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Urban mobility strategies in Portuguese District Capitals

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Dedication

Life is like a great train ride, filled with carriages, where it slowly goes away, as such is always worth waiting for and catching the right train. Here ended a demanding stage of my life, full of challenges, work and many uncertainties.

Achieving this dream is a full personal satisfaction, given that many obstacles I had to circumvent, long lost for the sake of writing this dissertation.

However, I cannot forget the people who helped me and motivated me along this work and thus realize this dream: to complete the master's degree in economics.

To my family for the availability and understanding throughout this year full of hard work.

To my best friend, André Campos, for all the motivation, advices, concern and for having been with me in all the stages and challenges that this dissertation has put me. I also dedicate this victory, to my Professor António Marques, for the help, patience, incentives and excellent guidance in the elaboration of the present project.

Without this unconditional support, none of this would be possible and this dissertation would not be fulfilled.

To all of them, I will be eternally grateful.

Acknowledgements

When we decide to write a master's thesis is a huge challenge in our life, a great walk we have to go through, filled by countless obstacles that we are forced to circumvent, a walk with some sorrows, displeasure, challenges and uncertainties, but as Thomas Edison said, "Our greatest weakness is in giving up. The right way to win is to try again."

The choice of the theme "Urban mobility strategies in the Portuguese district capitals", was not easy and was aware of the difficulty that would be in building something unique in that only with contacts and knowledge in various places would be possible. I often thought of giving up, I thought I could never move on with my idea, which was only possible with the energy, the strength and enthusiasm of several people who were crucial in this stage and to whom I dedicate this dissertation.

A special thanks to my professor António Marques, who conscious of my abilities always believed that it would be possible to conclude my dissertation. An orientation marked by a high level of demand and professionalism, following step by step, always with a well delineated vision and with well-defined tasks.

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"Persistence is the path of Success" – Charles Chaplin

Resumo

O elevado uso do automóvel nas deslocações diárias e a falta de uma rede de transportes eficaz continua a ser um problema nas cidades. O transporte público apresenta problemas em termos de cobertura nas cidades menos povoadas e problemas de capacidade e eficácia nas cidades mais povoadas. O planeamento da mobilidade ainda não está a ser feito de modo descentralizado, o que incentiva ás deslocações diárias através de um veículo particular, provocando efeitos negativos na qualidade de vida dos cidadãos e do ambiente. As cidades portuguesas ainda não estão preparadas para uma mobilidade e acessibilidade a todos, então urge fazer um planemanento da mesma, promovendo uma mobilidade mais sustentável.

A luta contra o congestionamento é um desafio constante, por isso as cidades estão a dar os primeiros passos no transporte inteligente inserido no contexto "smart cities". A frota de autocarros existente em portugal tem uma idade média consideravelmente elevada, trazendo consequências negativas para os utilizadores e ambiente, precisando por isso, de ser renovada. É urgente pensar noutros tipos de mobilidade e ver a aposta na mobilidade elétrica e sistemas partilhados como solução de futuro. A mobilidade elétrica tem crecido de forma acentuada em portugal, com a colocacão de postos de carregamento e com a introdução de autocarros elétricos em circulação.

A presente dissertação teórico-prática incide no estudo das redes de transportes existentes nas capitais de distrito portuguesas, analisando a sua frota de autocarros e tudo o que lhe é adjacente. Também incide no estudo das estratégias de mobilidade sustentável que as cidades têm vindo a tomar.

Keywords

Mobilidade urbana, mobilidade partilhada, mobilidade elétrica, autocarros elétricos, rede de transportes, mobilidade sustentável, capitais de distrito, ambiente.

Resumo Alargado

A mobilidade de uma cidade não pode continuar a ser pensada em torno de uma opção, o automóvel, sendo a luta contra o congestionamento das cidades um dos grandes desafios da atualidade. Um problema antigo, fruto da cultura automóvel que se foi desenvolvendo ao longo dos anos e das configurações das cidades que foram feitas a pensar apenas numa opção de transporte. A maioria do investimento público foi principalmente direccionado para criar, melhorar e expandir a infra-estrutura automóvel (túneis, autoestradas, etc).

A mobilidade não é a mesma nas cidades de grandes e pequenas dimensões, por isso é necessário olhar para isto como um sério problema. Nas cidades de pequenas dimensões, o transporte público apresenta problemas em termos de cobertura, onde os seus habitantes são cada vez mais dependentes de terem na sua posse um veículo para fazerem as suas deslocações diárias. Nas cidades de maiores dimensões, o transporte público apresenta problemas de capacidade e eficácia e por isso, o número de veículos em circulação tem tendência a aumentar, trazendo consequências muito negativas para a população, como por exemplo, maior congestionamento nas cidades, aumento do número de acidentes, aumento da poluição, ruído, o que torna a vida dos portugueses mais complicada, levando a uma redução da qualidade de vida (stress, mau estar etc.). Os transportes são, de facto um problema, e é preciso encontrar soluções sustentáveis e eficazes que permitam aumentar o acesso à mobilidade, minimizando os seus efeitos negativos.

A análise cluster efetuada nesta dissertação permitiu ter um conhecimento e agrupar as capitais de distrito portuguesas, tendo em conta as características das suas redes de transportes, nomeadamente: procura anual de passageiros, quantidade de estações, extensão da rede em quilómetros, número de autocarros em circulação e a idade média da frota de autocarros. Com uma simples análise, conseguimos agrupar as capitais de distrito em quatro grupos: O primeiro grupo, formado pelas cidades de Aveiro, Beja, Évora, Faro, Leiria, Viana do Castelo e Viseu, em que o seu planeamento e a organização dos transportes tem vindo a ser alvo de algumas intervenções, com o objetivo de tornar a mobilidade mais sustentável. Cidades como Viseu, Faro e Aveiro, têm apostado no conceito de “smart cities”, apostando na melhoria e inovação. Outro grupo foi formado pelas cidades de Braga, Bragança, Castelo Branco, Coimbra, Guarda, Portalegre, Santarém e Vila Real. A cidade de Setúbal com características muito próprias resultantes da sua atividade e rede de transportes ficou agrupado sozinho. Sem surpresa a cidade de Porto e Lisboa, as “grandes cidades portuguesas” ficaram agrupadas no mesmo grupo, dado que é nestas cidades que se aposta mais em termos de melhoria das infraestruturas, renovações de frota, aposta noutro tipo de mobilidade e são sem dúvida as cidades mais procuradas pelos utilizadores.

As capitais de distrito pelas suas dimensões e e características, é minimamente fácil chegar de um ponto ao outro da cidade recorrendo à sua rede de transportes, mas se olharmos para este problema de forma descentralizada, cidades menos densas e povoadas, temos a noção que é difícil nos deslocarmos usando um meio de transporte alternativo ao automóvel, que é uma maneira de mobilidade pouco sustentável ambientalmente e que poderia ser substituído por outras opções de transporte mais rápidas, económicas e sustentáveis. O transporte público é sem dúvida a solução para as cidades menos povoadas,impedindo que a população seja cada vez mais dependente de ter um veículo para se deslocar. A frota de autocarros em Portugal é elevada, precisando de ser renovada, que só será possível se as empresas de transporte alterarem as suas políticas de renovação e compra de autocarros e os decisores políticos implementarem medidas para os subídios que fornecem serem capitalizados da melhor forma. Com a crescente concentração da população nos centros urbanos e pelo facto de cerca de 2/3 das emissões de gases de efeito de estufa decorrerem da mobilidade, através veículos movidos em combustíveis fósseis, deve resultar numa profunda reflexão por parte da população a ter comportamentos sustentáveis. Na maioria das capitais de distrito nota-se que o planemento das cidades tem vindo a mudar, apostando no transporte inteligente inserido no contexto das “smart cities”.

Em conclusão, para desenvolvermos uma mobilidade urbana sustentável é preciso uma mudança de mentalidade. A população tem de deixar de dar prioridade a meios de transporte com elevadas emissões de carbono e estar receptivos a apostar noutros tipos de mobilidade e em soluções mais sustentáveis, como o uso de veículos elétricos, car sharing e outros tipos de mobilidade partilhada. Os decisores políticos têm um papel fundamendal neste processo, criando condições para que esta mudança aconteça, como por exemplo, maior aproveitamento das verbas dos fundos comunitários, tornar as redes de percurso acessíveis, investir em infraestruturas cicláveis e incentivar o uso do transporte público e sistemas partilhados, promovendo o desenvolvimento das cidades e o aumento da qualidade de vida.

Abstract

The high use of the car in daily journeys and the lack of an effective transport network remains a problem in cities. Public transport has problems in terms of coverage in less populated cities and problems of capacity and effectiveness in the most populated cities. Mobility planning is not yet being done in a decentralized way, which encourages daily travel through a private vehicle, causing negative effects in the quality of life of citizens and the environment. Portuguese cities are not yet prepared for mobility and accessibility to all, so it is urgent to make a plan of it, promoting a more sustainable mobility.

The fight against congestion is a constant challenge, so cities are taking the first steps in intelligent transport within the "smart cities" context. The existing bus fleet in Portugal has a considerably high average age, causing negative consequences for users and the environment, needing to be renewed. It is urgent to think of other types of mobility and to see the bet on electric mobility and shared systems as a future solution. The electric mobility has grown strongly in Portugal, with the placement of loading stations and the introduction of electric buses in circulation.

This theoretical and practical dissertation focuses on the study of the existing transport networks in the Portuguese district capitals, analyzing its fleet of buses and everything adjacent to it. It also focuses on the study of the sustainable mobility strategies that cities have been taking.

Palavras-chave

Urban mobility, shared mobility, electric mobility, electric buses, transport network, sustainable mobility, district capitals, environment.

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List of Acronyms

CO2	Carbon dioxide;
BEVS	Electric Vehicles;
GEE	Greenhouse Gases;
UBI	University of Beira Interior;

1. Introduction

Urban mobility differs from region to region, with differences in smaller and larger cities, but also its geographic dispersion is a very significant indicator to evaluate innovation and bet on improving mobility in the various municipalities. This problem must result in a profound reflection of politicians, since it is necessary to look at this as a serious problem.

This dissertation focuses on the study of urban mobility strategies in Portuguese district capitals. Being a subject that requires a serious reflection, it will contribute to the increase of the existing literature and identify problems and solutions taking into account the geographic dispersion of the municipalities under study and the lack of policies to invest in innovation, with a main focus on investing in electric mobility and replacing old means of transport. Urban mobility has been a highly questioned issue by researchers in recent years, as sustainable urban development must be a current priority in our country. Certainly, comes a financial problem, considering that the financial capacity differs from one municipality to another and this leads to that most cities are unable to have the desired capacity and the financial leverage to implement measures and policies that promote sustainable development.

In small towns, its inhabitants are increasingly dependent on having a vehicle for their daily journeys, however in larger cities there is an effective transport network, the number of vehicles in circulation have a tendency to increase, causing very negative consequences for the population, for example, greater traffic congestion in cities, increased number of accidents, increased pollution, noise, which makes the life of the portuguese people more complicated, leading to a reduction in quality of life.

This dissertation, as mentioned previously, focuses on the urban mobility strategies in Portuguese district capitals, having as objectives, to analyze the existing transport networks, through the knowledge of the number of buses in circulation, the age of the equipment, the type of fuel that is used by them, since sustainable development is fundamental and has to be seen as a goal to achieve. The population has the habit of making unnecessary travels, which leads to an increase in costs, and can sometimes take advantage of the existing transport network, so it is essential to know the number of passengers using this means of transport. Overcoming the problem of congestion in cities is paramount, but for this it is necessary to make people aware for the bet on urban mobility through equipment powered by electrical systems, given that they only come with advantages such as the reduction of pollution and also the improvement of comfort and quality of life.

Electric buses have in their characteristics beyond the modernization of equipment, the ability to emit little noise and contribute to the reduction of pollution. For this it is necessary to know the transport network in Portugal, which through the cluster analysis we will group the districts by groups, according to their characteristics. The surprises are not many, for example Lisbon and Oporto appear in the same group. There is a long way to go around sustainable mobility. This dissertation presents the evolution of electrical mobility in Portugal, as well as the offer that exists in the Portuguese district capitals in other types of mobility (shared mobility).

2. Literature Review

In this section are presented the evolution of urban mobility in cities and the research that has been elaborated with the meaning of making it more sustainable, identifying solutions and forms of action, so that policy makers and the population are sensitized to behavioral changes and their decisions. This literature review extends to the theme that currently marks the public discussion that is the focus on electric mobility and other types of more sustainable mobility.

2.1 Urban Mobility

Urban mobility has been a subject widely studied by several researchers in recent years, since sustainable urban development must be the priority of any politician. It is one of the biggest challenges facing cities today, with increasing population in urban areas and as a result of cities becoming increasingly congested. (Little, 2014). Mobility is more than just the mode of transport available. Urban planning should focus on how to bring together people and places, creating cities that focus on accessibility and optimum urban densities, rather than simply increasing the extent of urban transport infrastructures. (Giduthuri, 2015). As an example, 74% of Europeans are moving daily, leading to 40% of total CO2 emissions from transport as a consequence of urban mobility (Diez et al., 2018). With the development of urban areas and the excessive concentration of people, is necessary to implement measures to change infrastructures and measures that promote the use of other means of transport instead of the private vehicle. This can result in many positive consequences, for example, the reduction of accident rates, the reduction of pollution, making the environment more sustainable and improving people's quality of life. Decreasing the number of accidents, for example, has to be seen as a problem to be solved and a study carried out by (Pokorny et al., 2016), showed that the increase in the number of trucks and bicycles in circulation must be seen as a risk factor for urban mobility , given that it is a threat to road safety.

Collective transport, as well as associated systems, play a key role in mobility, economic competitiveness, social cohesion and sustainable growth. Many of the problems of urban transport affecting developing countries are today a combination of historical deficiencies (lack of human and financial resources) and recent global trends (strong dependence on the automobile as the main alternative transport to provide mobility for citizens). (Silva et al., 2008). The main goal of transport networks and services is to allow people and goods to move between different points in space, providing accessibility (Stasio et al., 2011).

In the last half century, authorities have improved accessibility by improving roads and building new motorways. Therefore, private transport has become the main means of transport, increasing congestion and pollution, but also the consumption of fossil fuels and GHG emissions, which led the authorities to promote the use of public transport (Stasio et al., 2011). The changes in the inhabitants' lifestyle, especially in congested and heavy port agglomerations, result in a continuous increase in their transport needs. As transport behaviors change, the number of vehicles in the streets increases, resulting in congestion, increased number of accidents, noise emissions and consequently a reduced quality of life. (Przybylowski, 2018).

One of the challenges is to find solutions and measures that allow the population to move easily, with the government having a fundamental role in doing a survey of existing problems and make the necessary interventions to improve life conditions. Leo et al., (2017), conducted a study in Mexico and identified urban mobility variables, such as security, congestion, accidents and pollution, concluding that government intervention is fundamental and a decisive factor in planning of urban mobility, as well as to implement measures for the perfection of each of these variables.

One of the measures that can be applied to improve these variables is the sharing of cars, which allows people to avoid unnecessary travel, as well as to offer other benefits to the population. Stiglic et al. (2016), proved that, through a study that involved the comparison of the perfect integration between car sharing and public transport, showing that the implementation of this measure can contribute to the reduction of negative externalities that are adjacent to urban mobility, but also stimulate the use of public transport.

Urban sprawl around the world is carried out in an uncontrolled way, leading to inefficient use of space and natural resources. For cities and towns to work efficiently, accessibility is essential for transporting goods and services, but accessible cities are being encouraged to bet on more sustainable modes of transport and attract more travelers in different types of mobility. (Giduthuri, 2015).

2.2 Electric Mobility

An electric vehicle is a vehicle in which its propulsion is accomplished entirely by electric motors only, regardless for the means of obtaining that electric energy (Ribeiro et al., 2010), and is characterized for not generating local emissions, which could be helpful to reduce the level of pollutant emissions and concentrations in urban areas, where vehicles, pedestrians and bicyclists could cohabit in a quieter environment with a high level of air quality, that is, in a healthier environment (Ribeiro et al., 2012). Electric mobility has numerous advantages and benefits, as it increases the quality of life by improving air quality in cities, since there is no emission of polluting gases.

Grauers et al. (2013), define electrical mobility as a road transport system based on vehicles that are powered by electricity. Some vehicles are equipped with technologies that allow the production of electricity itself (hybrid electric vehicles). Others use power supplied by a source outside the vehicle, usually the mains. This definition applies well, as it considers not only vehicles that store electricity but also vehicles that do not store electricity. With the emergence of electric buses, it is necessary to understand all its surroundings and characterization in order to make the most of its potentialities. Operating with different energy sources, (Mahmouda et al., 2016) identified some characteristics of the energy sources, such as their management, storage and consumption, in order to analyze their energy efficiency.

There are electric buses in circulation that are equipped with energy storage systems, but due to their age and wear of circulation, they can have a "new life", since they can be modernized without being destroyed. (Alexandrini et al., 2017). Some advantages and disadvantages come from this process. The difficulty in finding old buses in acceptable conditions (which does not entail excessive costs of repair and revision) and the difficulty in finding spare parts constitute some disadvantages. However, avoiding the elimination of buses and the production of waste, since it is reused will avoid the costs and pollution related to the operation of the elimination of buses, is an advantage from the process, as well as the reduction of energy consumption (Alexandrini et al., 2017).

Comparing diesel buses with electric buses, (Adheesh et al., 2016) argue that with the introduction of electric buses in cities, it brought economic and environmental benefits. Electric buses produce much less noise, helping to reduce pollution and noise when compared to diesel buses.

Considering 12 years of service life, electric buses can have slightly lower life cycles than diesel buses, however on average they have 7% higher lifecycle costs. (Lajunen, 2017). In February 2009, the Portuguese Government implemented the Electric Mobility program, with the objective of implementing charging stations for electric vehicles. (Pereira et al., 2012). This measure led to that at the end of 2011 were implemented about 1100 stations nationwide. (Pereira et al., 2012).

However, transitioning from conventional mobility to purely electrical mobility will not be a simple task, as it is necessary to change the mindset of users who are accustomed to the internal combustion vehicle. BEVs do not fit into the current mobility system and cannot compete with conventional cars under the established system (for example, the price) (Augenstein, 2015). The fight against congestion is a constant challenge, and it is necessary to draw a more sustainable path, considering the problem of urban mobility. Car sharing services have become increasingly popular around the world, (Ferrero et al., 2018). The bet on new forms of mobility, for example Car Sharing leads to several advantages. Baptista et al., (2014), identified this even though the bet on Car Sharing leads to less congestion, greater road safety with the reduction of vehicle accidents, reduced emissions of pollutant gases and energy consumption.

Another form of mobility is electric bicycles, in which people should be sensitized to their use, to the extent that they perfectly replace the use of cars or motorcycles, (Cherry et al, 2009). Some doubts arise when deciding on the implementation of this type of mobility, for example, when climatic conditions are adverse, it becomes an obstacle. Also, the lack of infrastructure, the fact that bicycles are not adapted and lack of bike lanes. (Ioakimidis et al., 2011). However, this type of shared mobility, such as other types, leads to improvements in the quality of the environment and the life of the population. Cherry et al, (2009) concluded that electric bicycles have a good performance in terms of environmental impacts compared to buses and motorcycles.

Electric mobility has exceeded a critical period and is currently benefiting from several developments, which depended on changes in infrastructure, changes in mobility, changes in the global car market, evolution of energy prices, climate policy and changes in the electricity sector (Dijk et al, 2013).

3. Transport Network

In this chapter are analyzed the transport network in Portuguese district capitals. With the successive changes in the municipal mobility plans, it is urgent to know which municipalities in their bus fleet already bet on modernity, comfort, less noise and less pollutant for the environment, that is, which municipalities in their fleet contain electric buses. Since the financial capacity depends on each municipality and the transport concessionaire, we should also note the average age of the bus fleet in Portugal.

3.1 Electric buses

Portugal consists of eighteen districts that are the subject of study in this dissertation (Aveiro, Beja, Braga, Bragança, Castelo Branco, Coimbra, Évora, Faro, Guarda, Leiria, Lisboa, Portalegre, Oporto, Santarém, Setubal, Viana do Castelo Vila Real and Viseu). As shown in the attached figure, of the eighteen municipalities that make up the country, only eight have in their fleet of buses electric vehicles, that is, only 44.4% of the districts.

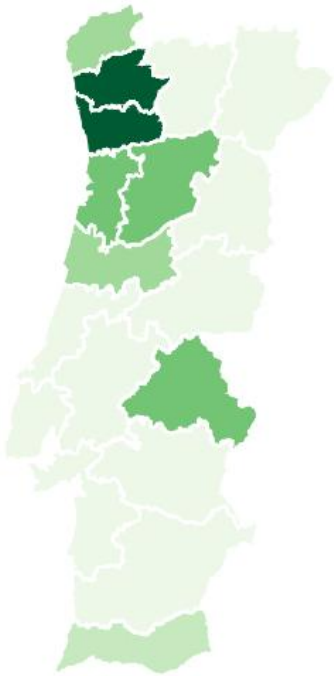

Fig. 1 – Municipalities with electric buses

3.2 Number of Electric Buses

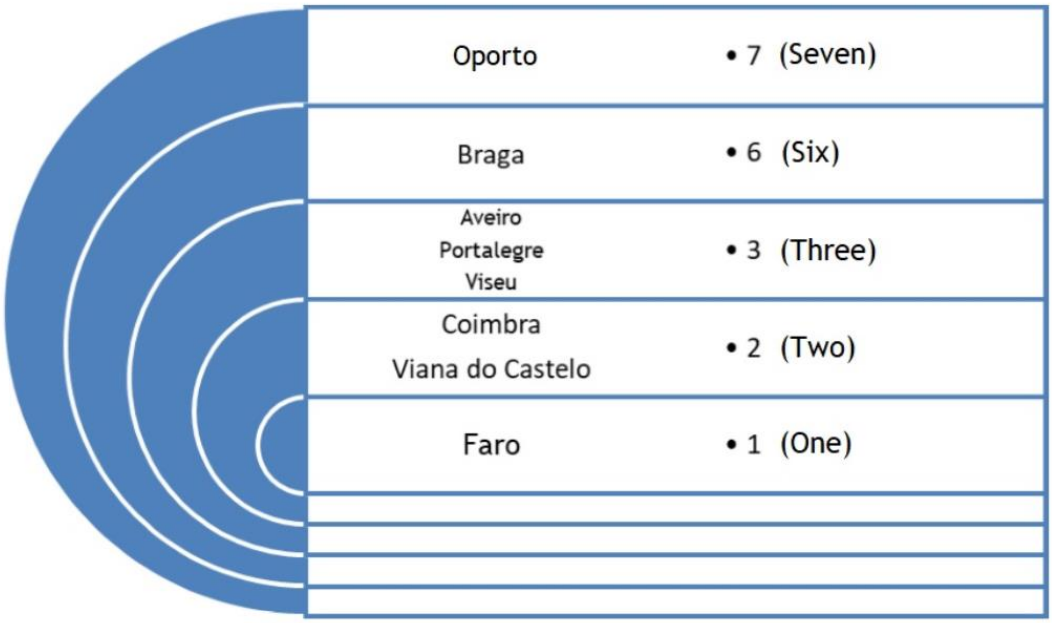

Fig.2 – Number of electric buses

The north of the country is the region of Portugal that has more bets on modernity and innovation, placing electric buses circulating in its transport network. The city of Oporto has already seven electric buses and it is expected that even during the year 2019 enter more buses in circulation. It follows the city of Braga with six electric buses in circulation and Viana do Castelo with two. In the central region of Portugal, the municipalities along with the urban transport concessionaires have included electric buses, with the city of Aveiro and Viseu appearing with 3 electric buses. Also, in the city of Coimbra, in the center region, its transport network has two electric buses. In the capital of Portugal, Lisbon, there are still no electric buses, but Carris is in the acquisition phase of 15 (fifteen) that will start service still in the course of this year of 2019. In the southern part of the coastline there is not a single city that counts with electric buses in circulation, apart from Faro. In the Alentejo, in the city of Portalegre, there are three electric buses that make up the transport network. The city of Faro has an electric vehicle in circulation.

In addition, a significant bet is noted (considering the rest of the country) on electric buses in the north and central of Portugal. In Bragança it is expected that in 2019, two electric buses will start up.

3.3 Buses fuel

The fuel of the bus fleet used in the Portuguese district capitals is mostly diesel (89% of the district capitals choose to use this fuel), while 11% of the Portuguese district capitals despite having vehicles circulating using diesel, they also have buses circulating with natural gas in their fleet. The city of Viseu is about to start a new transport plan and a new mobility plan in this municipality, titled "Move". In this plan, the bus fleet will be constituted, also by natural gas vehicles.

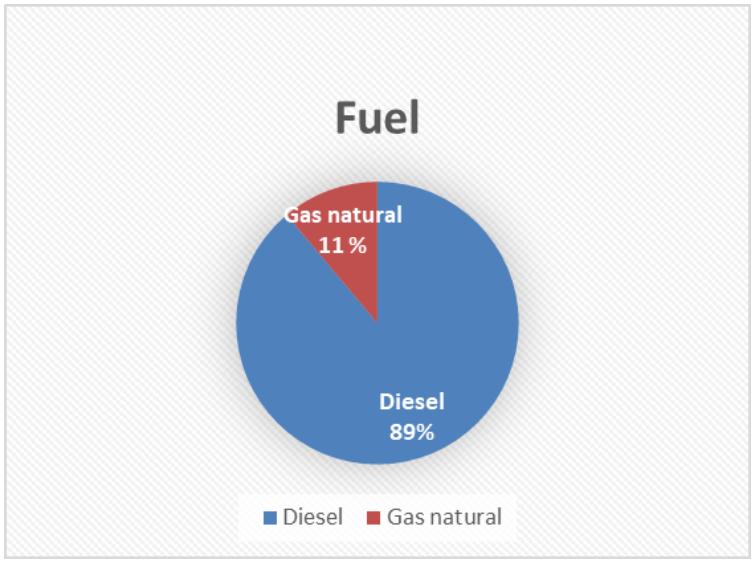

Fig.3 – Buses Fuel

3.4 Annual passenger demand

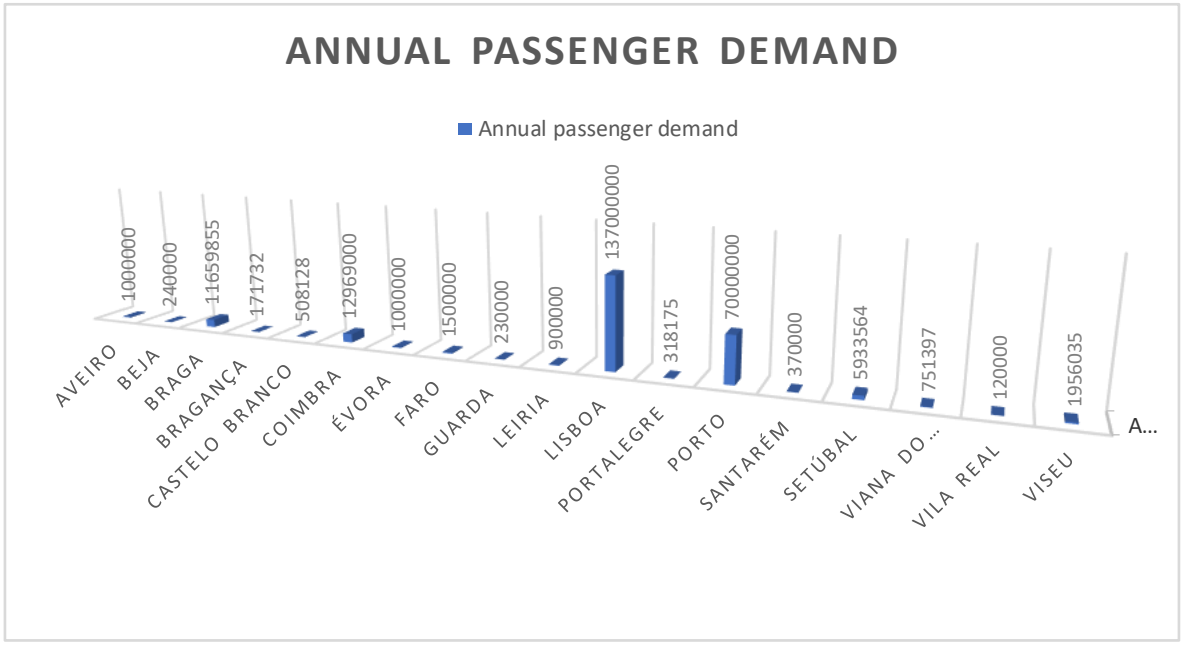

Fig. 4 - Annual passenger demand

The Portuguese district capitals have practically an effective transport network that allows avoiding unnecessary travel, but even so, the culture of the Portuguese people is systematically to use their private vehicles for their daily journeys instead of taking advantage of the transport network. However, there are always some criticisms of transport networks, namely that the provision of public transport does not cover the needs of the population at various levels: scope, frequency and quality of service (given that the bus fleet in Portugal is significantly old). Mobility planning in cities has been changing, with the aim of more sustainable mobility. Undoubtedly, a sustainable mobility has been a priority in most district capitals, but it is necessary to decentralize the intervention, since small towns do not have a transport network and this leads an increase in the number of private vehicles in circulation, contributing with negative effects on the environment and the quality of life of the Portuguese.

3.5 Bus Features

District	Number of buses	Age of buses
Aveiro	28	10
Beja	10	8
Braga	146	18
Bragança	24	17
Castelo Branco	5	17
Coimbra	116	14,51
Évora	19	8
Faro	28	13
Guarda	10	17
Leiria	13	10
Lisbon	603	13
Portalegre	14	15
Oporto	419	11
Santarém	7	15
Setúbal	120	15,3
Viana do Castelo	12	7
Vila Real	15	14
Viseu	30	9

Table 1 – Bus features

As can be seen, in most Portuguese district capitals, we are facing a fleet of buses aged which is often the result of Portugal buy buses to other countries already with a few years of circulation, which in other countries are about to be slaughtered, but Portugal buys to circulate. These buses, with a very high age of circulation, present some disadvantages for users and the general population, such as: greater emission of pollutant gases (increased pollution), more noise, less comfort for passengers etc. These decisions are the responsibility of transport undertakings, however, the state can play a major role, since the state grants subsidies to public transport undertakings. Being sure it comes out much more into account buy used buses, but as the old saying "what is cheap comes out expensive" and the constant purchase of used buses does not benefit the environment or users. The Portuguese state could have another preponderant role for the reduction of the average age of buses, creating a legislation to limit in quantity and age the importation of used buses. This legislation is already in force in Spain and France.

4. Metro

4.1 Lisbon

Fig. 5 – Lisbon Metro

The Lisbon Metropolitan operates in the city and in the neighboring cities of Amadora and Odivelas with a fleet of 333 carriages. It has a network consisting of four lines about 44.5 km long and 56 stations. (Metropolitano de Lisboa, 2016).

4.2 Oporto

Fig. 6 – Oporto Metro (www.wikipedia.org)

The Oporto Metro is one of the largest light rail networks in Europe. With a network extension of 67 km, consisting of 6 lines and 102 vehicles, currently serves 7 counties, consisting of 82 stations. In the Oporto Metro, 9000 people can be transported per hour on each line. (www.metrodoporto.pt).

In other municipalities, they do not opt for this type of mobility. Currently, the municipality of Coimbra does not yet have this type of mobility system, and it can be operated from 2021, in the Metrobus system (ART).

5. Shared Mobility

In this chapter are presented other types of mobility offer by municipalities, especially the focus on shared mobility. The mobility services available in the Portuguese district capitals will be identified, such as Uber, Car sharing, Bike Sharing, electric scooters and moto sharing.

5.1 UBER

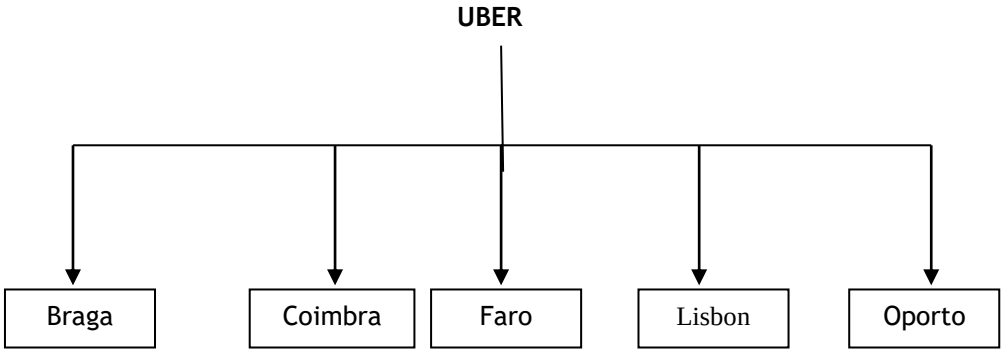

Fig. 7 - UBER

Currently, UBER serves users in the metropolitan areas of Lisbon and Oporto, as well as in the region of Algarve, Braga and Guimaraes, and has recently become available in the city of Coimbra. Therefore, from the Portuguese district capitals, only the city of Braga, Coimbra, Faro, Lisbon and Oporto offers the population the opportunity to enjoy UBER for their travels.

5.2 Car Sharing

There are three companies that make carsharing in Lisbon:

-DriveNow (200 petrol cars + 40 electric cars);

-EMOV (150 electric cars);

-Hertz 27/7 City (only electric cars, fleet of number adjustable on demand);

As for the other municipalities under study, they do not opt for this type of mobility.
In Lisbon there are several operators of TVDE (private carriers), which according to the law identifies, cars at the service of "individual and remunerated passenger transport in vehicles mischaracterized from electronic platform". The operators of TVDE are: UBER, Cabify, Taxify and Chauffeur Privé.

5.3 Bike Sharing

Fig. 8 – Bike Sharing (www.timeout.pt)

The network of shared bicycles has already reached some Portuguese district capitals, with the aim of contributing to an improvement in the quality of life of the population and encouraging the practice of physical exercise. A new form of mobility, easier and simpler, is now present in the following district capitals: Aveiro and Lisbon. The city of Viseu, which is about to start a new mobility plan in this city, titled "Move" will have electric bicycles.

5.4 Electric Scooters

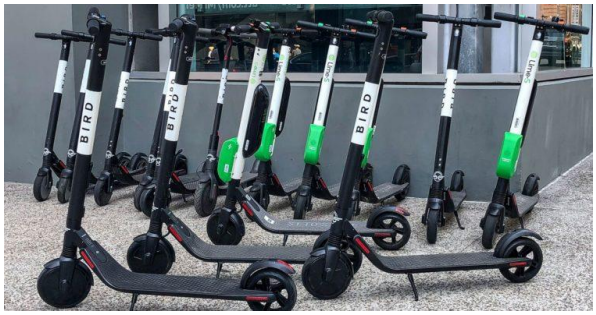

Fig. 9 - Electric Scooters (www.nit.pt)

The Portuguese cities are already taking the first steps in the intelligent transport inserted in the concept of "SMART CITIES". Proof of this is the bet on other types of mobility, as is the case with electric scooters, which began to start working in the city of Lisbon and has already extended to cities like Faro and Coimbra. The city of Oporto and Viseu, will also receive soon electric scooters. Bike Sharing and electric scooters are the sign that there is a change in city mobility planning, with the aim of making it more sustainable. Many benefits come from this strategy, such as reducing emissions of pollutant gases, reducing traffic congestion, improving air quality and the environment.

5.5 Moto Sharing

Fig 10 - Moto Sharing (www.moto.it)

Of all the Portuguese district capitals, only the city of Lisbon, bet on this system of shared mobility, reflecting the intention to present to citizens sustainable solutions for mobility.

6. Data and Methodology

In this section will be presented the data of the variables in study regarding buses: average annual passenger demand, number of stations, length of the network in kilometers, number of buses and the age of buses.

To analyze the eighteen Portuguese district capitals, the "cluster analysis" will be used. Cluster analysis is a group of multivariate technique whose primary purpose to group objects based on the characteristics of these possessions (Setyaningsiha, 2012). The data are described and analyzed, its main characteristics and data sources.

6.1 Data Description and Data Collection Sources

District	Number of passengers	Number of stations	Length of the network in kilometers	Number of buses	The age of buses
Aveiro	1 000 000	502	210	28	10
Beja	240 000	60	82.1	10	8
Braga	11 659 855	1816	300,47	146	18
Bragança	171 732	90	267.2	24	17
Castelo Branco	508 128	71	82.850	5	17
Coimbra	12 969 000	1113	560.4	116	14,51
Évora	1 000 000	320	263,7	19	8
Faro	1 500 000	139	337.5	28	13
Guarda	230 000	117	79.4	10	17
Leiria	900 000	125	195	13	10
Lisbon	137 000 000	1963	680	603	13
Portalegre	318 175	42	127	14	15
Oporto	70 000 000	2491	488	419	11
Santarém	370 000	50	20	7	15
Setúbal	5 933 564	1134	1047	120	15,3
Viana do Castelo	751 397	230	120	12	7
Vila Real	120 000	199	60	15	14
Viseu	1 956 035	610	482.8	30	9

Table 2 – Data for cluster analysis

Data Collection Sources:

The research was carried out by obtaining data provided by the all city councils and by its concessionaires of transports.

6.2 Analysis and discussion of results

6.2.1 Results presentation

Case Processing Summary[a]

Cases					
Valid		Missing		Total	
N	Percent	N	Percent	N	Percent
18	100,0%	0	0,0%	18	100,0%

a. Squared Euclidean Distance used

Table 3 – Number of cases considered

As we can see from the table above, we know how our data work, with eighteen (which are the district capitals) valid data, which represented 100% of our sample. Thus, we obtained a response to all the district capitals, therefore, the 18 cases were valid.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Number of passengers	18	120000	137000000	13701549,22	34843576,19
Length of the network in kilometers	18	20	1047	300,17	266,063
Number of stations	18	42	2491	615,11	765,397
Number of buses	18	5	603	89,94	162,179
The age of buses	18	7	18	12,88	3,542
Valid N (listwise)	18				

Table 4 - Descriptive Statistics

We obtained descriptive statistics that allow us to know the variables under study, describing and summering the distribution of the variables.

Proximity Matrix

Squared Euclidean Distance

Case	1:Aveiro	2:Beja	3:Braga	4:Bragança	5:Castelo Branc	6:Coimbra	7:Évora	8:Faro	9:Guarda	10:Leiria	11:Lisbon	12:Portalegre	13:Oporto	14:Santarém	15:Setúbal	16:Viana do Cast	17:Vila Real	18:Viseu
1:Aveiro	,000	,896	8,787	4,242	4,471	4,405	,419	1,172	4,412	,254	35,286	2,459	17,658	2,868	13,159	,968	1,757	1,149
2:Beja	,896	,000	14,718	6,949	6,457	9,063	,585	2,938	6,461	,507	41,999	3,935	23,501	3,960	19,855	,150	2,910	2,878
3:Braga	8,787	14,718	,000	5,855	6,805	2,804	12,516	7,427	6,508	10,907	24,945	7,283	10,817	7,992	9,300	15,178	7,317	9,995
4:Bragança	4,242	6,949	5,855	,000	,495	3,952	6,548	1,351	,507	3,986	37,837	,604	23,346	1,196	11,059	8,315	1,347	6,221
5:Castelo Branc	4,471	6,457	6,805	,495	,000	6,165	7,031	2,220	,005	4,090	41,364	,351	25,679	,376	15,818	8,034	,757	7,878
6:Coimbra	4,405	9,063	2,804	3,952	6,165	,000	6,170	2,906	6,017	5,697	23,305	5,158	10,467	6,656	3,437	9,100	5,508	3,318
7:Évora	,419	,585	12,516	6,548	7,031	6,170	,000	2,129	7,009	,452	37,250	4,302	19,478	4,874	14,453	,387	3,482	,905
8:Faro	1,172	2,938	7,427	1,351	2,220	2,906	2,129	,000	2,231	1,013	35,029	,969	19,759	1,774	9,561	3,562	1,182	1,951
9:Guarda	4,412	6,461	6,508	,507	,005	6,017	7,009	2,231	,000	4,095	40,965	,361	25,217	,377	15,709	8,015	,735	7,829
10:Leiria	,254	,507	10,907	3,986	4,090	5,697	,452	1,013	4,095	,000	38,298	2,070	21,048	2,436	14,687	,816	1,543	1,661
11:Lisbon	35,286	41,999	24,945	37,837	41,364	23,305	37,250	35,029	40,965	38,298	,000	39,516	6,300	41,600	26,516	40,996	39,399	32,455
12:Portalegre	2,459	3,935	7,283	,604	,351	5,158	4,302	,969	,361	2,070	39,516	,000	23,589	,164	14,452	5,162	,185	5,217
13:Oporto	17,658	23,501	10,817	23,346	25,679	10,467	19,478	19,759	25,217	21,048	6,300	23,589	,000	24,987	15,811	22,162	22,500	15,926
14:Santarém	2,868	3,960	7,992	1,196	,376	6,656	4,874	1,774	,377	2,436	41,600	,164	24,987	,000	17,423	5,298	,143	6,448
15:Setúbal	13,159	19,855	9,300	11,059	15,818	3,437	14,453	9,561	15,709	14,687	26,516	14,452	15,811	17,423	,000	19,490	15,835	8,454
16:Viana do Cast	,968	,150	15,178	8,315	8,034	9,100	,387	3,562	8,015	,816	40,996	5,162	22,162	5,298	19,490	,000	3,958	2,435
17:Vila Real	1,757	2,910	7,317	1,347	,757	5,508	3,482	1,182	,735	1,543	39,399	,185	22,500	,143	15,835	3,958	,000	4,814
18:Viseu	1,149	2,878	9,995	6,221	7,878	3,318	,905	1,951	7,829	1,661	32,455	5,217	15,926	6,448	8,454	2,435	4,814	,000

This is a dissimilarity matrix

Table 5 – Proximity Matrix

The table shows the proximity matrix, that is, indicates the distance between the districts under analysis. As it is a symmetric matrix, we can observe only one of the diagonals. For example, the distance between the district of Aveiro and the district of Beja is 0.896; The distance between Beja and Braga is 14.718. The software only displays the first table of the distance calculation. As groupings occur, new distances are calculated based on this array. It is also observed that the shortest distance from the table is between the districts of Castelo Branco and Guarda that were grouped first.

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	5	9	,005	0	0	7
2	14	17	,143	0	0	4
3	2	16	,150	0	0	8
4	12	14	,185	0	2	9
5	1	10	,254	0	0	6
6	1	7	,452	5	0	8
7	4	5	,507	0	1	9
8	1	2	,968	6	3	12
9	4	12	1,347	7	4	14
10	8	18	1,951	0	0	12
11	3	6	2,804	0	0	14
12	1	8	3,562	8	10	15
13	11	13	6,300	0	0	17
14	3	4	7,992	11	9	15
15	1	3	15,178	12	14	16
16	1	15	19,855	15	0	17
17	1	11	41,999	16	13	0

Table 6 - Agglomeration Schedule

The table also indicates how the groupings were made according to the method chosen (furthest neighbor). It's another way of indicating the procedure. The first districts to be agglomerated were the district of Guarda and Castelo Branco, since their distance (0.365) is the smallest of the table. Then the district of Vila Real is associated with the district of Santarém, whose distance is the second smallest. Note that both the Guarda district and Castelo Branco had not been grouped in any cluster before, so it appears the number 0 in the columns "cluster 1" and "Cluster 2" (in "Stage cluster first appears"). It is observed that in the column "Next Stage" appears number 7, this is because, on line 7 the district of Castelo Branco returns to appear, when it is grouped with the district of Bragança.

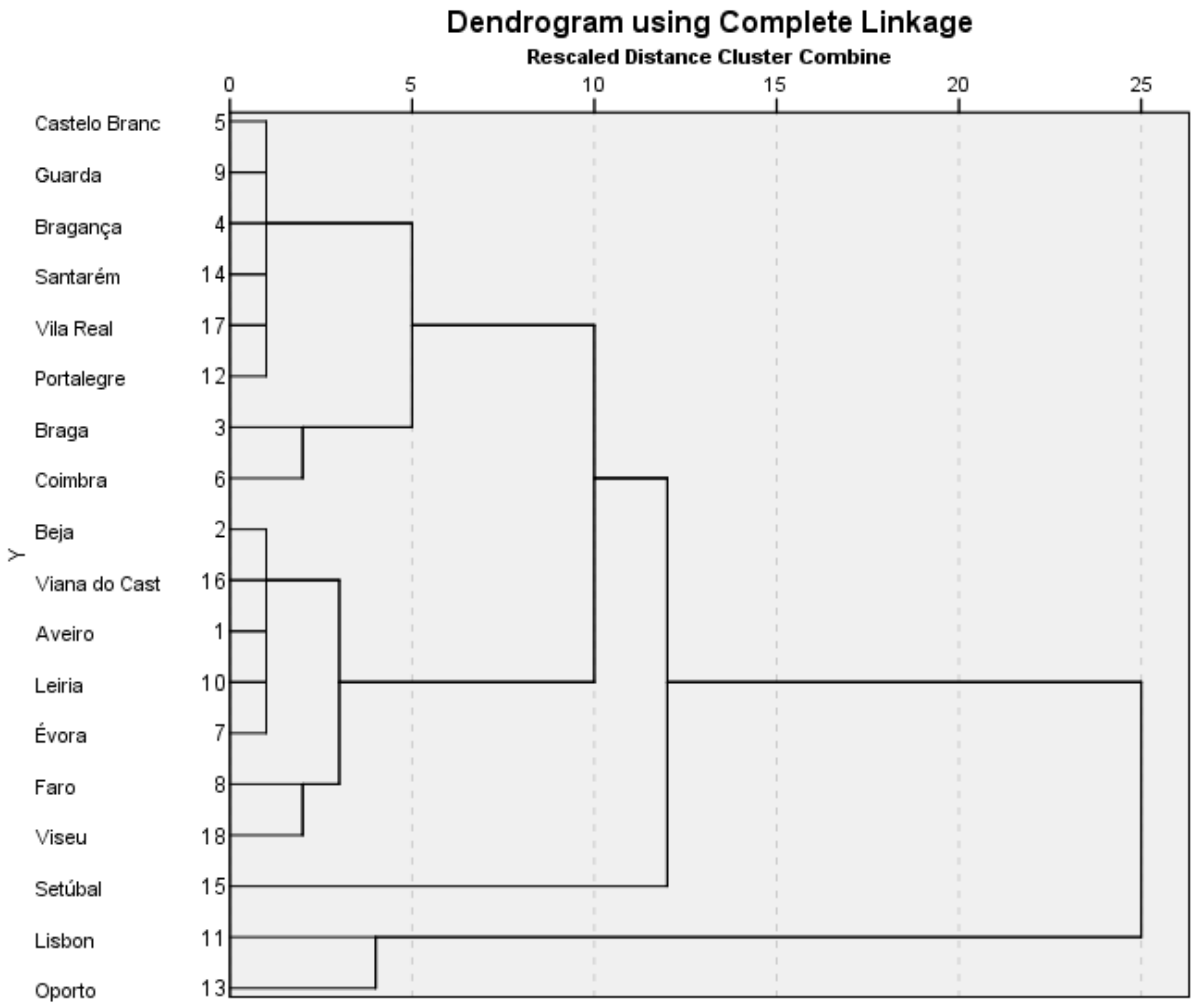

Fig. 11 – Dendrogram (furthest neighbor method)

Cluster Membership

Case	4 Clusters	3 Clusters	2 Clusters
1:Aveiro	1	1	1
2:Beja	1	1	1
3:Braga	2	1	1
4:Bragança	2	1	1
5:Castelo Branc	2	1	1
6:Coimbra	2	1	1
7:Évora	1	1	1
8:Faro	1	1	1
9:Guarda	2	1	1
10:Leiria	1	1	1
11:Lisbon	3	2	2
12:Portalegre	2	1	1
13:Oporto	3	2	2
14:Santarém	2	1	1
15:Setúbal	4	3	1
16:Viana do Cast	1	1	1
17:Vila Real	2	1	1
18:Viseu	1	1	1

Table 7 – Cluster membership

The identification of homogenous groups of districts can be seen in the table mentioned above. The solutions with 2, 3 and 4 clusters are presented in this framework, using the agglomeration method of the nearest neighbor. With two clusters, two homogenous clusters are formed, one of which includes Aveiro, Beja, Évora, Faro, Leiria, Viana do Castelo and Viseu.

Using 4 clusters, the following homogeneous clusters are created, which are identified in column 4 clustering by the same number:

-(cluster 4): formed by the city of Setúbal.

-(cluster 3): formed by the city of Lisbon and Oporto.

-(cluster 2): formed by the cities of Braga, Bragança, Castelo Branco, Coimbra, Guarda, Portalegre, Santarém and Vila Real.

-(cluster 1): Formed by Aveiro, Beja, Évora, Faro, Leiria, Viana do Castelo and Viseu.

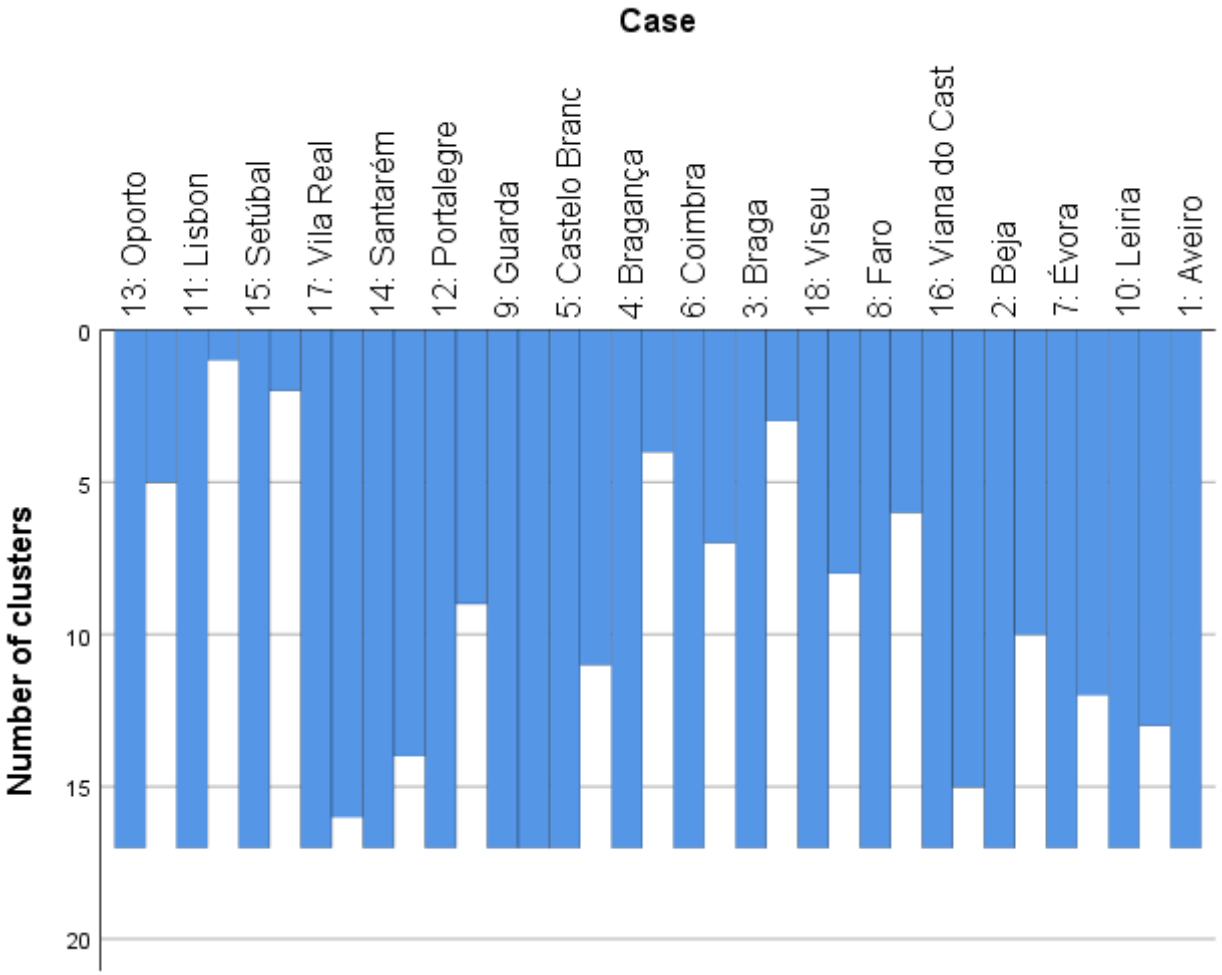

Fig 12 – Number of Clusters

The table shows a representation of how the groupings were made. The columns represent the grouped cases, therefore 18 cases.

By modifying the method to "between groups", we obtain the following dendrogram:

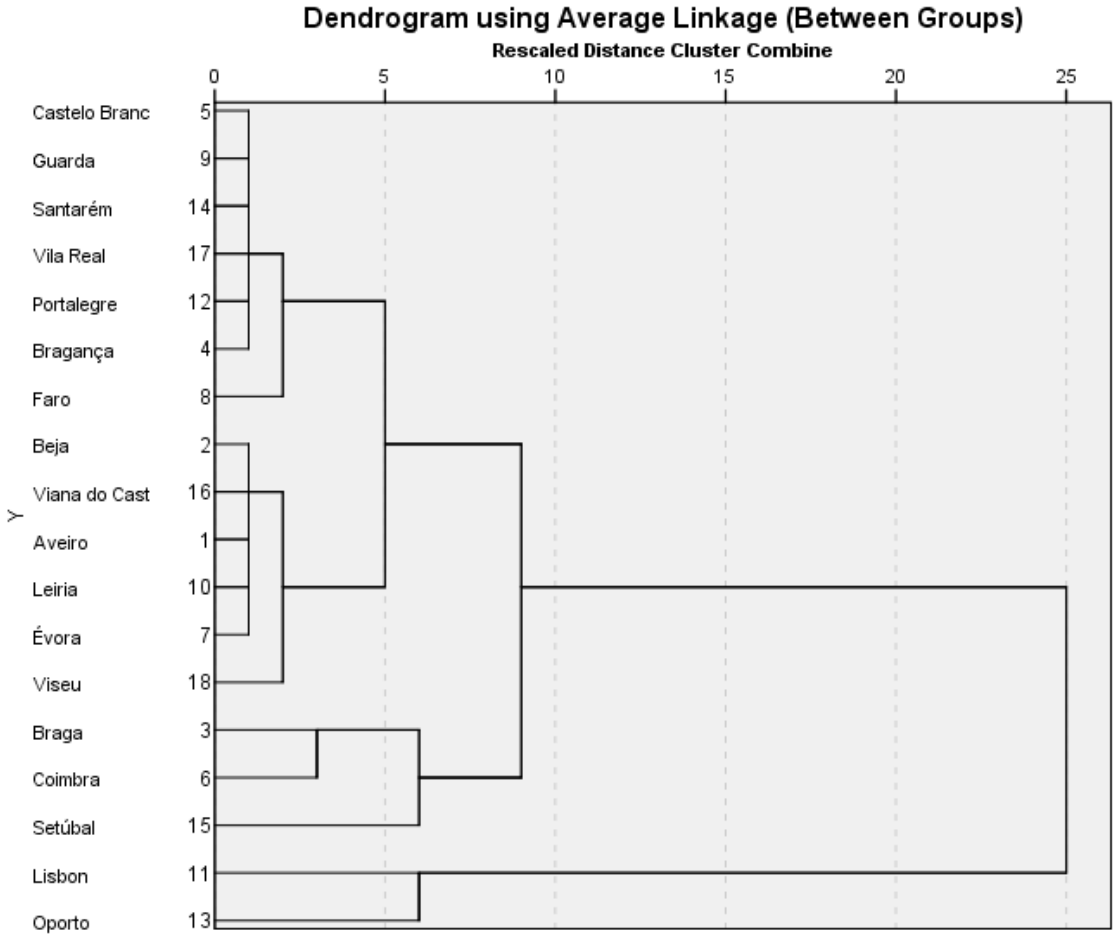

Fig. 13 – Dendrogram (between groups method)

Observing the dendrogram, which used the agglomeration method between groups, and given its similarity with the previous method (farthest neighbor) and on the other hand, the fact that the four clusters are formed before the distance between other clusters is very allows grouping the districts in the same 4 homogeneous agglomerates already defined.

7. Discussion

With the cluster analysis carried out, it allowed to know the similarities between the existing transport networks, through its characteristics and variables under study such as: the number of passengers, quantity of stations, length of the network in kilometers, number of buses, bus age. Through this analysis it was possible to group the districts by groups.

The research was carried out by obtaining data provided by the city councils and by its concessionaires of transports. The first group, formed by the cities of Aveiro, Beja, Évora, Faro, Leiria, Viana do Castelo and Viseu. A group consisting of cities in which their planning and transport organization has been changing, with the aim of making mobility more sustainable. Cities like Viseu, Faro and Aveiro, have been betting on the concept of "smart cities", betting on improvement and innovation. Another group was formed by the cities of Braga, Bragança, Castelo Branco, Coimbra, Guarda, Portalegre, Santarém and Vila Real. The city of Setúbal with very typical characteristics resulting from its activity and transport network was grouped alone. Without surprising the city of Oporto and Lisbon, they were grouped together, since it is in these cities that more bets in terms of infrastructure improvement, fleet renewals, bet on another type of mobility and are undoubtedly the cities most sought by users.

The existing transport network in Portugal is not effective or efficient, and it proves that in most cities that have a transport network, it is unable to respond to demand. In other cities there is no comprehensive transport network. Public transport is undoubtedly the solution for the less populated cities, preventing the population from becoming increasingly dependent on having a vehicle to move. The results contribute to the literature regarding the organization of district capitals, considering the characteristics of their transport networks. By the size and characteristics of these district capitals, it is minimally easy to get from one point to the other of the city using its transport network, but if we look at this problem in a decentralized way (cities that are not district capitals), we have the notion that it is difficult to travel using an alternative means of transport to the automobile, which is a way of environmentally unsustainable mobility that could be replaced by other, more economical, faster and efficient transport options sustainable.

In this analysis, through the descriptive statistics it was verified that the bus fleet circulating in Portugal is high (13 years-average), resulting from the bad strategy chosen by the transport companies that a policy of cost containment prefer to buy buses to other countries already with a few years of circulation, than investing in new buses. With negative consequences for the population and the environment, the governments must have a preponderant role, given

that grants to these companies are not used in the best alternative. Creating legislation to limit in quantity and age the importation of used buses, like other countries, was essential to take another step towards more sustainable mobility. Although there is a change in the planning of cities, there must be a change in behavior and ways of thinking for citizens, as the use of the private vehicle remains excessive, making unnecessary travels. Transport is undoubtedly one of the main sources of GHG, damaging the quality of the air and consequently the quality of life of the population.

Most cities are not yet prepared for mobility and accessibility to all. The politicians can take advantage of applications for community funds, trying to reinforce the increase in funds for the municipality to apply in this area and thus to try to circumvent this situation, making travel networks accessible, and for example, another proposal, close urban centers to automobile traffic, implementing cyclable infrastructures and extending the quality of other infrastructures. Creating incentives to replace fossil fuel vehicles with electric vehicles is another challenge and policy that should be followed by policy makers or exchange private cars for more sustainable modes (use of bicycles, public transport, shared mobility). So, political decision-makers have a fundamental intervention, creating conditions for this change to happen.

This study was productive to know the reality of transport networks in Portugal, and to know the steps, which in this case, the district capitals are following around a more sustainable mobility. For future research, there is the suggestion of the introduction of another variable in the cluster analysis, for example, the tariff that each city practices, since the social passes and the tariffs of public transport are being the subject of a recast.

8. Conclusion

Mobility, whether by necessity or leisure, is innate to people, being the objective of making it more sustainable, a theme that requires a lot of reflection, for the construction of a fairer and equitable territory, providing the implementation of measures and changes in behaviors. As can be seen in the elaborate dissertation, the planning of cities and the organization of transport has been changing, with the aim of making mobility more sustainable. Cities like Lisbon, which contains more and more technological innovations, offering a set of services and alternatives. But also, cities like Aveiro, Coimbra, Faro, Oporto and Viseu are taking the first steps in intelligent transport inserted in the context of Smart Cities. People must be first, less inequality and more inclusion, promoting demographic inclusion and sustainability. In order to develop sustainable urban mobility, we must all have a preponderant role, for example, to stop giving priority to means of transport with the intention of carbon emissions and to be open to more sustainable solutions. In Portugal there has been an incentive for the betting on electric mobility, currently existing 564 loading stations, distributed by 73 municipalities.

With this study we know the reality of the transport networks in Portugal, where it is concluded that the fleet of buses in circulation is very aged, consequence of bad political decisions and lack of implementation of policies that change this reality. The small medium-sized cities do not have the same advantages as the district capitals, where almost everything is concentrated in them, and it is urgent to decentralize the intervention around an accessible mobility for all. We have been able to know the steps, which in this case, the district capitals are following around a more sustainable mobility. The mobility needs have grown considerably, and in urban spaces the reality is increasingly complex, marked mainly using motorized individual transport, a reality that has serious atmospheric consequences such as atmospheric pollution, greater noise and consequently a decrease in quality of life.

The state has the key and decisive role for Portugal to continue the path of sustainable mobility, implemented policies, creating conditions and incentives for the remaining cities to tread the same path. Sustainable mobility, based on public transport and shared systems, has advantages for all, being the basis of an economic development of the cities of the future, making the experience in the city more fluid and inclusive.

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