LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MASTER

ECONOMICS AND PUBLIC POLICY

MASTER´S FINAL WORK

DISSERTATION

EXPLORING THE DRIVERS OF COMMUTING MODE CHOICE IN LISBON´S METROPOLITAN AREA

ERIC NOVAZALI IBRAHÍMO HABIBO

NOVEMBER - 2020

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SUPERVISION:
PROFESSOR DOCTOR PATRÍCIA C. MELO

NOVEMBER - 2020

“Education is the most powerful weapon which you can use to change the world”

Nelson Mandela

The opportunity of education is a privilege.

I’d like to acknowledge the endowers of my beloved progenitors, to my mum, the greatest women I’ve ever met. To my father, my sister, my brothers and my nanas.

GLOSSARY

AML – Lisbon's Metropolitan Area

AMP - Porto Metropolitan Area

IMoB – Inquérito à Mobilidade nas Áreas Metropolitanas do Porto e de Lisboa, 2017

INE – Portugal National Statistics Office

SPSS – Statistical Product and Service solutions

TRA – Theory of Reasoned Action

ABSTRACT, KEYWORDS AND JEL CODES

This master's final work aims to provide a better understanding of the drivers that influence travel mode choice for commuting trips (i.e., home to work) in Lisbon's Metropolitan Area (AML). It starts by providing a review of the literature and research done in this field of study. It then describes the travel survey implemented in the AML in 2017 (IMob 2017). A descriptive analysis is done for the metropolitan area and for the municipality of Lisbon comparing with the rest of AML. To answer the research question, two regression models are developed – i.e., multinomial, and logistic discrete choice model for different combinations of commuting modes.

The empirical analysis provides us with some insights on the determinants of travel behaviour, in particular commuting mode choice. Travellers prefer active mode (cycling and walking) for shorter trips; higher income individuals tend to commute more by car; Parking conditions at home and at work are the main drivers of the decision to drive a car or an alternative mode to work. Then policy makers should adopt a strategy using a combination of measures, promoting a sustainable urban mobility with an inter-modal reality. For that, they should increase the quality of public transportation, develop a campaign focusing on the benefits of active commute mode – making sure that the infrastructure is safe -, and support parking management.

One important conclusion is that, the travel surveys needs to be conducted on a more regular basis in order to measure the evolution of travel behaviour and its response to changes in public policies. Also, we suggest a reorganization of the survey structure to facilitated studies, creating different sections, and focusing on the individual, instead of having different sections with different statistical units.

KEYWORDS: Mode Choice; Commuting; Travel Survey; Sustainable Mobility; AML; Lisbon.

JEL CODES: O18; C10

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Final recognition goes to my family (and you). Can't thank you enough.

EXPLORING THE DRIVERS OF COMMUTING MODE CHOICE IN LISBON'S METROPOLITAN AREA

By Eric I. Habibo

THIS WORK aims to improve the understanding of the factors influencing travel mode choice in AML for commuting trips. Considering the literature in the field, it explores the influence of the main factors through a descriptive analysis of the most recent travel survey and two travel mode choice regressions. Public policies can promote sustainable mobility more efficiently if they are informed by evidence-based recommendations. Based on the results from the empirical analysis, we conclude that parking management is an important driver of mode choice, especially parking at work; that active mode is preferred to shorter trips and people with higher incomes are more likely to use car.

1. INTRODUCTION

Travel mode choice is a complex process affected by many different factors, including individuals' demographic and socioeconomic characteristics, the type of trip, and, among other factors, the characteristics of the residential and workplace locations. Given the growing importance of promoting sustainable urban mobility, local and regional governments need to have a better understanding of the importance of the various factors affecting travel mode choice.

To monitor travel behaviour and help support the design of evidence-based public policies, many governments fund the implementation of regular national or regional travel surveys. Unfortunately, however, there is no practice of conducting regular travel surveys in Portugal. The main source of information on travel behaviour is the national population census, which collects data on people's homeplace, travel purposes, travel modes and duration of travel. However, the national population censuses are only carried out every 10 years and, since they are not a travel survey, the description of individuals' and households' travel behaviour is very limited.

In 2017, a bespoke travel survey - *Inquérito à Mobilidade nas Áreas Metropolitans de Lisboa e do Porto, IMob 2017* - was conducted by the National Statistics Office (INE) in Portugal's two metropolitan areas: Lisbon Metropolitan Area (AML) and Porto Metropolitan Area (AMP). Despite the limited geographical coverage, this is the best data source available to study travel behaviour.

The goal of this dissertation is to study the main drivers of commuting mode choice in Lisbon Metropolitan Area using data from IMob 2017 and to discuss the implications

for policy making in the context of promoting urban sustainable mobility. According to the population census of 1981, commuting by car represented 12.70% of total trips, and this value increased to 22%, 43%, 54% and 58.9% in 1991, 2001, 2011 and 2017, respectively. In contrast, commuting by public transport decreased from 62% in 1981 to 47%, 34%, 28% and to 15.8% in 1991, 2001, 2011 and 2017, respectively. Until 2017, Trips by walking represented between 15% to 23% and commuting by bicycle or motorcycle had a residual value in all years between 0.9% and 2%. (Costa, 2016) (INE, 1992; INE, 2002; INE, 2013; INE, 2017)

According with the European Union (EU) orientations and from examples of good practices in Europe, policy makers should adopt a strategy using a combination of measures. Improving public transport and implementing an inter-modal transport system, invest in infrastructure for cyclists and pedestrians in order to increase road safety for these users, and develop communication campaigns that focus on the benefits of active modes (Interreg Europe, 2019).

This work focuses on the factors that influence travel mode choice for commuting trips in Lisbon's Metropolitan Area. Some of the findings are in agreement with previous research: for shorter trips, active mode (walking and cycling) is preferred to car or public transportation. A main driver of mode choice is the type of parking at home and at work; people who have free parking at work (provided by the company or by public infrastructure) tend to commute more by car.

The work is divided in six main parts. Following this introduction, Chapter 2 carries out a review of the literature trying to capture the most relevant existing work relevant for the research question. To understand which factors and how to organize the empirical part, several scientific papers were consulted. This part is divided in 5 sub-sections: socio-demographic factors, the built environment and spatial factors, journey characteristics, socio-psychological factors and finally the importance of public policy. The last sub-section is different from the others, instead of referring the factors that influence commute mode choice, it tries to introduce to the mechanisms and tools available to public policy – giving some successful examples as well. Chapter 3 offers a descriptive analysis of the sample from IMob 2017 using both Excel and SPSS. The main goal of this section was to provide an overview of the travel patterns and the factors hypothesized to affect

commute mode choice in the AML and Lisbon municipality Chapter 4 briefly describes the multinomial logistic regression and the binary logistic regression for commuting mode choice, while Chapter 5 discusses the results. Finally, in Chapter 6 we state the conclusions of this work.

2. LITERATURE REVIEW

It is important to understand the factors that influence travel mode choice to guide public policies that can promote sustainable mobility in an effective way (Witte, Hollevoet, Dobruskes, Hubert, & Macharis, 2013). There is abundant research on the determinants of travel mode choice; this chapter provides an overview of the main types of factors that have been studied.

De Witte et al. (2013) proposed three approaches to help understand the complexity underlying travel mode choice: rationalist approach, socio-geographical approach, and socio-psychological approach.

The rationalist approach, which is the mainstream approach, portrays travelers as a *homo economicus* agent comparing the utilities of all alternatives given the information available (i.e. travel time and costs) and choosing the option that maximizes utility. This approach is based on the random utility theory and applies the theory of consumer behavior to urban transportation demand (Domencich & McFadden, 1975). According to this theory, the consumer/traveler ranks the possible alternatives in order of preferences and chooses the one that maximizes his utility, considering relevant constraints (e.g., income).

The socio-geographical approach introduces a spatial dimension into the modal choice process and explains that the demand for travel is a derived demand, that is, the act of travelling is not the end but the means to do something (e.g., go to work, to school, shopping). This approach starts from the activity schedule of individuals or households to explain modal choice.

The socio-psychological approach introduced the study of values and attitudes (intentions and habits) of individuals. It reflects the need to consider subjective factors into travel mode choice. On this matter, Scheiner and Holz-Rau (2007) also underlined the importance of objective and subjective dimensions to explain travel mode choice. According to them, one´s lifestyle perception (the subjective dimensions) – that include behavioral aspects (leisure behavior, consuming behavior, social networks, etc.) – influence travel mode choice, although they also depend on more objective conditions relating to socioeconomic and demographic factors. They conclude that lifestyle plays an

important role by affecting residential location, which in turn influences travel mode choice.

De Witte et al. (2013) reviewed 76 papers and listed 26 determinants of travel behavior. They divided the indicators in four sections: socio-demographic indicators, spatial indicators, journey characteristics and socio-psychological. The following paragraphs describe each type of factors.

2.1. Socio-demographic factors

Ewing and Cervero (2001) recognized in their work - that was focused on built environment - that socioeconomics plays a very important role, in their words "Mode choice depends on both built environment and socioeconomics (although they probably depend more on the latter)".

Socio-demographics generally refers to individual´s age, gender, education, occupation, income, household composition and car ownership. Amongst the indicators mentioned above, income is one of the main determinants of modal choice. Higher income levels tend to be associated with higher rates of car ownership and car use and lower public transport use.

According to De Witte et al. (2013) household composition is also important because larger households, with children, are more likely to have and use the car. Considering other socio-demographic factors such as age, gender, and education, there is no consensus on their impact on travel mode choice. Regarding the role of employers' policies towards mobility, De Witte et al. (2018) concluded that when the employees have a company car or receive compensation for home-to-work transport, they tend to drive regardless of income level or the price of public transport because they can commute by car; likewise, when employers support public transport, employees are more likely to use public transport.

2.2. Built environment and spatial factors

The relationship between the built environment and travel mode choice has been widely studied. According to Ewing and Cervero (2010) there is a strong association

between the built environment and travel mode choice. They characterize the built environment using the "D's" and in the diverse studies they try to explain the importance of each one. (Ewing & Cervero, Travel and Built Environment: A Meta-Analysis, 2010). Cervero and Kockelman (1997) studied the influence of built environment on travel demand in three dimensions using the term "3Ds" for density, diversity, and design. Density is a measure at the variable of interest per unit area, this variable can be "population, dwelling units, employment, building floor area, or something else" (Ewing & Cervero, Travel and Built Environment: A Meta-Analysis, 2010); Diversity refers to the different uses of the land in a given area; Design refers to the characteristics of the street network within an area (Ewing & Cervero, Travel and Built Environment: A Meta-Analysis, 2010). In 1997, Cervero and Kockelman, conclude that the built environment in the area that they studied, had a modest to moderate effect on travel demand.

More recently, the "3Ds" were expanded to include other dimensions affecting travel behavior, namely: destination accessibility that measures ease of access to trip destinations (travel time, distance to major employment or residential neighborhoods); distance to transit that " is usually measured as an average of the shortest street routes from the residences or workplaces in an area to the nearest rail station or bus stop" (Ewing & Cervero, 2010); demand management, including parking supply and cost; and Demographics (the personal and economical characteristics of the population) not being part of built environment, demographics makes the seven D's.

According to the meta-analyses of Ewing and Cervero (2010), whilst the separate effect of built environment factors on mode choice is small, their combined effect can be quite large. They found that destination accessibility is the variable with the strongest effect, followed by design, diversity, and density (Ewing & Cervero, Travel and Built Environment: A Meta-Analysis, 2010).

2.3. Journey characteristics

These factors refer to the elements of the trip, particularly the purpose, time and cost, distance, departure time, trip chaining, information, and interchanges (Witte, Hollevoet, Dobruskes, Hubert, & Macharis, 2013). Travel purpose refers to the reason why the traveler is taking the trip, if it is for commuting, business, or leisure. For instance,

Limtanakool et al. (2006) found in their study that the private car is very prominent for business trips, while train travel is more used in leisure trips than for business trips. Travel distance influences mode choice because faster modes are preferred for longer distance trips. Travel cost is important due to individuals' sensitivity to prices. Departure time flexibility is important too: public transport is less attractive during off-peak, and if trip chaining is complex (i.e. too many activities bundled in the same journey), then the commuter is more likely to choose car. Access to information may also influence mode choice since travelers do not want to spend additional time searching for information, so they will favor modes for which there is less uncertainty about travel times and scheduling (Witte, Hollevoet, Dobruskes, Hubert, & Macharis, 2013).

2.4. Socio-psychological factors

The socio-psychological factors refer to more subjective components, including personal values, preferences, and perceptions about one's lifestyle. According to Scheiner and Holz-Rau (2007), the simple spatial comparisons of travel behavior might lead to wrong conclusions because they ignore individual's values, preferences, and habits. Consequently, researchers started integrating the subjective dimension in transport research by analyzing attitudes and preferences related to residential location and lifestyle. Van Acker et al. (2010) advocate that travel demand is influenced by the perceptions that result of rational choices. That is, individuals, as rational human beings, transform and process the information on a stimulus (issue, object, or person) and according to the Theory of Reasoned Action (TRA) this is called a belief. The sum of all related beliefs determines the attitude towards the stimulus. They give the example of an individual who perceives cycling as healthy, environmentally friendly and thus may adopt a positive attitude toward cycling. Although this will not result necessarily in the use of cycling, it reveals an intention to use the bicycle. So, they argued that intentions are closely related to preferences (Van Acker, Van Wee, & Witlox, 2010). However, there is also evidence suggesting that people may not act in accordance to their pro-environmental values and attitudes (Melo, Ge, Craig, Brewer, & Thronicker, 2018), a phenomenon known in the literature as the pro-environmental value-action gap (Kollmuss & Agyeman, 2002).

2.5. The importance of public policy

Achieving a sustainable development system of transports has become a major policy for many cities. Promoting the use of environmentally friendly modes implies choosing the proper tools. (Ko, Lee, & Byun, 2019).

There are several tools available, Sheepers et al. (2014) categorized them as legal, economic (subsidy, reward system, penalty), communicative (written materials, behavior tools) and physical (providing better bicycle facilities at work, adjustment of environment). In that study most of the reviewed literature showed a positive effect and most of them used more than one tool. Some of the tools used and found to be significance included mass media campaigns (when combined with other tools), rewards (incentives like healthy breakfast/lunch) or penalty systems (increasing parking charges or having to pay a toll fee when entering the city center).

The need to implement a mix of policies is highlighted by Buehler (2016), he suggests that the combination of provision of convenient, safe, and connected walking and cycling infrastructure is the key to promoting active travel. The protection and safety of pedestrians and cyclists are considered a major barrier to active modes. So, infrastructure, including public transports, is a key factor.

There is some evidence of public policies implemented throughout Europe, with noteworthy achievements such as the case of Bicipolitana Pesaro (Italy), where they planned, introduced, and marketed a comprehensive cycle path network (87 km of cycle lanes). In this project the aim was to increase the use of bicycle which they achieved by 50% in two years after the launch. Another good example is the cycling exam established in the Netherlands targeted to children between 8-12 years which reassured parents that their kids' safety and in turn the number of children allowed to travel by bike to school increased by 10%. Also, at the level of spatial planning, the first superblock applied in Barcelona – where the priority is in pedestrians and cyclists, where some are cars authorized to enter but at a speed limit at 10km/h. This measure had also a positive effect in air quality and noise pollution, they complemented this with bike-sharing scheme and parking spots moved off street. (Interreg Europe, 2019)

The report from Interreg Europe – a European Union platform – recommends public policies to invest in public transportation – as a way of promoting multi-modal transport – invest in infrastructure for bike lanes and pedestrian crossings, always with safety in mind, urban planning (superblock example), and in communication (focusing on the benefits of changing to active mode of transport).

Furthermore, the recent advance of smart mobility technologies is also likely to accelerate the shift of urban mobility paradigm towards more sustainable and actives modes, whilst also making the mobility system more complex because of the new actors, networks, and technologies (Dochery, Marsden, & Anable, 2018).

3. DATA AND DESCRIPTIVE STATISTICS

3.1 The Travel Survey IMoB 2017

The empirical analyses use data from IMob 2017, a one-off travel survey carried out by INE in 2017 in the metropolitan areas of Porto and Lisbon. The survey adopted Eurostat Guidelines to provide comparable EU-harmonized statistics (INE, 2017). IMob 2017 is structured in seven sections: 1 – Residence information; 2 – Household size and members information (e.g. age, gender, education, occupation) ; 3 – Vehicles available; 4 – Characterization of the household members travel mobility (e.g. travel distance, travel time, mode of transport); 5 – Daily Trips (destination, mode of transportation, purpose); 6 – Expenses regarding transportation (fuel cost, parking cost, cost of public transportation and tolls) and income information; 7 – Opinions about private and public transportation regarding quality, comfort, security, accessibility, duration and information. Consequently, the survey provides information for different types of statistical units, namely: households, individuals, vehicles, and trips.

We focus on individual commuting trips - i.e., home-to-work trips -, and the variables discussed in the literature review as potential factors influencing travel mode choice. The survey methodology is such that only one respondent per household is selected. This individual must then respond all question that refer to his behaviour and the behaviour of the remaining members of the household – the respondent was choose by the family, being the two conditions satisfied: 18 years old or more, knowledge and contact with every members of the household. This can lead to some measurement error in the responses pertaining to the remaining members of the household. To minimize the impact of this potential source of bias, we decided to focus only on the sample of main respondents (i.e., one per household). The downside of this approach is that we use a considerably smaller sample in our analyses.

We focus on the data concerning the AML. The AML is constituted by 18 municipalities: Alcochete, Almada, Amadora, Barreiro, Cascais, Lisboa, Loures, Mafra, Moita, Montijo, Odivelas, Oeiras, Palmela, Seixal, Sesimbra, Setúbal, Sintra and Vila Franca de Xira. In 2016, the AML had approximately 2.8 million inhabitants, which is around 27% of Portugal´s population. In fig.1 we can see the Lisbon's Metropolitan Area and its system of transport.

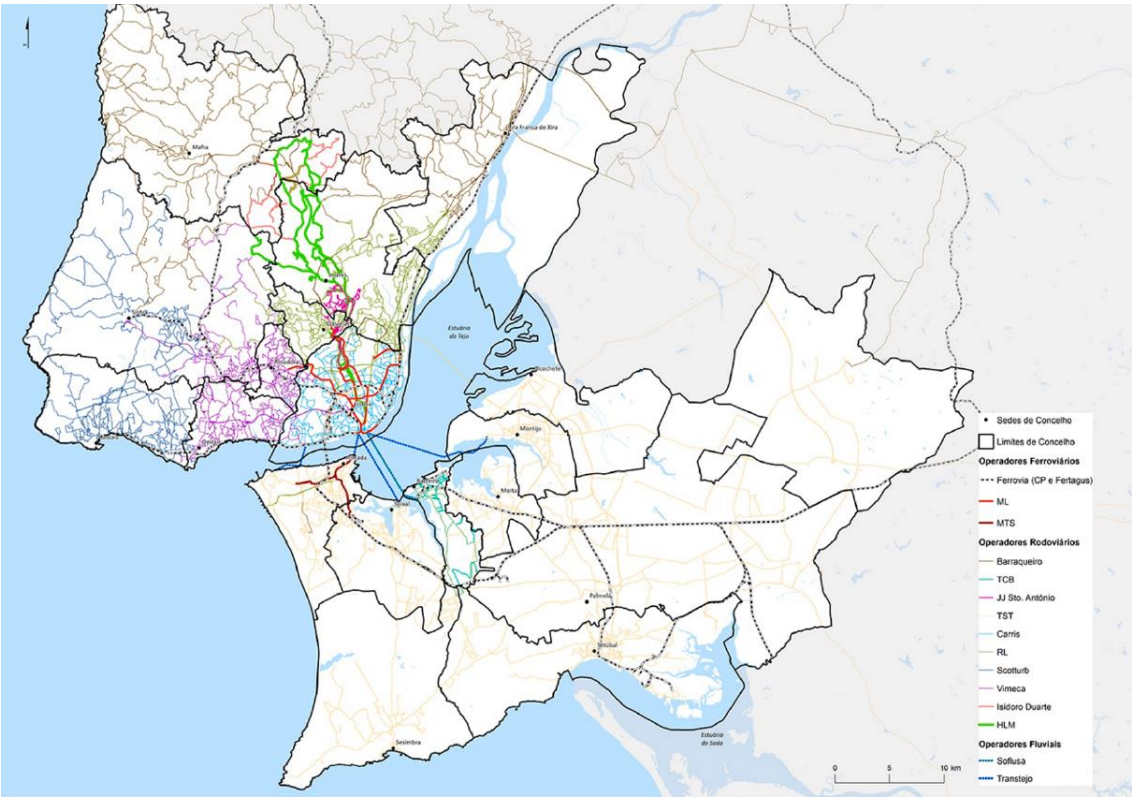


Fig. 1 – Transport system of Lisbon's Metropolitan Area

Source: (Melo, Sobreira, & Goulart, 2019)

As stated above, the focus of this study is on the individual commuting mode choice. From the initial sample of 62 712 individuals, we applied several restrictions to obtain the working sample suitable for our analyses. The first restriction was to keep only the main respondent per household. Since we are interested in commuting trips only, we excluded all the respondents who did not have a paid work occupation. Amongst those individuals with an occupation, we kept only those who do not work from home and those whose work does not require constant travel. In addition, we also had to perform several validity tests on the set of variables referring to individual and trip characteristics. The final sample comprises 8 074 individuals.

Table 1 provides a summary of the sample for the set of explanatory variables to be used in the empirical analyses. Regarding household characteristics we consider the household size and the number of children. We also included the parking conditions at home and at work, and considered commuting modal shares by different groups of travel distance. About 82.2% of the individuals have free parking at home and a majority of

60.2% has free parking at the workplace. A great share of our sample travels 11 or more kilometers to go to work, and almost half have income between 1000 and 2600 euros per month.

Table 1 - Explanatory Variables

Explanatory Variables			Overall Sample (n=8074)			
			n	mean	%	SD
Household Characteristics	Number of people		8074	2.54		1.251
	Number of Children			1.43		0.603
	Parking Conditions	Public/Free	6639		82%	
		Private or Payed	492		6.10%	
		Other/Not applied	943		11.70%	
Socio-Demographic	Gender	Female	3910		48.40%	
		Male	4164		51.80%	
	Age	15-24	204		2.50%	
		25-44	3546		43.90%	
		45-64	4140		51.30%	
		65-84	182		2.30%	
		>= 85	2		0.02%	
	Education	Less than college dregree	3723		46.10%	
		College degree or higher	4328		53.60%	
		Refuses to answer or other	23		0.30%	
Travel Characteristics	Distance	0 - 2999	1566		19.40%	
		3000 - 5999	1305		16.20%	
		6000 - 10999	1734		21.50%	
		11 and higher	3469		43%	
	Parking Conditions at work	Public/Free	4864		60.20%	
		Private or Payed	678		8.40%	
		Other/Not applied	2532		31.40%	
Socio-Economic	Household Income	[0;430[	55		0.70%	
		[430;600[	323		4%	
		[600;1000[	1090		13.50%	
		[1000;1500[	1774		22%	
		[1500;2600[	2577		31.90%	
		[2600;3600[	1026		12.70%	
		[3600;5700[	567		7%	
		[5700;7000[	110		1.40%	
		7000 and more	121		1.50%	

3.2 Overview of commuting patterns in AML

To analyze commuting mode share we re-grouped the original variable in the survey to have the categories showed in table 2. We combined *Bus* and *Coach*, and created a new category *other* (i.e., aviation, van/lorry/tractor/camper, Táxi (as passenger) and others). As we can see in the table, the main commuting mode is *Passenger Car – as driver* with 56.8%, followed by *Bus and Coach* representing 11.2 % and *walking* with 9.9%, respectively. Commuting by *Regular Train* and *Urban rail* (i.e., metro) accounts for 7.0% and 5.5% of trips, respectively. Cycling only accounts for 0.7% of commuting trips.

TABLE II

FREQUENCY OF COMMUTE MODE CHOICE

Commute mode	Frequency	Percent (%)
Bus and Coach	902	11.2 %
Cycling	54	0.7 %
Motorcycle and moped	209	2.6 %
Others	78	1 %
Passenger car - as driver	4586	56.8 %
Passenger car - as passenger	396	4.9 %
Regular train	566	7 %
Urban rail	446	5.5 %
Walking	797	9.9 %
Waterways	40	0.5 %
Total	8074	100 %

3.2.1 Mode shares by commuting distances

Given that mode choice is likely to differ according to travel distance, and the fact that for short(er) urban commutes, active transport can be a very efficient mode of transport, table 3 shows the modal share of commuting trips by travel distance. We considered four groups of distance: less than 3 km; 3 to 5 999 km, 6 to 10 999 km, 11 km

and more. As we can see, *Passenger car – as driver* continues to represent more than half of the trips, but it can also be observed that the longer the trips, the more likely the individual is to use the car, i.e., 36%, 58.3%, 60.7%, and 63.6%, respectively. *Walking* is the main mode for the shorter trips with a share of 45.2%. *Regular train* is mainly used for the longest commuting trips. Cycling accounts for a tiny fraction of trips, regardless of the distance (but the ratio of trips by bike for the shorter trips is twice the size of the ratio for the other longer distances). In our sample, 43% of the trips belong to the long-distance group.

TABLE III

COMMUTE MODE*DISTANCE

		Distance (km)				
		0-2.999	3.000-5.999	6.000-10.999	11.000 and more	Total
commute mode	Bus and coach	136 (8.7%)	225 (17%)	238 (13.7%)	303 (8.7%)	902
	Cycling	22 (1%)	6 (0.5%)	10 (0.6%)	16 (0.5%)	54
	Motorcycle and moped	59 (4%)	71 (5%)	78 (5%)	188 (5.4%)	396
	Others	8 (0.5%)	17 (1%)	9 (0.5%)	44 (1.3%)	78
	Passenger car - as driver	565 (36.1%)	761 (58.3%)	1053 (60.7%)	2207 (63.6%)	4586
	Passenger car - as passenger	59 (4%)	71 (5%)	78 (4.5%)	188 (5.4%)	396
	Train	7 (0.4%)	21 (2%)	82 (4.7%)	456 (13.1%)	566
	Urban rail (metro)	42 (2.7%)	121 (9%)	181 (10.4%)	102 (2.9%)	446
	Walking	708 (45.2%)	49 (4%)	33 (1.9%)	7 (0.2%)	797
	Waterways	1 (0.1%)	5 (0.4%)	6 (0.3%)	28 (0.8%)	40
	Total	1566 (100%)	1305 (100%)	1734 (100%)	3469 (100%)	8074
% Trips by the distance		19%	16%	21%	43%	100%

3.2.2 Preliminary analysis of the relation between individual and household characteristics and commuting mode shares

It is interesting to consider the relation between commuting mode and individual and household characteristics, as reported in Tables A. II to A.IV of the appendices. When a family has 4 children, 67% of respondents indicated they use car to commute. Regarding the level of education, people with higher academic degree have a larger share for commuting by car (62%), while people with lower academic degree (less than bachelor's degree) have a higher share for commuting by Bus and Coach, and Walking.

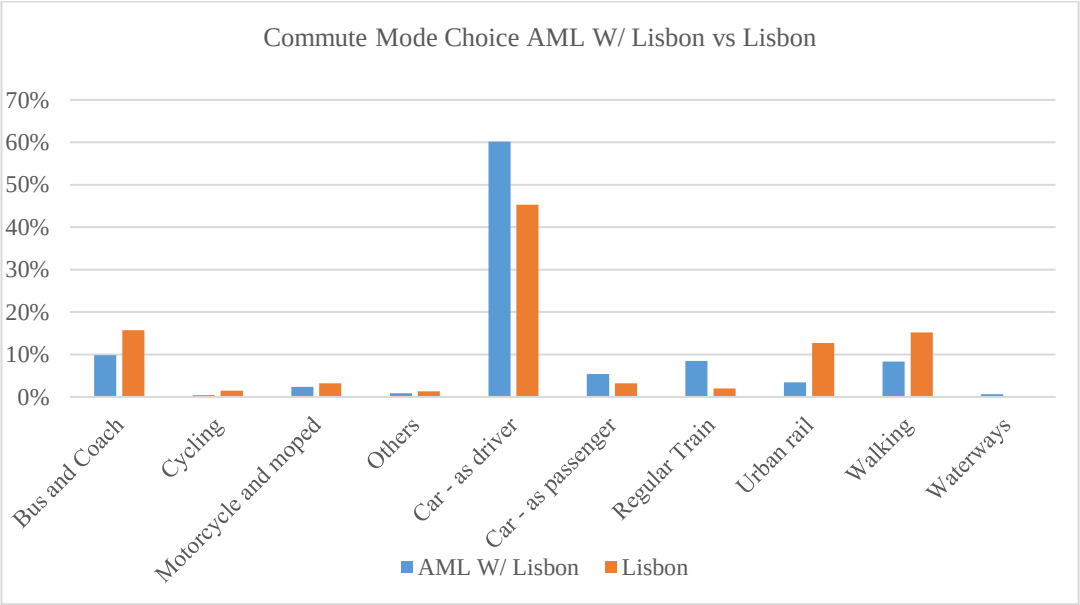
Regarding the level of income – table A.IV -, we can see some tendencies that individuals that earn less income (from 600€ up until 1000, and less than 600€) tend to commute more by bus and coach, 18% and 22%, respectively. Also, for the two lower levels of income, the share of commuting by regular train is around 9%, and by walking (15% and 11% respectively). Comparatively, people who have higher wages – more than 3600 € - have a share of commuting by car as driver around 75%.

It can also be observed in table A.IV that the conditions of parking in households' residence influence commute mode. Individuals who have free parking (private garage / city permit or free on-street parking), have higher shares of commuting by car as driver (69% and 61% respectively). These frequencies fall to 44% and 50% when parking is not free. This suggests that the cost of parking may affect car use. Looking at the availability of parking at work, we can see that when parking is provided for free, free on-street parking or by the company, almost 80% of the individuals commute by car. When parking is paid, car use falls: if provided at reduced cost, the share reduces do 58%; for normal prices, the sample is too small to make any conclusions.

3.2.3 Comparing Lisbon with other municipalities of the AML

It is interesting to compare Lisbon with the rest of the metropolitan area, both in terms of commuting mode shares and the potential explanatory variables affecting mode choice. The sample size is 1818 individuals for Lisbon and 6256 for the rest of the AML. Tables A.I; A.V to A.XII in the Appendix give an overview of the main points discussed here, AML without Lisbon vs Lisbon. There was also an intention to analyze and compare

the mode choice in every different municipality of the metropolitan area, but the sample sizes are become very small.



Graphic 1 – Commute Mode Choice in AML without Lisbon vs Lisbon

With respect to commuting mode shares, the percentage of car as a driver is bigger outside of Lisbon (60.2% to 45.3%) which is very significant. We can also see that in Lisbon people tend to use more sustainable and active modes: *Walking* represents 15.2% in Lisbon and 8.3% in the rest of AML, also *Bus and Coach* 15.7% (in Lisbon) to 9.8% (outside) and *urban rail* 12.7% to 3.5%.

One variable that might justify the type of mode choice is the distance of the trip. Commuting trips outside Lisbon tend to have more medium and long-distances, whilst in Lisbon half of the trips are less than 6 km and only 19% trips are 11000 km or above. If we look at Lisbon, most trips by walking are in the shorter trips, also in medium trips, they tend to use bus or urban rail. An interesting fact is that outside Lisbon, for trips longer than 11000 km, commuting by regular train represents 14%, which is larger than the average (8%) for this area.

As for the number of children in the household, in areas outside Lisbon families with 4 children and more have a share of commuting by car of 68% – table A.VI. People who live in Lisbon have higher degrees of education (75% with bachelor's degree or

higher) when comparing to the rest of AML (52% with bachelor's degree or higher). Also, people with higher degree tend to commute more by car outside Lisbon– Table A.VII.

Looking to the level of income (Tables A.VIII and A.IX), the first obvious conclusion is that people who live in Lisbon have a higher level of income (18% earn more than 3600 euros in Lisbon while 8% earn more than 3600 euros outside Lisbon). Another conclusion is that people who earn less than 600 euros have a share of 11% of commuting as car driver - for those who live in Lisbon – and 40% for those who live outside. Those who live outside Lisbon and earn more than 5700 euros have a share of 84% of commuting by car as driver. For those who earn less than 1000 euros, the shares of commuting by *Bus and Coach*, *Urban rail*, *Regular train*, for those who live outside Lisbon, are higher than for those who earn more than 1000 euros. In Lisbon, *Walking* has a bigger share of commuting for those who earn more less than 1000 euros, when comparing to those who earn more than 1000 euros.

The parking availability at the residence – Table A.X - has some impact too. Outside Lisbon, households that have free parking in their building/house commute 71% by car and people who must pay parking in their residency tend to use more other ways of commuting, such as walking indicated by the bigger share when the parking is paid at normal costs outside of Lisbon (25%) and in Lisbon (32%).

If we look to the parking availability at work – Tables A.XI and A.XII -, 79% and 80% of those who have free on-street parking and free parking provided by the employer, respectively, commute by car as driver, in the rest of AML. In Lisbon, 73 % and 79% of those who have free on-street parking and free parking provided by the employer, respectively, commute by car as driver. For those outside Lisbon, 86% of those who have parking paid at lower prices commute by car. Car driving shares decrease in both areas when the parking at work is paid.

4. REGRESSION MODELS FOR COMMUTE MODE CHOICE

To identify the relative importance of the different factors affecting mode choice, we developed two econometric models using the sample described above. Some filters and merges were applied to the explanatory variables, excluding categories with very few observations. The final sample used in the regressions is 7353 individuals.

The first model consists of a multinomial logistic regression because the dependent variable - commute mode - is categorical with more than two categories and with no order. With the purpose of having a more accurate model, commute mode has now 3 categories: 1 – *Car* (driver plus passenger); 2 – *Public Transportation* (includes Train, Urban rail, Bus and coach, Waterways); 3 - *Active mode* (which includes Walking and Cycling). Ideally, we would have liked to separate walking from cycling, as well as some of the public transport modes, but the small number of cases did not allow for this. The regression model is presented in equations 1 and 2.

(1) $y_i^{(m)} = \beta^{(m)\prime} x_i + \varepsilon_i^{(m)}$

(2) $P(Y_i = m|x_i, \varepsilon_i) = \frac{\exp\{y_i^{(m)}\}}{1+\sum_{l=2}^{M} \exp\{y_i^{(l)}\}}$

The *y* stands for the dependent variable with *m* = 1,2 … M represents the mode choice category (Car, Public Transportation and Active Mode), *I* = 1,2,…,*n* denotes the individual that answered. $\beta^{(m)}$ is the parameter that will be estimated to understand the relationship between the explanatory covariates and how they affect commute mode choice. The reference category of the dependent variable (mode choice) is m=3, the active mode. $\varepsilon_i^{(m)}$ is a vector of random errors that represent unobserved heterogeneity.

The logit model for the binary choice car vs non-car is given below:

(3) $y_i^{(mc)} = \beta^{(mc)\prime} x_i + \varepsilon_i^{(mc)}$

(4) $P(Y_i = 1|Xi = x_i) = \frac{\exp\{y_i^{(1)}\}}{1+\exp\{y_i^{(l)}\}}$

In equations 3 and 4, *y* stands for the dependent variable with *mc* = 0,1 representing the mode choice category (Car as Driver, No Car Driver), *I* = 1,2,…,*n* denotes the individual that answered. For the logistic regression mc= 0 (no car driver) is the reference category. The rest is the same as above.

5. Results and Discussion

The results obtained for the multinomial and the logistic regressions are presented in table IV and table V, respectively. Both the multinomial and the binary regressions have a McFadden Pseudo R-Square of 0.4, suggesting a good overall model fit. We also analyzed the potential for multicollinearity by inspecting correlations between the explanatory variables (see table A13 of the appendices).

The reference mode in the multinomial model is active travel (walking, cycling), compared to car and public transport. The output and relevant results are presented in Table IV. For the interpretation of the statistical significance of the variables, the reference was significance at 5%, thus only variables that have P-value smaller than 0.05 are considered significant. The meaning of Exp(B) (the odds ratio) in this case is, for example, an individual who has free parking at work relatively to an individual who has to pay, the relative probability of the individual to commute by car compared to active mode is expected to increase by a factor of 2.213, everything else remaining constant.

Comparing car to active mode, we can see that the number of children and age do not appear to be significant drivers of mode choice. In contrast, education, commuting distance, income, parking at work and at home all seem to be significant drivers of mode choice.

Regarding education, people with less education are less likely to commute by car then people with higher education. This makes sense since people with higher education may tend to earn more, and in the descriptive analysis we saw that people with higher income commute more by car – which is corroborated in the model, people with lower income tend to commute less by car compared to active mode than with higher income.

Regarding distance, we can see that the relative probability of an individual to choose car over active mode, decreases while the distance increases compared to longer distance, which is reasonable, because active modes are competitive only for shorter trips.

Looking at parking at work, there is evidence that people who have free on-street public parking or free parking provided by their employer are more likely to commute by car compared to active mode, compared to people who have to pay for parking at work.

According to the results, this is the explanatory variable that influences commuting mode choice the most. Also, we find a similar result for parking conditions at home, that is, thus people who have free parking at home are more likely to commute by car.

We now consider the results for commuting by public transport in relation to commuting by active mode. In this case, the explanatory variables that do not seem to affect mode choice are the number of children, age, education, income and parking at home and at work[1]. In this case, only travel distance seems to affect the choice of commuting mode. We can see that the probability of choosing public transport over active mode increases while the distance increases, which is reasonable.

5.1 Multinomial regression estimation

TABLE IV

MULTINOMIAL REGRESSION FOR COMMUTE MODE CHOICE

		Multinomial Regression			
Commute mode		Car		Public Transport	
		(Reference Category is Active mode)			
		Sig.	Exp(B)	Sig.	Exp(B)
Number of Children (Reference 3 or more)	1	0.498	1.186	0.541	1.178
	2	0.469	1.207	0.438	1.239
Age (Reference 65 to 84)	15 to 24	0.712	0.847	0.884	1.066
	24 to 44	0.430	0.771	0.217	0.66
	45 to 64	0.612	0.848	0.313	0.716
Education (Reference College Degree or higher)	Refuses to answer	0.287	1.143	0.948	1.009
	Less than College Degree	0.036	1.377	0.561	1.096
Distance (Reference 11000 and higher)	0 to 2999	0.000	0.012	0.000	0.006
	3000 to 5999	0.000	0.174	0.000	0.154
	6000 to 10999	0.000	0.316	0.000	0.276
Parking Conditions at work (Reference Paid)	Not applicable	0.000	0.221	0.031	1.612
	Public/Free	0.000	2.213	0.156	0.729

[1] The cases with "not applicable" are not worthy to interpretate in the case of home parking. The survey only asks this to households that have vehicles and there were a number of households that did not answer this question; for parking at work, there were some cases where people did not match to any of the options available.

Parking Conditions at home (Reference Paid)	Not applicable	0.08	0.66	0.004	1.896
	Public/Free	0.000	2.067	0.2	1.280
Income (Reference 2600 and more)	[0;600[	0.02	0.552	0.482	0.834
	[600;1000[	0.000	0.409	0.291	0.809
	[1000;1500[	0.011	0.655	0.351	1.182
	[1500;2600[	0.075	0.757	0.578	1.099
Overall Sample		7353			
Pseudo R-Square McFadden		0.4			

5.2 Binary logistic Regression

The reference mode in the logistic regression refers to commuting by modes other than the private car (i.e. not driving to work). The output and relevant results are presented in Table V. Compared to the multinomial regression, the level of statistical significance is smaller. We did not find a significant effect for the number of children, age, and education.

Parking at work is also a strong driver of commuting mode choice, promoting driving to work. Similarly, having free parking at home relatively to paid parking, increases the relative probability of commuting by car. Regarding distance, there is evidence that for shorter trips (less than 3 km), individuals are less likely by car than y alternative modes (i.e. public transport and active mode). Income level also has some significance: for an individual who earns [1500;2600[euros relatively to an individual earning more than 2600, the relatively probability to commute by car is expected to increase by a factor of 1.502, everything else remaining the same, which is a surprise because it indicates they are more likely to commute by car than the people with higher income. However, overall, we do not find strong evidence for income in this model.

TABLE V

BINARY LOGISTIC REGRESSION FOR CAR DRIVER

		Binary Logistic Regression	
Commute mode		Car as driver	
		(Reference Category is Not Driving)	
		Sig.	Exp(B)
Number of Children (Reference 3 or more)	1	0.676	1.067
	2	0.879	0.976
Age (Reference 65 to 84)	15 to 24	0.128	0.621
	24 to 44	0.819	0.949
	45 to 64	0.983	0.995
Education (Reference College Degree or higher)	Refuses to answer	0.002	1.275
	Less than College Degree	0.233	1.125
Distance (Reference 11000 and higher)	0 to 2999	0.000	0.339
	3000 to 5999	0.637	0.957
	6000 to 10999	0.216	1.112
Parking Conditions at work (Reference Paid)	Not applicable	0.000	0.365
	Public/Free	0.000	1.737
Parking Conditions at home (Reference Paid)	Not applicable	0.000	0.12
	Public/Free	0.000	2.626
Income (Reference 2600 and more)	[0;600[	0.394	0.855
	[600;1000[	0.661	0.925
	[1000;1500[	0.726	1.063
	[1500;2600[	0.027	1.502
Overall Sample		7353	
Pseudo R-Square McFadden		0.4	

6. CONCLUSION

This dissertation aims to provide a better understanding of the drivers that influence travel mode choice for commuting trips in Lisbon's Metropolitan Area. Our findings indicate that for shorter trips, active mode (walking and cycling) is preferred to car or public transportation. This gives us a lead that, if there are suitable conditions, people will prefer these more healthy and sustainable modes of transport (essentially in short trips).

Promoting sustainable urban mobility is a challenge for the local and regional governments. The literature suggests that Public policies can promote sustainable mobility more efficiently if they are informed by evidence-based recommendation.

The main driver of mode choice in both regressions was the parking conditions at work. It seems obvious that having free parking at work is favourable to driving to work. Free parking at the workplace can be provided by the municipality in the form of free on-street parking or by the employer. It was not possible to distinguish between the two in our study, and future research should evaluate the impact of both measures separately. In terms of public policy, this suggests that parking management is a very important instrument to achieve modal shift away from the car. As concluded by De Witte et. (2018), the policy of employers is very important, and policy makers must regulate not only on-street parking but also off-street private parking in order to reduce car use. The same conclusion can be extended to parking conditions at home. The results indicate that the people who had free parking at home are more likely to commute by car.

Our main recommendation is that local authorities should develop integrated Sustainable Urban Mobility Plans (SUMPs), and make parking management one of the key ingredients of these plans. But parking management is a very polemic and unpopular topic for politicians because people tend to oppose to having parking supply reduced and to paying for parking.

It is important to carried more often this kind of survey, census does not provide enough information to access the impact of public policies. Also, the survey itself should be organized in a different way. It should be organized by groups of drivers, for instance: Socio-Demographic section; Spatial factors section; Journey Characteristics section; Socio-Psychological Section, and always focused on the individual. This reorganization of the survey will enable more studies in this area. One of the examples of limitation is

the fact that parking conditions in the residence is conditional to a statistical unit of vehicle, thus people that do not have vehicle do not answer to this question. The same goes to parking at work, although with less impact, one of the options is “don’t use car”.

This survey provides a lot of information that can be studied. A limitation of this work is that – because of time limitation – did not focus on the characteristics of the built environment in the households and at work. Future researched should include the built environment throw a creation of new variables, like density. Also, there are other important information in the survey as the perception that people have of public transportation and why they use them; why they should commute in a solo mode. Exploring this area could give us more information about the traveler and consequently more accurate public policy.

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APPENDICES

TABLE A.I

COMMUTE MODE CHOICE AML, AML WITHOUT LISBON AND LISBON

		AML		AML without Lisbon		Lisbon	
		Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Commute Mode	Bus and Coach	902	11.2%	616	9.8%	286	15.70%
	Cycling	54	0.7%	27	0%	27	1.50%
	motorcycle and moped	209	2.6%	150	2.4%	59	3.20%
	Others	78	1.0%	55	0.9%	23	1.30%
	passenger car - as driver	4586	56.8%	3763	60.2%	823	45.30%
	passenger car - as passenger	396	4.9%	338	5.4%	58	3.20%
	Regular train	566	7.0%	530	8.5%	36	2%
	Urban rail	446	5.5%	216	3.5%	230	12.70%
	Walking	797	9.9%	521	8.3%	276	15.20%
	Waterways	40	0.5%	40	0.6%	0	0%
	Total	8074	100%	6256	100%	1818	100%

TABLE A.II

COMMUTE MODE*DISTANCE, NUMBER OF CHILDREN AND LEVEL OF EDUCATION IN AML

		Distance (km)				Number of Children				Level of education			
		0-2,999	3,000-5,999	6,000-10,999	11.000+	1	2	3	4	Less than College Degree	College degree or higher	Refuses to answer or other	Total
Commute mode	Bus and coach	136 (8.7%)	225 (17%)	238 (13.7%)	303 (8.7%)	564 (11%)	297 (11%)	37 (11%)	4 (10%)	571 (15%)	328 (8%)	3 (13%)	902
	Cycling	22 (1%)	6 (0.5%)	10 (0.6%)	16 (0.5%)	35 (1%)	16 (1%)	3 (1%)	0 (0%)	19 (1%)	35 (1%)	0 (0%)	54
	Motorcycle and moped	59 (4%)	71 (5%)	78 (5%)	188 (5.4%)	119 (2%)	83 (3%)	7 (2%)	0 (0%)	81 (2%)	126 (3%)	2 (9%)	209
	Others	8 (0.5%)	17 (1%)	9 (0.5%)	44 (1.3%)	49 (1%)	25 (1%)	4 (1%)	0 (0%)	35 (1%)	43 (1%)	0 (0%)	78
	Passenger car - as driver	565 (36.1%)	761 (58%)	1053 (60.7%)	2207 (63.6%)	2856 (7%)	1517 (57%)	187 (58%)	26 (67%)	1910 (51%)	2668 (62%)	8 (35%)	4586
	Passenger car - as passenger	59 (4%)	71 (5%)	78 (4.5%)	188 (5.4%)	236 (5%)	142 (5%)	18 (6%)	0 (0%)	218 (6%)	176 (4%)	2 (9%)	396
	Regular train	7 (0.4%)	21 (2%)	82 (4.7%)	456 (13.1%)	370 (7%)	167 (6%)	27 (8%)	2 (5%)	279 (7%)	283 (7%)	4 (17%)	566
	Urban rail	42 (2.7%)	121 (9%)	181 (10.4%)	102 (2.9%)	276 (5%)	156 (6%)	12 (4%)	2 (5%)	149 (4%)	296 (7%)	1 (4%)	446
	Walking	708 (45.2%)	49 (4%)	33 (1.9%)	7 (0.2%)	503 (10%)	260 (10%)	29 (9%)	5 (13%)	436 (12%)	358 (8%)	3 (13%)	797
	Waterways	1 (0.1%)	5 (0.4%)	6 (0.3%)	28 (0.8%)	27 (1%)	12 (0.4%)	1 (0.3%)	0 (0%)	25 (1%)	15 (0.3%)	0 (0%)	40
	Total	1566	1305	1734	3469	5035	2675	325	39	3723	4328	23	8074

TABLE A.III

COMMUTE MODE * INCOME AML

		Level of Income (euros)							
		5700 and more	[3600;5700[	[2600;3600[	[1500;2600[	[1000;1500[	[600;1000[	[0;600[	Total
Commute mode	Bus and coach	12 (5%)	20 (4%)	56 (5%)	232 (9%)	254 (14%)	196 (18%)	82 (22%)	902
	Cycling	0 (0%)	3 (1%)	10 (1%)	10 (0.4%)	12 (1%)	15 (1%)	1 (0,3%)	54
	Motorcycle and moped	7 (3%)	20 (4%)	45 (4%)	79 (3%)	29 (2%)	16 (1%)	4 (1%)	209
	Others	4 (2%)	6 (1%)	9 (1%)	20 (0.8%)	12 (1%)	19 (2%)	0 (0%)	78
	Passenger car - as driver	177 (77%)	423 (75%)	672 (65%)	1555 (60.3%)	924 (52%)	458 (42%)	130 (34%)	4586
	Passenger car - as passenger	4 (2%)	26 (5%)	46 (4%)	141 (5.5%)	91 (5%)	42 (4%)	19 (5%)	396
	Regular train	5 (2%)	22 (4%)	57 (6%)	171 (6.6%)	153 (9%)	97 (9%)	35 (9%)	566
	Urban rail	6 (3%)	19 (3%)	63 (6%)	147 (5.7%)	96 (5%)	76 (7%)	24 (6%)	446
	Walking	15 (6%)	27 (5%)	66	206 (8%)	194 (11%)	163 (15%)	80 (1%)	797
	Waterways	0 (0%)	1 (0.2%)	2 (0.2%)	16 (0.6%)	9 (1%)	8 (1%)	3 (1%)	40
	Total	231	567	1026	2577	1774	1090	378	8074
	% Trips by income	3%	7%	13%	32%	22%	14%	5%	100%

TABLE A.IV

COMMUTE MODE * PARKING AT RESIDENCE AND AT WORK AML

		Parking at Residence					Parking at Work							
		Free	Public Free	Paid Private	Paid	Missing*	Public Free	Work Free	Paid	Parking low prices	Others	Does not Drive	Does not Applies	Total
Commute mode	Bus and coach	142 (5%)	377 (10%)	44 (10%)	1 (3%)	338	76 (3%)	84 (3%)	41 (8%)	7 (4%)	12 (8%)	2 (29%)	624 (26%)	902
	Cycling	14 (1%)	21 (21%)	8 (2%)	1 (3%)	10	6 (0.3%)	9 (0.3%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)	39 (2%)	54
	Motorcycle and moped	95 (4%)	90 (2%)	10 (2%)	0 (0%)	14	43 (2%)	87 (3%)	12 (2%)	7 (4%)	4 (3%)	0 (0%)	60 (3%)	209
	Others	21 (1%)	40 (1%)	4 (1%)	2 (5%)	11	19 (1%)	23 (1%)	5 (1%)	1 (1%)	3 (2%)	1 (14%)	30 (1%)	78
	Passenger car - as driver	1880 (69%)	2391 (61%)	201 (44%)	19 (50%)	95	1767 (78%)	2073 (80%)	284 (59%)	143 (74%)	92 (58%)	0 (0%)	319 (13%)	4586
	Passenger car - as passenger	133 (5%)	199 (5%)	22 (5%)	2 (5%)	40	93 (4%)	106 (4%)	26 (5%)	9 (5%)	28 (18%)	0 (0%)	162 (7%)	396
	Regular train	148 (5%)	289 (7%)	16 (4%)	1 (3%)	112	79 (3%)	70 (3%)	44 (9%)	2 (1%)	5 (3%)	1 (14%)	371 (16%)	566
	Urban rail	102 (4%)	165 (4%)	57 (13%)	1 (3%)	121	40 (2%)	39 (2%)	40 (8%)	2 (1%)	5 (3%)	0 (0%)	325 (14%)	446
	Walking	162 (6%)	338 (9%)	91 (20%)	11 (29%)	195	140 (6%)	101 (4%)	31 (6%)	21 (11%)	9 (6%)	3 (43%)	504 (21%)	797
	Waterways	15 (1%)	17 (0,4%)	1 (0,2%)	0 (0%)	7	3 (0.1%)	6 (0.2%)	3 (1%)	0 (0%)	0 (0%)	0 (0%)	28 (1%)	40
	Total	2712	3927	454	38	943	2266	2598	486	192	159	7	2366	8074
	%Trips for Parking at Residence	34%	49%	6%	0.5%	11.7%	28.1%	32.2%	6.0%	2.4%	2.0%	0.1%	29.3%	100%

*The missing values are a mix of people who did not answer (the ones who have car) and people who do not have car.

TABLE A.V - COMMUTE MODE * DISTANCE IN AML WITHOUT LISBON AND IN LISBON

		Distance (kms)									
		0-2,999		3,000-5,999		6,000-10,999		10.999 and +		Total	
		AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon
Commute mode	Bus and coach	88 (8%)	48 (10%)	118 (14%)	107 (23%)	139 (12%)	99 (18%)	271 (9%)	32 (9%)	616	286
	Cycling	2 (0.2%)	20 (4%)	6 (0.7%)	0 (0%)	3 (0.3%)	7 (1%)	16 (0.5%)	0 (0%)	27	27
	Motorcycle and moped	7 (1%)	11 (2%)	12 (1%)	17 (4%)	22 (2%)	22 (4%)	109 (3%)	9 (3%)	150	59
	Others	6 (1%)	2 (0.4%)	8 (1%)	9 (1.9%)	4 (0.3%)	5 (0.9%)	37 (1%)	7 (2%)	55	23
	Passenger car - as driver	460 (42%)	105 (22%)	569 (68%)	192 (41%)	786 (66%)	267 (50%)	1948 (62%)	259 (76%)	3763	823
	Passenger car - as passenger	45 (4%)	14 (3%)	52 (6%)	19 (4%)	63 (5%)	15 (3%)	178 (6%)	10 (3%)	338	58
	Regular train	7 (0.6%)	0 (0%)	15 (2%)	6 (1%)	62 (5%)	20 (4%)	446 (14.3%)	10 (3%)	530	36
	Urban rail	15 (1%)	27 (6%)	27 (3%)	94 (20%)	84 (7%)	97 (18%)	90 (3%)	12 (4%)	216	230
	Walking	459 (42%)	249 (52%)	30 (4%)	19 (4%)	26 (2%)	7 (1%)	6 (0.2%)	1 (0.3%)	521	276
	Waterways	1 (0.1%)	0 (0%)	5 (0.6%)	0 (0%)	6 (0.5%)	0 (0%)	28 (0.9%)	0 (0%)	40	0
	Total	1090	476	842	463	1195	539	3129	340	6256	1818
	%Trips by distance	17.40%	26%	13.5%	25%	19.1%	30%	50.0%	19%	100%	100%

TABLE A.VI - COMMUTE MODE * NUMBER OF CHILDREN AML WITHOUT LISBON AND IN LISBON

		Number of Children									
		1		2		3		4 and more		Total	
		AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon
Commute Mode	Bus and coach	386 (10%)	178 (16%)	203 (10%)	94 (15%)	23 (10%)	14 (15%)	4 (12%)	0 (0%)	616	286
	Cycling	22 (1%)	13 (1%)	5 (0.2%)	11 (2%)	0 (0%)	3 (3%)	0 (0%)	0 (0%)	27	27
	Motorcycle and moped	90 (2%)	29 (3%)	57 (3%)	26 (4%)	3 (1%)	4 (4%)	0 (0%)	0 (0%)	150	59
	Others	31 (1%)	18 (2%)	21 (1%)	4 (1%)	3 (1%)	1 (1%)	0 (0%)	0 (0%)	55	23
	Passenger car - as driver	2350 (60%)	506 (47%)	1251 (61%)	266 (42%)	139 (60%)	48 (51%)	23 (68%)	3 (60%)	3763	823
	Passenger car - as passenger	203 (5%)	33 (3%)	120 (6%)	22 (3%)	15 (7%)	3 (3%)	0 (0%)	0 (0%)	338	58
	Regular train	352 (9%)	18 (2%)	151 (7%)	16 (3%)	25 (11%)	2 (2%)	2 (6%)	0 (0%)	530	36
	Urban rail	142 (4%)	134 (12%)	67 (3%)	89 (14%)	5 (2%)	7 (7%)	2 (6%)	0 (0%)	216	230
	Walking	344 (9%)	159 (15%)	158 (8%)	102 (16%)	16 (7%)	13 (14%)	3 (9%)	2 (40%)	521	276
	Waterways	27 (1%)	0 (0%)	12 (1%)	0 (0%)	1 (0.4%)	0 (0%)	0 (0%)	0 (0%)	40	0
	Total	3947	1088	2045	630	230	95	34	5	6256	1818
	% Trips by Nr Children	63.1%	60%	32.7%	35%	3.7%	5%	0.5%	0.3%	100.0%	100.0%

TABLE A.VII

COMMUTE MODE * EDUCATION IN AML WITHOUT LISBON AND IN LISBON

		Education							
		Less than College Degree		College degree or higher		Refuses to answer or other		Total	
		AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon
Commute Mode	Bus and coach	449 (14%)	122 (27%)	165 (6%)	163 (12%)	2 (11%)	1 (25%)	616	286
	Cycling	13 (0.4%)	6 (1%)	14 (0.5%)	21 (2%)	0 (0%)	0 (0%)	27	27
	Motorcycle and moped	69 (2%)	12 (3%)	79 (3%)	47 (3%)	2 (11%)	0 (0%)	150	59
	Others	30 (1%)	5 (1%)	25 (1%)	18 (1%)	0 (0%)	0 (0%)	55	23
	Passenger car - as driver	1771 (54%)	139 (31%)	1985 (67%)	683 (50%)	7 (37%)	1 (25%)	3763	823
	Passenger car - as passenger	204 (6%)	14 (3%)	132 (4%)	44 (3%)	2 (11%)	0 (0%)	338	58
	Regular train	272 (8%)	7 (2%)	254 (9%)	29 (2%)	4 (21%)	0 (0%)	530	36
	Urban rail	102 (3%)	47 (10%)	114 (4%)	182 (13%)	0 (0%)	1 (25%)	216	230
	Walking	338 (10%)	98 (22%)	181 (6%)	177 (13%)	2 (11%)	1 (25%)	521	276
	Waterways	25 (1%)	0 (0%)	15 (1%)	0 (0%)	0 (0%)	0 (0%)	40	40
	Total	3273	450	2964	1364	19	4	6256	1818
	%Trips by Education	52.3%	25%	47.4%	75%	0.3%	0%	100%	100%

TABLE A.VIII

COMMUTE MODE * INCOME (EUROS) - AML WITHOUT LISBON

		Level of Income (euros)								
		5700 and more	[3600;5700[	[2600;3600[	[1500;2600[	[1000;1500[	[600;1000[	[0;600[	No answer	Total
Commute mode	Bus and coach	3 (2%)	11 (3%)	37 (5%)	150 (7%)	183 (13%)	142 (16%)	59 (19%)	32 (8%)	616
	Cycling	0 (0%)	1 (0.3%)	4 (1%)	4 (0.2%)	8 (1%)	8 (1%)	1 (0.3%)	1 (0.2%)	27
	Motorcycle and moped	2 (2%)	10 (3%)	34 (4%)	61 (3%)	22 (2%)	10 (1%)	3 (1%)	9 (2%)	150
	Others	2 (2%)	3 (1%)	7 (1%)	13 (1%)	8 (1%)	16 (2%)	0 (0%)	7 (2%)	55
	Passenger car - as driver	110 (84%)	270 (78%)	529 (69%)	1313 (64%)	814 (56%)	405 (46%)	122 (40%)	259 (63%)	3763
	Passenger car - as passenger	2 (2%)	17 (5%)	39 (5%)	117 (6%)	83 (6%)	39 (4%)	19 (6%)	24 (6%)	338
	Regular train	4 (3%)	19 (6%)	56 (7%)	162 (8%)	144 (10%)	88 (10%)	32 (10%)	27 (7%)	530
	Urban rail	3 (2%)	4 (1%)	22 (3%)	70 (3%)	53 (4%)	45 (5%)	14 (5%)	6 (1%)	216
	Walking	5 (4%)	9 (3%)	32 (4%)	133 (7%)	129 (9%)	125 (14%)	54 (18%)	37 (9%)	521
	Waterways	0 (0%)	1 (0.3%)	2 (0.3%)	16 (1%)	9 (1%)	8 (1%)	3 (1%)	1 (0.2%)	40
	Total	131	345	762	2039	1453	886	307	410	6256
	%Trips by level of Income	2.1%	5.5%	12.2%	32.6%	23.2%	14.2%	4.9%	6.6%	100.0%

TABLE A.IX

COMMUTE MODE * INCOME (EUROS) IN LISBON

		Level of Income (euros)								
		5700 and more	[3600;5700[	[2600;3600[	[1500;2600[	[1000;1500[	[600;1000[	[0;600[	No answer	Total
Commute mode	Bus and coach	9 (9%)	9 (4%)	19 (7%)	82 (15%)	71 (22%)	54 (26%)	23 (32%)	19 (19%)	286
	Cycling	1 (%)	2 (1%)	6 (2%)	6 (1%)	4 (1%)	7 (3%)	0 (0%)	1 (1%)	27
	Motorcycle and moped	5 (5%)	10 (5%)	11 (4%)	18 (3%)	7 (2%)	6 (3%)	1 (1%)	1 (1%)	59
	Others	2 (2%)	3 (1%)	2 (1%)	7 (1%)	4 (1%)	3 (1%)	0 (0%)	2 (2%)	23
	Passenger car - as driver	67 (67%)	153 (69%)	143 (54%)	242 (45%)	110 (34%)	53 (26%)	8 (11%)	47 (48%)	823
	Passenger car - as passenger	2 (2%)	9 (4%)	7 (3%)	24 (4%)	8 (2%)	3 (1%)	0 (0%)	5 (5%)	58
	Regular train	1 (1%)	3 (1%)	1 (0.4%)	9 (2%)	9 (3%)	9 (4%)	3 (4%)	1 (1%)	36
	Urban rail	3 (3%)	15 (7%)	41 (16%)	77 (14%)	43 (13%)	31 (15%)	10 (14%)	10 (10%)	230
	Walking	10 (10%)	18 (8%)	34 (13%)	73 (14%)	65 (20%)	38 (19%)	26 (37%)	12 (12%)	276
	Waterways	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
	Total	100	222	264	538	321	204	71	98	1818
	%Trips by level of income	5.5%	12.2%	14.5%	29.6%	17.7%	11.2%	3.9%	5.4%	95%

TABLE A.X

COMMUTE MODE * PARKING AT RESIDENCE - AML WITHOUT LISBON AND IN LISBON

		Parking at Residence											
		Free		Public Free		Paid Private		Paid		Missing*		Total	
		AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon	AML W/ Lisbon	Lisbon
Commute Mode	Bus and coach	107 (5%)	35 (6%)	280 (8%)	97 (17%)	9 (8%)	35 (10%)	1 (6%)	0 (0%)	219	119 (38%)	616	286
	Cycling	7 (0.3%)	7 (1%)	14 (0.4%)	7 (1%)	2 (2%)	6 (2%)	0 (0%)	1 (5%)	4	6 (2%)	27	27
	Motorcycle and moped	72 (3%)	23 (4%)	72 (2%)	18 (3%)	0 (0%)	10 (3%)	0 (0%)	0 (0%)	6	8 (3%)	150	59
	Others	18 (1%)	3 (1%)	28 (1%)	12 (2%)	1 (1%)	3 (1%)	1(6%)	1 (5%)	7	4 (1%)	55	23
	Passenger car - as driver	1531 (71%)	349 (63%)	2096 (63%)	295 (51%)	58 (54%)	143 (41%)	7 (44%)	12 (55%)	71	24 (8%)	3763	823
	Passenger car - as passenger	116 (5%)	17 (3%)	179 (5%)	20 (3%)	7 (7%)	15 ($%)	2 (13%)	0 (0%)	34	6 (2%)	338	58
	Regular train	140 (6%)	8 (1%)	279 (8%)	10 (2%)	11 (10%)	5 (1%)	1 (6%)	0 (0%)	99	13 (4%)	530	36
	Urban rail	46 (2%)	56 (10%)	110 (3%)	55 (9%)	7 (7%)	50 (14%)	0 (0%)	1 (5%)	53	68 (22%)	216	230
	Walking	107 (5%)	55 (10%)	268 (8%)	70 (12%)	11 (10%)	80 (23%)	4 (25%)	7 (32%)	131	64 (21%)	521	276
	Waterways	15 (1%)	0 (0%)	17 (1%)	0 (0%)	1 (1%)	0 (0%)	0 (0%)	0 (0%)	7	0 (0%)	40	0
	Total	2159	553	3343	584	107	347	16	22	631	312	6256	1818
	%Trips by Parking	34.5%	30.4%	53.4%	32.1%	1.7%	19.1%	0.3%	1.2%	10.1%	17.2%	100.0%	100.0%

*The missing values are a mix of people who did not answer (the ones who have car) and people who do not have car.

TABLE A.XI

COMMUTE MODE * PARKING AT WORK AML WITHOUT LISBON

		Parking at Work							
		Public Free	Work Free	Parking paid	Paid low price	Others	Does not Drive	Does not Applies	Total
Commute Choice	Bus and coach	60 (3%)	66 (3%)	22 (7%)	3 (2%)	4 (4%)	1 (20%)	460 (28%)	616
	Cycling	3 (0.2%)	6 (0.3%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)	17 (1%)	27
	Motorcycle and moped	28 (1%)	69 (3%)	6 (2%)	4 (3%)	3 (3%)	0 (0%)	40 (2%)	150
	Others	18 (1%)	17 (1%)	1 (0.3%)	1 (1%)	3 (3%)	0 (0%)	15 (1%)	55
	Passenger car - as driver	1545 (79%)	1644 (80%)	209 (63%)	105 (86%)	60 (55%)	0 (0%)	200 (12%)	3763
	Passenger car - as passenger	85 (4%)	92 (4%)	20 (6%)	3 (2%)	23 (21%)	0 (0%)	115 (7%)	338
	Regular train	73 (4%)	68 (3%)	42 (13%)	2 (2%)	5 (5%)	1 (20%)	339 (20%)	530
	Urban rail	27 (1%)	19 (1%)	16 (5%)	1 (1%)	4 (4%)	0 (0%)	149 (9%)	216
	Walking	118 (6%)	66 (3%)	14 (4%)	3 (2%)	6 (6%)	3 (60%)	311 (19%)	521
	Waterways	3 (0.2%)	6 (0.3%)	3 (1%)	0	0	0 (0%)	28 (2%)	40
	Total	1960	2053	333	122	109	5	1674	6256
	%Trips by Parking at work	31%	33%	5%	2%	2%	0.1%	26.8%	100%

TABLE A.XII

COMMUTE MODE * PARKING AT WORK IN LISBON

		Parking at Work							
		Public Free	Work Free	Parking paid	Paid low price	Others	Does not Drive	Does not Applies	Total
Commute Mode	Bus and coach	16 (5%)	18 (3%)	19 (12%)	4 (6%)	8 (16%)	1 (50%)	220 (32%)	286
	Cycling	3 (1%)	3 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	21 (3%)	27
	Motorcycle and moped	15 (5%)	18 (3%)	6 (4%)	3 (4%)	1 (2%)	0 (0%)	16 (2%)	59
	Others	1 (0.3%)	6 (1%)	4 (3%)	0 (0%)	0 (0%)	1 (50%)	11 (2%)	23
	Passenger car - as driver	222 (73%)	429 (79%)	75 (49%)	38 (54%)	32 (64%)	0 (0%)	27 (4%)	823
	Passenger car - as passenger	8 (3%)	14 (3%)	6 (4%)	6 (9%)	5 (10%)	0 (0%)	19 (3%)	58
	Regular train	6 (2%)	2 (0.4%)	2 (1%)	0 (0%)	0 (0%)	0 (0%)	26 (4%)	36
	Urban rail	13 (4%)	20 (4%)	24 (16%)	1 (1%)	1 (2%)	0 (0%)	171 (25%)	230
	Walking	22 (7%)	35 (6%)	17 (11%)	18 (26%)	3 (6%)	0 (0%)	181 (26%)	276
	Waterways	0(0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
	Total	306	545	153	70	50	2	692	1818
	%Trips by Parking at Work	17%	30%	8%	4%	3%	0%	38%	100%

TABLE A.XIII

COLLINEARITY STATISTICS

	Multinomial Regression		Binary Logistic Regression	
	Tolerance	VIF	Tolerance	VIF
Age	0.972	1.028	0.972	1.028
Education	0.905	1.106	0.905	1.106
Distance	0.962	1.039	0.962	1.039
Income	0.810	1.234	0.810	1.234
Parking at Work	0.883	1.133	0.883	1.133
Parking at Home	0.859	1.163	0.859	1.163
Income	0.810	1.234	0.810	1.234
Number of Children	0.996	1.004	0.996	1.004
Distance	0.962	1.039	0.962	1.039

a. Dependent Variable: Vehicle Regression