tr><td></td><td></td><td>Outros ☐</td></tr>
<tr><td>11. Se respondeu sim à questão anterior, qual era o modo de transporte que usava nessas deslocações, antes de mudar para os Transportes Públicos?</td><td colspan="2">A pé ☐ Bicicleta ☐ Carro ☐ Outro ☐
Se escolheu “Outro”, indique qual: _____</td></tr>
<tr><td>12. Teve presente em alguma ação de Marketing de Transportes Públicos na Escola?</td><td>Sim ☐ Não ☐</td><td>Se sim, indique a(s) ação(ões) onde esteve presente:
• Debate Público ☐
• Circuitos de Bus Papers ☐
• Passe gratuito como prémio dos Bus Papers ☐
• Jogos de Mobilidade (ex. Serpente Papa Léguas) ☐
• Grupo de Reflexão ☐
• Divulgação de produtos dos operadores de transportes ☐
• Divulgação da App de transportes ☐</td></tr>
<tr><td>13. Teve conhecimento de alguma ação de Marketing de Transportes Públicos na Escola?</td><td>Sim ☐ Não ☐</td><td>Se sim, indique a(s) ação(ões) de que teve conhecimento:
• Debate Público ☐
• Circuitos de Bus Papers ☐
• Passe gratuito como prémio dos Bus Papers ☐
• Jogos de Mobilidade (ex. Serpente Papa Léguas) ☐
• Grupo de Reflexão ☐
• Divulgação de produtos dos operadores de transportes ☐
• Divulgação das rotas dos autocarros na App de transportes ☐</td></tr>
<tr><td>14. Concorda com a afirmação: ”Estas iniciativas alteraram a maneira como avalio os Transportes Públicos”.</td><td colspan="2">Avalie numa escala de 0 a 9, sendo que 0 representa “discordo totalmente” e 9 representa “concordo totalmente”:
<table><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>15. Concorda com a afirmação: “Estas iniciativas poderão alterar no futuro o meu comportamento no sentido de recorrer mais ao Transporte Público”.</td><td colspan="2">Avalie numa escala de 0 a 9, sendo que 0 representa “discordo totalmente” e 9 representa “concordo totalmente”:
<table><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
</table>

16. Existiu alguma outra melhoria nos veículos dos transportes públicos (p.e., autocarros, comboio, outros)?		**Sim**	**Não**	**Não sei**
	Conforto	☐	☐	☐
	Segurança	☐	☐	☐
	Limpeza	☐	☐	☐
	Informação dentro do autocarro	☐	☐	☐
17. Existiu alguma outra melhoria nos serviços de transportes públicos?		**Sim**	**Não**	**Não sei**
	Alteração dos preços dos passes (**Novo Passe**)	☐	☐	☐
	Horários (mais autocarros por hora)	☐	☐	☐
	Pontualidade (chegar a horas)	☐	☐	☐
	Paragem do autocarro (p.e., mais conforto)	☐	☐	☐
	Localização das paragens	☐	☐	☐

<u>2ª secção: Dirigido aos (às) alunos (alunas)</u>

18. Idade (Anos)		
19. Género	Feminino ☐	Masculino ☐
20. Ciclo que estudas	1º ciclo ☐ 2º ciclo ☐ 3º ciclo ☐ ensino secundário ☐	
21. Vais para a escola sem os teus pais/encarregados de educação	Sim ☐ Não	
22. Passaste a andar de Transportes Públicos, nos últimos 2 anos letivos: **2017/2018** ou **2018/2019**?	Sim, em 2017 Sim, em 2018 Sim, em 2019 Não ☐	**Se sim**, escolha a opção mais adequada: Menos de uma vez por semana ☐ 1 vez por semana ☐ 2 vezes por semana ☐ + de 3 vezes por semana ☐
		Se sim, em que **mês** passaste a andar de Transportes Públicos? _____

<table>
<tr><td></td><td></td><td>Causa (s) – Indica apenas as que te fizeram mudar:
<table>
<tr><td>Melhor serviço oferecido ☐</td><td>Pior serviço oferecido ☐</td></tr>
<tr><td>Preço mais baixo ☐</td><td>Preço mais alto ☐</td></tr>
<tr><td>Mais divulgação dos serviços oferecidos ☐</td><td>Menos divulgação dos serviços oferecidos ☐</td></tr>
<tr><td>Campanhas/promoções adequadas ☐</td><td>Campanhas/ promoções desadequadas ☐</td></tr>
<tr><td colspan="2">Necessidade (p.ex, impossibilidadede conduzir) ☐</td></tr>
<tr><td colspan="2">Outros☐</td></tr>
</table></td></tr>
<tr><td colspan="2">23. Se respondeste sim à questão anterior, qual era o modo de transporte em que ias para a escola, antes de mudar para os Transportes Públicos?</td><td>A pé ☐ Bicicleta ☐ Carro ☐ Outro ☐
Se indicaste “Outro”, qual: _____</td></tr>
<tr><td>24. Estiveste presente em alguma ação de Marketing de Transportes Públicos na Escola?</td><td>Sim ☐ Não</td><td>Se sim, indica a(s) ação(ões) onde estiveste presente:
• Debate Público ☐
• Circuitos de Bus Papers ☐
• Passe gratuito como prémio dos Bus Papers ☐
• Jogos de Mobilidade (ex. Serpente Papa Léguas) ☐
• Grupo de Reflexão ☐
• Divulgação de produtos dos operadores de transportes ☐
• Divulgação da App de transportes ☐</td></tr>
<tr><td>25. Tiveste conhecimento de alguma ação de Marketing de Transportes Públicos na Escola?</td><td>Sim ☐ Não</td><td>Se sim, indica a(s) ação(ões) de que tiveste conhecimento:
• Debate Público ☐
• Circuitos de Bus Papers ☐
• Passe gratuito como prémio dos Bus Papers ☐
• Jogos de Mobilidade (ex. Serpente Papa Léguas) ☐
• Grupo de Reflexão ☐
• Divulgação de produtos dos operadores de transportes ☐
• Divulgação das rotas dos autocarros na App de transportes ☐</td></tr>
</table>

26. Concordas com a afirmação: " ***Estas iniciativas alteraram a maneira como avalio os Transportes Públicos*****.**"

Avalia numa escala de 0 a 9, sendo que 0 representa "discordo totalmente" e 9 representa "concordo totalmente":

0	1	2	3	4	5	6	7	8	9

27. Concordas com a afirmação: "***Estas iniciativas poderão alterar no futuro o meu comportamento no sentido de recorrer mais ao Transporte Público.***"

Avalia numa escala de 0 a 9, sendo que 0 representa "discordo totalmente" e 9 representa "concordo totalmente":

0	1	2	3	4	5	6	7	8	9

28. Existiu alguma outra melhoria nos veículos dos transportes públicos (p.e., autocarros, comboio, outros)?

	Sim	**Não**	**Não sei**
Conforto	☐	☐	☐
Segurança	☐	☐	☐
Limpeza	☐	☐	☐
Informação dentro do autocarro	☐	☐	☐

29. Existiu alguma outra melhoria nos serviços de transportes públicos?

	Sim	**Não**	**Não sei**
Alteração dos preços dos passes (**Novo Passe**)	☐	☐	☐
Horários (mais autocarros por hora)	☐	☐	☐
Pontualidade (chegar a horas)	☐	☐	☐
Paragem do autocarro (p.e., mais conforto)	☐	☐	☐
Localização das paragens	☐	☐	☐

Sugestões: _____