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Identifying the determinants of bicycle use: the case of Copenhagen and Lyon

Louis-Marie Portal

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Travail de fin d'études

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- Expert : Matthieu Adam

Par

Louis-Marie Portal

Identifying the determinants of bicycle use: the case of Copenhagen and Lyon

**Danmarks Tekniske Universitet (Université Technique du
Danemark)**



Notice analytique

AUTEUR			
Nom	Portal		
Prénom	Louis-Marie		
ORGANISME D'ACCUEIL			
Nom de l'organisme et Localité	Université du Technique du Danemark, Bâtiment 358 Akademivej, 2800 Kgs. Lyngby, Danemark		
Noms des Tuteurs	Michael Bruhn Barfod et Sonja Haustein		
ANALYSE DU TFE			
Titre (français)	Identification des déterminants à l'usage du vélo : le cas de Copenhague et Lyon		
Titre (anglais)	Identifying the determinants of bicycle use: the case of Copenhagen and Lyon		
Résumé (français)	<p>L'objectif premier de ce mémoire est l'identification des déterminants à l'usage du vélo dans un contexte urbain. La méthodologie repose sur deux études. La première consiste en la comparaison de deux enquêtes de mobilité, l'une réalisée à Copenhague, l'autre à Lyon. Pour cela différents outils statistiques sont utilisés. Ensuite, des entretiens qualitatifs sont conduits auprès d'étudiants internationaux à Copenhague et analysés pour compléter l'étude sur les déterminants. Les résultats permettent de mettre en avant les effets que certaines caractéristiques individuelles (âge, abonnement aux transports en commun), du trajets (distance, météo), spatiales (infrastructures), et le rôle de facteurs socio-psychologiques (normes sociales). Ces résultats permettent d'envisager des propositions de politique d'aménagement pour inciter à l'utilisation du vélo.</p>		
Résumé (anglais)	<p>The main objective of this thesis is to identify the determinants of bicycle use in an urban context. The methodology is based on two studies. The first one consists of a comparison of two mobility surveys, one conducted in Copenhagen and the other in Lyon. For this purpose, different statistical tools are used. Then, qualitative interviews are conducted with international students in Copenhagen and analysed to complete the study on the determinants. The results highlight the effects that certain individual characteristics (age, public transport subscription), journey (distance, weather), spatial (infrastructure), and the role of socio-psychological factors (social norms). These results make possible to consider proposals for a development policy to encourage the use of bicycles.</p>		
Mots-clés (français, 5 maxi)	Vélo, mobilité, déterminants, entretiens, enquêtes		
Mots-clés (anglais, 5 maxi)	Bicycle, mobility, determinants, interviews, surveys		
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1. Introduction

Climate change is a serious issue which catches the attention of several players, such as government, researchers, and populations. The effects are numerous and could jeopardize the way humanity lives¹. Climate change is directly related to greenhouse gas emissions, including carbon dioxide. Several sectors account for all greenhouse gas emissions as shown in Figure 1. Transport is the second largest source of emissions, and the amount of CO₂ emitted by transport activities has increased by 71% compared to 1990².

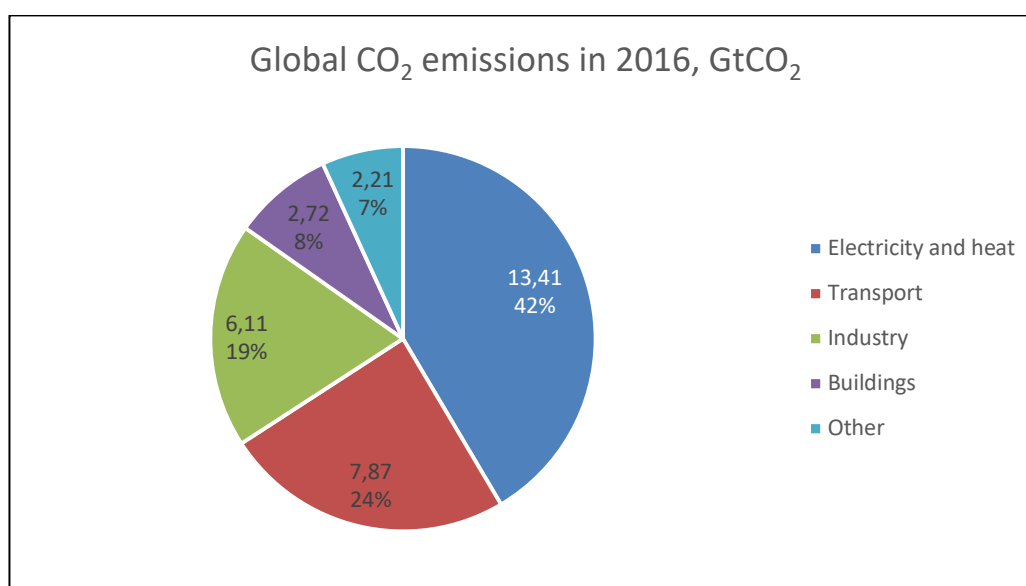


Figure 1 - Breakdown of the CO₂ emissions by sector (2016) - Source: International Energy Agency

In addition, cities around the world are facing problems due to air pollution, noise, accidents, and congestion. One of the main sources of these annoyances is linked to transport. Indeed, road traffic in cities is mainly composed of combustion engine vehicles that are sources of pollution. Many cities exceed the pollutants concentration limits defined by the European Union. For instance, the city of Milan, Italy has exceeded the PM₁₀ limit during 125 days in the period 2002-2007 (Rotaris et al. 2010). It inevitably has an impact on the health of inhabitants (Dockery et al. 1993), and also a cost for the society.

¹ IPCC Press Release (2018):

https://www.ipcc.ch/site/assets/uploads/2018/11/pr_181008_P48_spm_en.pdf

² International Energy Agency (2016): <https://www.iea.org/statistics/co2emissions/>

Some challenges described above have given rise to the concept of sustainable development. This notion has been defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland 1987). This definition clearly highlights the need to rethink many areas as the way energy is produced or the way people travel. Seventeen “Sustainable Development Goals” have been created by the United Nations³. They cover many themes such as poverty, hunger, climate change, and each goal has targets with indicators to meet. One of these goals is about sustainable cities and communities and some targets are about transports:

- Target 11.2: “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.”
- Target 11.6: “By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management”, one of the indicators of which is “Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted).”

Many other goals can be linked to transport as shown in Appendix 1. As a consequence of this awareness, many cities are in the process of reviewing their mobility policies, facilitating the use of less polluting means of transport.

Bicycles can be regarded as a good alternative to private cars as they take less space, do not emit greenhouse gases or polluting particles during their use, are faster than walking, and are cheaper for the user and society. According to Gössling et al. (2019), the cost of car use is 0.885 €₂₀₁₇/km as a private cost and 0.108 €₂₀₁₇/km as an external cost, while bicycle has a private cost of 0.147 €₂₀₁₇/km and an external benefit of 0.184 €₂₀₁₇/km, in the case of the European Union.

Nevertheless, the proportion of bicycle use in daily travels varies greatly from one country to another as shown in Figure 2. Only few countries have a high rate of cyclists, as the Netherlands, Denmark or Finland. In the same time, many European countries have a huge proportion of citizens who never cycle. For instance, in France more than 50% of the population never cycle while this figure is only 18% in Denmark. Moreover, several associations try to develop the use of bicycle in different countries. It is the case of Cycling Embassy of Denmark or Dutch Cycling Embassy which

³ Source: The United Nations, <https://sustainabledevelopment.un.org/?menu=1300>

aims to help policy makers, architects, etc. all around the world to improve the way bicycles are considered thanks to their experience and knowledge. The French Federation of Bicycle Users works to connect local associations and promote the use of bicycles.

It is interesting to compare these two countries as they are both European, and both suffered from the energy crisis in the 1970's. The two countries managed this event differently and Denmark improved conditions for cyclists with specific facilities.

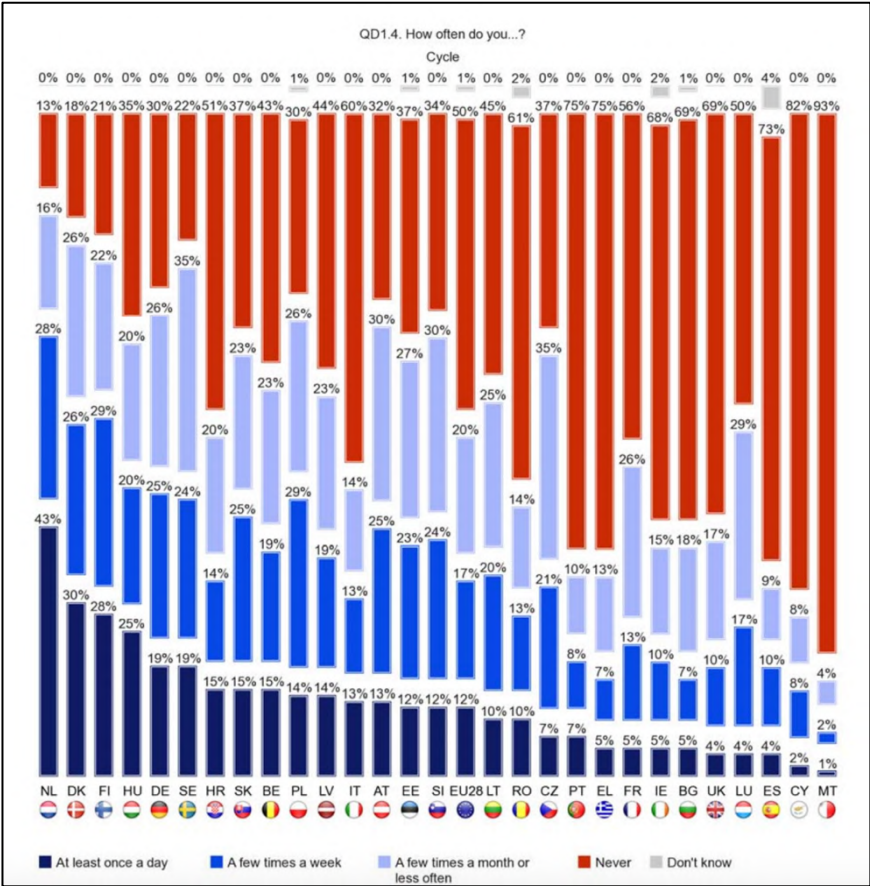


Figure 2 - Breakdown of responses to the question "How often do you cycle" in the survey requested by the European Commission on attitudes of Europeans toward mobility (2013)

In September 2018, the French government has released the bicycle program, "Plan Vélo", aiming at increasing the bicycle use proportion to 9% by 2024, which is equivalent to tripling the use in 6 years. The report highlights the benefits and barriers of using the bicycle in France. It also plans to create a national fund of 350 million Euros aiming at helping local authorities⁴. This amount reflects the French government's desire to develop cycling throughout the country. However, bicycle use

⁴ Source: French government, "Plan vélo & mobilités actives", www.ecologique-solidaire.gouv.fr/plan-velo-et-mobilites-actives

varies between cities. In Strasbourg the modal share of cycling is about 10%, while in Lyon it is around 2-3%⁵. Lyon is one of the largest French cities and therefore faces problems caused, among other things, by the massive use of cars (air pollution, noise, congestion...). The transition to sustainable transport seems to be an important goal for this city. Since the use of a means of transport can be greatly influenced by incentive policies, it seems valuable to look at countries where cycling level is high.

The cities of Copenhagen and Lyon are interesting subjects for study because surveys have been carried out recently, and the Danish capital city has strongly developed cycling culture in recent decades. Moreover, the two cities have rather similar characteristics such as their population size, and different bicycle use as it was 30% of all journeys in the City of Copenhagen in 2014, and 2.5% of all journeys in the City of Lyon-Villeurbanne in 2015 ('Copenhagen City of Cyclists: The Bicycle Account 2014' 2015; 'Enquête déplacements 2015 de l'aire métropolitaine lyonnaise : Résultat sur le SCOT de l'agglomération lyonnaise' 2016).

In the context described above, it is important to examine what differentiates countries from each other in terms of cycling use, and also what elements can lead to the development of cycling. The purpose of this thesis is therefore to answer the question: **How can different factors affect use of bicycle in different urban contexts?** This thesis therefore aims to improve knowledge on the effect of factors in a city where the level of bicycle use is high (here Copenhagen) and in a city where the level of bicycle use is low (here Lyon). It can be expected that between a city where almost everyone rides a bike and another city, some indicators tend to diverge on how they influence this use. It could then be proposed to identify elements from policies, urban planning and culture that could increase the modal share of cycling in a city where its use is low.

First, the study areas will be described in order to set up the working context. In a second part, a literature review will be carried out to find the results obtained so far in other research work and to clarify what can be expected from the upcoming analysis. Thereafter, the general methodology of the thesis will be described. Then, the presentation of the results and their analysis will be carried out. Finally, a part of the discussion will put into perspective what has been done in this thesis.

⁵ Source: Fédération Française des usagers de la bicyclette – French Federation of Bicycle Users

2. Copenhagen and Lyon: two similar cities but still with differences

In this paper, two cities are studied: Copenhagen, the capital of Denmark, and Lyon, one of the most populated cities in France. It seems interesting to start with a brief description of the environment of these two cities, starting with the countries in which they are located.

2.1 France and Denmark, two countries with different characteristics and environment

Although both countries are European and members of the European Union, there are wide disparities in many aspects such as geography, demography and economy.

In terms of geography, the two countries differ in particular in their location within the continent with France in Western Europe and Denmark in Northern Europe. In addition, the sizes of the two countries are totally different: while Denmark's area is about 43,000 km²⁶, France's is about 15 times larger with nearly 633,000 km²⁷. In the same way, the topography of the two territories is totally different, with Denmark showing a slight difference in altitude, while France is composed of different landscapes, some of which are mountainous. Finally, France is composed of a large continental territory called "Metropolitan France" with 13 regions, as well as many overseas territories, whereas Denmark is composed of 3 main parts: Jylland that links the country with Germany, Fyn one of the two main islands of the country, and Sjælland, the other island, where Copenhagen is located. Denmark borders only Germany, but a bridge (Øresundbron) with cars, trucks and trains now links the Copenhagen region to Sweden. France is adjacent to many countries such as Spain, Italy and Germany.

Then, in terms of demographics, the two countries are once again very different. Thus, the French population is estimated in 2019 at almost 67 million inhabitants⁸, while Denmark has about 5.8

⁶ Source: Statistics Denmark, <https://www.dst.dk/en/Statistik/emner/geografi-miljoe-og-energi/areal/areal>

⁷ Source: Institut national de la statistique et des études économiques (INSEE), <https://www.insee.fr/fr/statistiques/1405599?geo=FRANCE-1>

⁸ Source: INSEE, https://www.insee.fr/fr/statistiques/2012713#tableau-TCRD_004_tab1_departements

million inhabitants⁹. Nevertheless, given the different areas of the two countries, the result is a higher population density in Denmark (134 inhabitants/km²) than in France (106 inhabitants/km²). Finally, in terms of economy, countries differ logically in terms of the weight of their GDP, but also in terms of GDP per capita. Indeed, France's GDP amounts to US\$ 2,775 billion in 2018¹⁰ (approximately US\$ 41,400 per capita), while it is US\$ 351 billion in 2018 (approximately US\$ 60,500 per capita) in Denmark¹¹. The unemployment rate is also very different between the two countries, with Denmark having a rate of 5.0% in 2018 (5.7% in 2017), while the unemployment rate in France is 9.1% in 2018 (9.4% in 2017)¹². Finally, although both countries are members of the European Union and the Schengen area, Denmark is not a member of the euro zone and therefore has its own currency: the Danish krone (DKK), whose conversion rate is about 1 DKK = 0.134 €¹³.

These characteristics show that the two countries are different in many aspects. Nevertheless, it can be assumed that the cultures of the two countries are relatively close compared to other more distant countries.

2.2 The two study areas: Copenhagen and Lyon

As mentioned above, Copenhagen is the capital of Denmark, while Lyon is one of the main cities in France.

It seems interesting to start by locating these two cities in Denmark and France. As can be seen in Figure 3 and Figure 4, the two cities are located in different environments. While Copenhagen is

⁹ Source: Statistics Denmark, <https://www.dst.dk/en/Statistik/emner/befolkning-og-valg/befolkning-og-befolkningsfremskrivning/folketal>

¹⁰ Source: International Monetary Fund (IMF), <https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/weorept.aspx?pr.x=59&pr.y=10&sy=2018&ey=2018&scsm=1&ssd=1&sort=country&ds=.&br=1&c=132&s=NGDPD%2CPPP&gdp=0&a=>

¹¹ Source: IMF, https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/weorept.aspx?pr.x=66&pr.y=17&sy=2016&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&c=128&s=NGDP_RPCH%2CNGDPD%2CPPP&gdp=0&a=

¹² Source: Eurostat, <https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tps00203&plugin=1>

¹³ Source: XE.com, <https://www.xe.com/fr/currencyconverter/convert/?Amount=1&From=DKK&To=EUR>

located on the Baltic Sea, near Sweden, Lyon is far from any coastline but is relatively close to Italy and Switzerland. The populations and areas of the cities of Copenhagen and Lyon are about 600,000 inhabitants over 87 km² (6,900 inhabitants/km²)¹⁴ and 500,000 inhabitants over 48 km² (10,400 inhabitants/km²)¹⁵ respectively. However, the two cities form a larger and more populated territory with their suburbs. Both cities have densely populated suburbs and are located close to other large cities (e. g. Malmö in Sweden for Copenhagen, and Saint-Etienne or Grenoble for Lyon). It is important to take into account a larger territory than that of municipalities alone, because mobility, even daily, is not limited to these areas alone. The geographical positions of the two cities also lead to a difference in climate and in daylight and darkness. Indeed, the duration of December 21st in Denmark is about 7 hours (sunrise at 8:37, sunset at 15:38), while it is 8 hours 40 minutes in Lyon (sunrise at 8:18, sunset at 16:58). On the other hand, on June 21, the day lasts 17 hours 32 minutes in Copenhagen (sunrise at 4:25, sunset at 21:57) and 15 hours 43 minutes in Lyon (sunrise at 5:50, sunset at 21:34).



Figure 3 - Location of Lyon, France - Source: Google Maps

¹⁴ Source : Statistics Denmark, <https://statistikbanken.dk/statbank5a/default.asp?w=768>

¹⁵ Source : INSEE, <https://www.insee.fr/fr/statistiques/1405599%3Fgeo%3DCOM-69123>

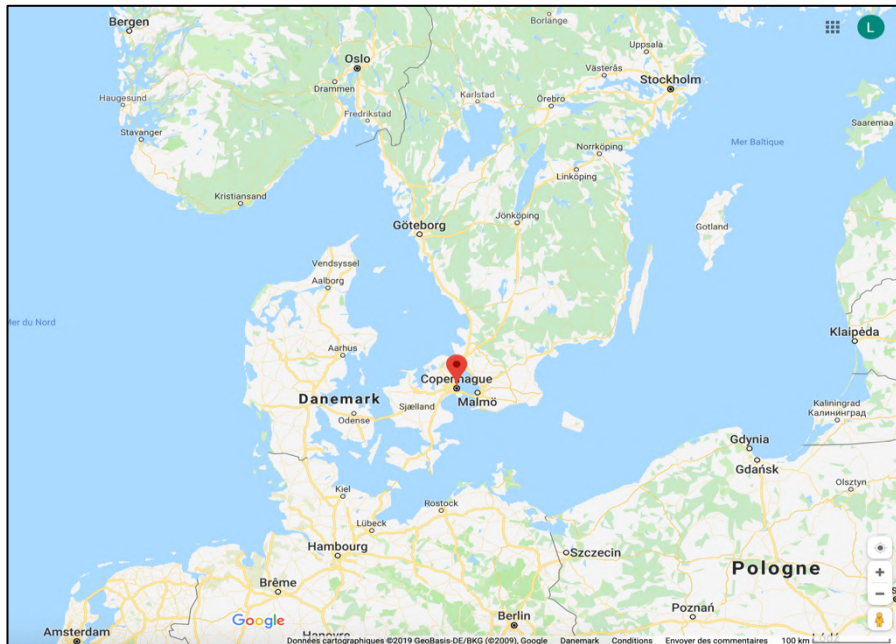


Figure 4 - Location of Copenhagen - Source: Google Maps

As presented above, the two cities have many geographical differences, but are rather similar in size (both in terms of area and population). Transport in both cities seems an interesting aspect to describe here.

First of all, the location of Copenhagen leads to a development of the city and therefore of its road network to the north, west and south, but the east is only served by the road over the Øresund bridge to Sweden. A few high-capacity roads converge towards the city, and rings surround the city and its suburbs. Lyon is served by highways from the 4 cardinal points, and a ring road surrounds the city from the north, east and south.

In terms of public transport, the two cities have different offers. Lyon has 4 metro lines, 5 tram lines, many bus lines and is served by national (and international) trains as well as regional trains in different stations. The city of Copenhagen also has a developed bus network, but no tramway and only two active metro lines (2 more are under construction, including one for September 2019). Nevertheless, there are 7 commuter train lines that also serve several stations in the city centre, and many regional and national trains serve cities further from Copenhagen. Finally, there is a regular train service between Sweden and Denmark. It may also be interesting to note that there are boats that serve several points in the city using the canals.

Finally, it is relevant to look at the cycling infrastructure in both cities. It appears that the two cities have very different bicycle infrastructure networks, as shown in Figure 5 and Figure 6, which are on the same scale. These two quarters show in particular that cycle routes in Lyon are limited and that there is little continuity of cycle paths, contrary to what can be observed in Copenhagen.

Although the density of cycling development seems high in the centre of Lyon, it tends to decrease sharply as soon as the perimeter of the city of Lyon is exceeded, while infrastructure seems to continue throughout the Copenhagen urban area. In addition to cycling infrastructure, both cities have a bicycle rental system, "Vélo'v" for Lyon and "Bycyklen" for Copenhagen. While Vélo'v are normal 3-gear bicycles, Copenhagen city bikes are equipped with an electric motor to assist pedalling. Both systems offer similar pricing schemes in that occasional use is different from regular use. For instance, in Copenhagen it is possible to rent a bike by paying 30 DKK (approximately 4€) for each commenced hour, or to subscribe and get a certain amount of free usage time per month and then pay for each additional minute. In Lyon, for cycling occasionally, users have to pay a ticket for one day or one trip (4 € and 1.8 € respectively) with the first 30 minutes of each trip free, and then to pay for each additional time. It is also possible to subscribe and to have the first 30 minutes of each trip free.

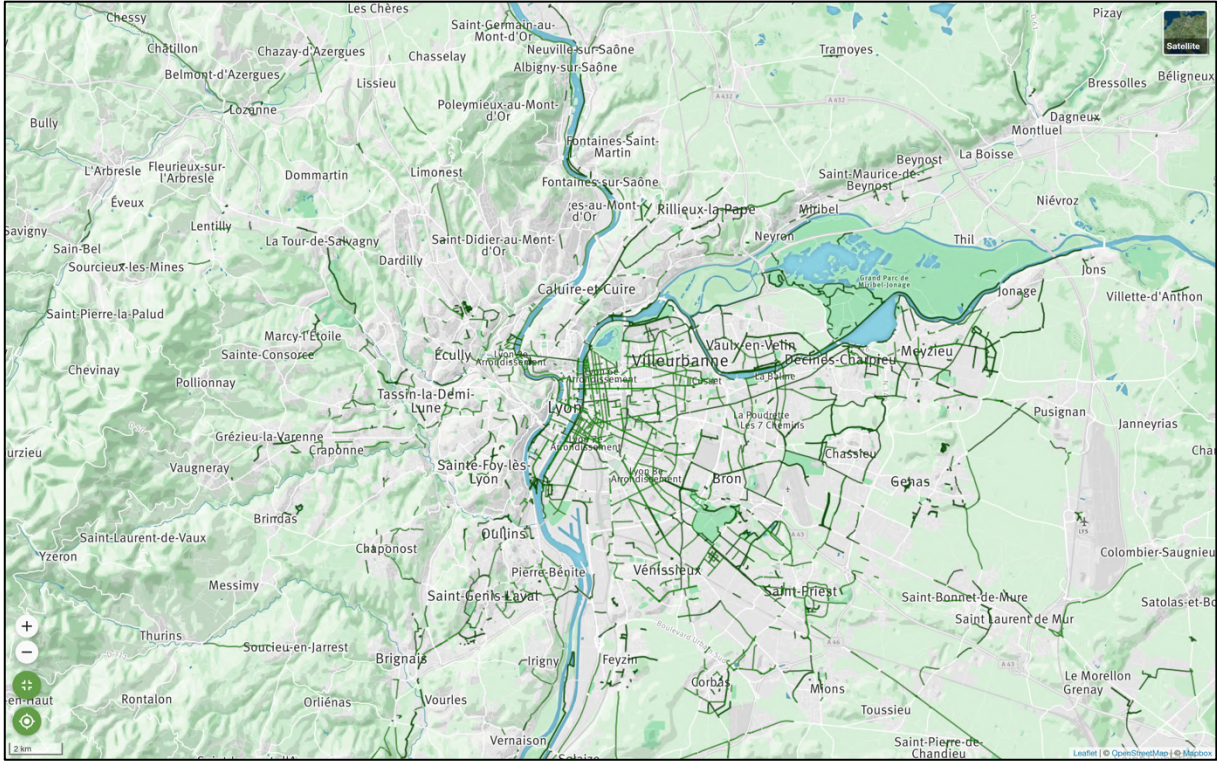


Figure 5 - Bicycle infrastructures (in green) in Lyon, France - Source: Geovelo

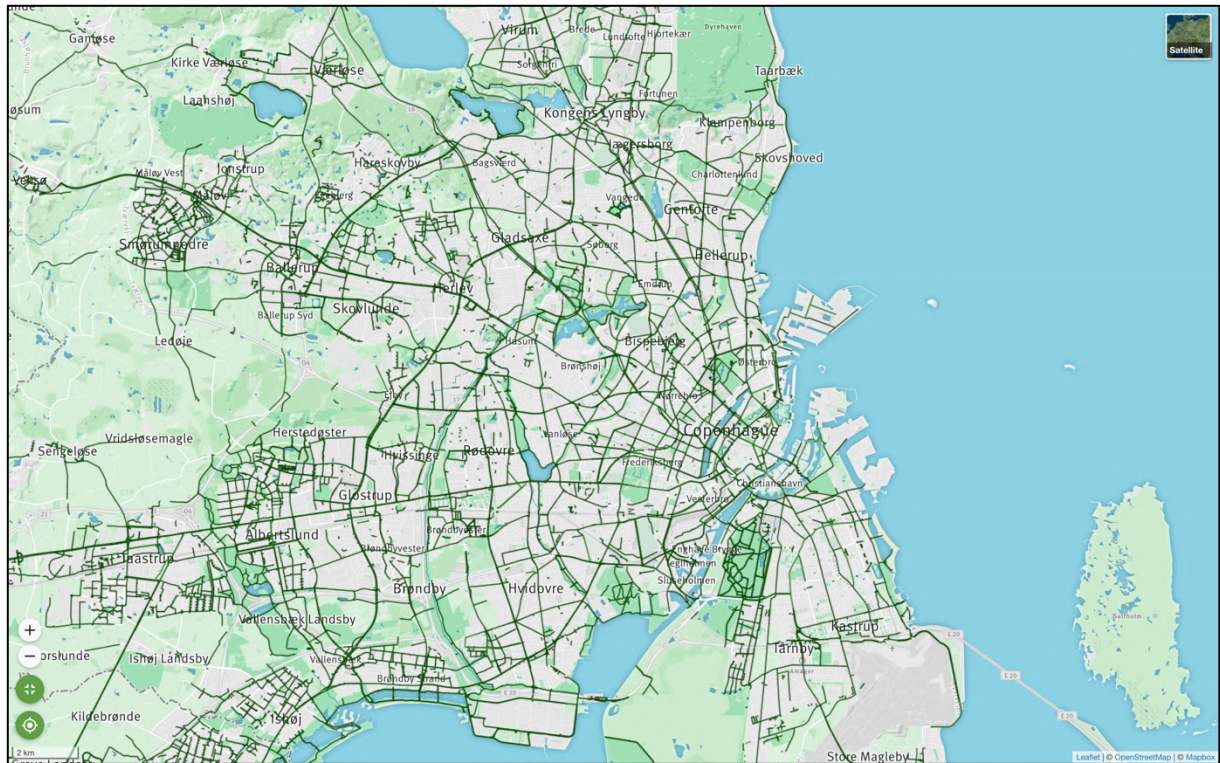


Figure 6 - Bicycle infrastructures (in green) in Copenhagen, Denmark - Source: Geovelo

The cities of Copenhagen and Lyon therefore have some similarities but are also different in many respects, even in terms of the organisation of public transport and bicycle rental. It is interesting to present these differences and similarities because they provide part of the context of the study. The use of bicycles in these two cities will be described in a following section.

3. Literature review

3.1 Historical evolution of bicycle use

The use of the bicycle varies a lot from one country to another. These countries can be categorized in groups depending on the place that bicycles take in the mobility culture (Carré 1998). Carré distinguishes five groups: (i) countries where the bicycle is the main means of transport but the modal share is decreasing, (ii) countries where the bicycle is one of the main means of transport and stays at a high level, (iii) countries with a high level of cycling but decreasing for urban use, (iv) countries with less developed cycling infrastructures, and (v) countries with a really low use of bicycle and an uncertain future. Differences between countries can be explained by several factors. For instance, many countries where the use of bicycle used to be high but decreases for years, are countries with a recent strong increase in purchasing power, which increases citizens transport options and possibilities of car use. The situation of countries where bicycling has never been popular can be explained by different factors, such as a lack of tradition for cycling and policy support.

Over the years, the use of bicycles has evolved in society. According to Carstensen and Ebert (2012), the history of the bicycle can be divided into two eras: the “Golden Age of cycling” and the “Renaissance”. The first era corresponds to the technical development of the bicycle into a safe vehicle and the evolution of the culture. During the 1890s, students and merchants from the upper middle class were the main users of the bicycle. In the following years, the place of the bicycle has changed. Before the end of the nineteenth century, the bicycle was a leisure mode for the upper class, while in the middle of the twentieth century, it had become a popular means of transport. This trend is most pronounced in Denmark and the Netherlands, where the bicycle is a part of the national identity.

The interwar period corresponds to the raise of the car culture. This vehicle was seen as a huge technological progress offering a more practical means of transport. This period has seen the modal share of bicycling falling in all European countries. However, the cycling culture survived in Denmark and the Netherlands, where it was a national symbol. Moreover, in the 1970s and 1980s, the oil crisis revealed a dependence on potentially expensive and limited energy. Environmental awareness has been added to the existing elements leading to a “Renaissance” of the bicycle. For Carré, the same kind of chronological classification can be done in France. It includes three eras: “bourgeois age”, “popular age” and “ecological age”. These three periods are similar to the evolution of the cycling culture described by Carstensen and Ebert. While European countries have experienced almost the same economic and sociological events, the difference in bicycle use shows

that other factors need to be taken into account to explain why the proportion of cyclists differs considerably across countries.

3.2 Mobility within cities: externalities from the use of car and bicycles as a solution

Even if national figures can give an idea of bicycle use, differences can exist between cities within the same country. For instance, the difference about bicycle culture in four English cities is explored in (Aldred and Jungnickel 2014). This paper reveals that it is important for policy makers to take into account all aspects of the local transport culture when it comes to change it. This article also highlights the need to analyse the mobility behaviour on a fine-scale, such as that of cities.

In today's society, urban car use is at a high level, and the place it is given in cities is very important. The use of car is an issue for cities, as it is a transport mode with a high level of negative externalities. It should be recalled that negative externalities could be defined as external costs that are not borne by the user, but by the community. The main kinds of externalities can be identified as being road congestion, air pollution, noise and accidents (de Palma and Zaouali 2007; Santos et al. 2010). All these externalities have an impact on society, and research has sought to monetarize these effects to give them an economic meaning. As a result, citizens of cities suffer from health risk through air pollution, time lost through congestion, etc.

Moreover, the populations are sensitive to the financial crisis when it comes to mobility (Cascajo et al. 2018). In this paper, the effects of the financial crisis that emerged in 2007 are analysed through the Spanish case. The conclusion is that the financial crisis caused a decrease of the use of transport (car and public transport). The share of transport in household expenditures has been reduced, mainly by the decision of not buying new car and by reducing the use of car. However, the household wealth is a factor influencing how the transport budget has evolved. For instance, the richest households have hugely reduced their expenditures, while the poorest households could not strongly reduce their budgets as they were already as small as possible. This study also shows that the residential density is potentially related to the access to alternative means of transport. Moreover, the financial crisis forced Spanish cities to reduce their public transport operation costs. Some of them found a way to reduce the costs without decreasing the performance of their systems, but other had to decrease transport supply. This situation raises the question of how another means of transport could be used by the population at lower costs. Moreover, this issue is a current topic given the evolution of fuel prices and policies that discourage the use of polluting, and therefore often old, cars in cities.

Bicycles could be an answer to this question. Indeed, it appears that bicycle use is less expensive than the use of car (Gössling et al. 2019). This paper focuses on cost-benefit analyses used for transport projects. After a review of the different parameters taken into account to calculate the cost-benefit analysis, external and private costs of three transport modes are presented:

- Private cost:
 - Car: 0.885 €₂₀₁₇/km; Bicycle: 0.147 €₂₀₁₇/km; Walking: 0.499 €₂₀₁₇/km
- External cost:
 - Car: 0.108 €₂₀₁₇/km; Bicycle: -0.184 €₂₀₁₇/km; Walking: -0.370 €₂₀₁₇/km

Another paper conducts a study in the city of Copenhagen and aims at doing a cost-benefit analysis to compare bicycle and car (Gössling and Choi 2015). The conclusion is that the total (for user and society) cost of car use is 0.511€/km, while it is 0.243 €/km for bicycle. As shown in Figure 7, it takes into account several elements as the time cost (through the travel time, which is longer as bicycle speed is lower), the vehicle operating costs, health impact of having an active mode, etc. Costs are allocated whether they are paid by the user or by the community.

	Cycling (16 km/h)			Car (50 km/h)			
	Private	Social	Total	Private	Social	Duties	Total
Time costs (travel time)	0.672	0	0.672	0.215	0	0	0.215
Vehicle operating costs	0.044	0	0.044	0.296	0	-0.159	0.137
Prolonged life	-0.358	0.008	-0.348	0	0	0	0
Health	-0.149	-0.242	-0.391	0	0	0	0
Accidents	0.034	0.073	0.105	0	0.030	0	0.030
Perceived safety	+ (?)	0	+ (?)	?	?	0	?
Discomfort	?	0	+ (?)	?	?	0	?
Branding/tourism	0	-0.003	-0.003	?	?	0	?
Air pollution	0	0	0	0	0.004	0	0.004
Climate change	0	0	0	0	0.005	0	0.005
Noise	0	0	0	0	0.048	0	0.048
Road deterioration	0	0	0	0	0.001	0	0.001
Congestion	0	0	0	0	0.062	0	0.062
Total	0.243	-0.164	0.081	0.511	0.152	-0.159	0.503

Figure 7 - Average cost per kilometre for cycling/car for 2008 (Euro) (Gössling and Choi 2015)

This cost gap is an important element in the socio-economic analysis of bicycle use. If it is perceived as such by users, it can affect their modal choice. It is also a way to show the social cost of these two means of transport.

3.3 The use of bicycle in Copenhagen and Lyon

In the two cities there are regular studies on the mobility of residents:

- The Bicycle Account, for Copenhagen, is a report released every 2 years since 1996 and is conducted by the City of Copenhagen.
- L'Enquête Ménage Déplacement is a survey regularly conducted in French cities. It has been conducted three times for the city of Lyon (1995, 2006 and 2015). The main results from these surveys are presented in various reports.

In order to have global information of the mobility in both cities, two of these reports are employed ('Copenhagen City of Cyclists: The Bicycle Account 2014' 2015; 'Enquête déplacements 2015 de l'aire métropolitaine lyonnaise : Résultat sur le SCOT de l'agglomération lyonnaise' 2016). The first deals with the use of bicycle in the City of Copenhagen. In 2014, the proportion of people who cycle to work and education was 45%. In 2004, this proportion was 36%, which corresponds to a large increase in 10 years. Other elements are presented, such as the satisfaction of users with state of cycle tracks which rose from 50% to 63% in the same period, and the number of casualties which has strongly decreased compared to 1995. The use of bicycle is less developed in Lyon, as the report shows. For inhabitants from the city of Lyon-Villeurbanne, the modal share was 3% in 2015, stable compared to 2006. However, this report shows comparison of modal share between 2006 and 2015: use of car has decreased by 10% while use of public transport and walking have increased by 6% and 4% respectively. The Table 1 highlights the breakdown of all journeys with start or stop in the two cities. The main results are the difference about use of bicycle, but also walking modal share which is significantly higher in Lyon-Villeurbanne than in Copenhagen.

Although these two reports are based on data that do not have exactly the same scope of study, it is possible to identify a difference in mobility behaviours.

<i>Modal share in number of trips</i>	City of Copenhagen	City of Lyon-Villeurbanne
Car	33%	26%
Public transports	20%	26%
Bicycle	30%	3%
Walking	17%	45%

Table 1 – Breakdown of the main transport modes trips in the cities of Copenhagen and Lyon
 ('Copenhagen City of Cyclists: The Bicycle Account 2014' 2015; 'Enquête déplacements 2015 de l'aire métropolitaine lyonnaise : Résultat sur le SCOT de l'agglomération lyonnaise' 2016)

3.4 Understanding modal choice and determinants of the bicycle use

The difference in bicycle use observed in Lyon and Copenhagen reveals that citizens from both cities do not make the same decisions about their mobility. According to De Witte et al. (2013),

there are three approaches to explain decision: (i) the rationalist approach, (ii) the socio-geographical approach, and (iii) the socio-psychological approach. The *rationalist approach* defines the choice made as the least costly alternative in terms of time and money (Shen, Sakata, and Hashimoto 2009). This approach also assumes that people have access to all the information about their travel and they all perceive the same characteristics. The *socio-geographical approach* takes into account the activities which are the reasons of the travel. This approach conducts to the inclusion of a spatial component in the modal choice. Then, the *socio-psychological approach* is related to psychological factors as attitudes, habits, norms, etc. Many papers conclude that a proper model of modal choice should consider economic aspects added with factors from geography and psychology. As a result, both objective and subjective factors would be taken into consideration.

A structure describing the role of elements in the modal choice is composed of two aspects illustrated in Figure 8:

- Three types of determinants: socio-demographics indicators (age, gender, education, occupation, income, household composition, car availability), spatial indicators (density, diversity, proximity to infrastructure and services, frequency of public transport, parking), journey characteristics indicators (travel motive, distance, travel time, travel cost, departure time, trip chaining, information, interchange). These three types of determinants are linked, meaning they can influence each other.
- Socio-psychological indicators (experiences, familiarity, lifestyle, habits, perceptions), referring to subjective indicators.

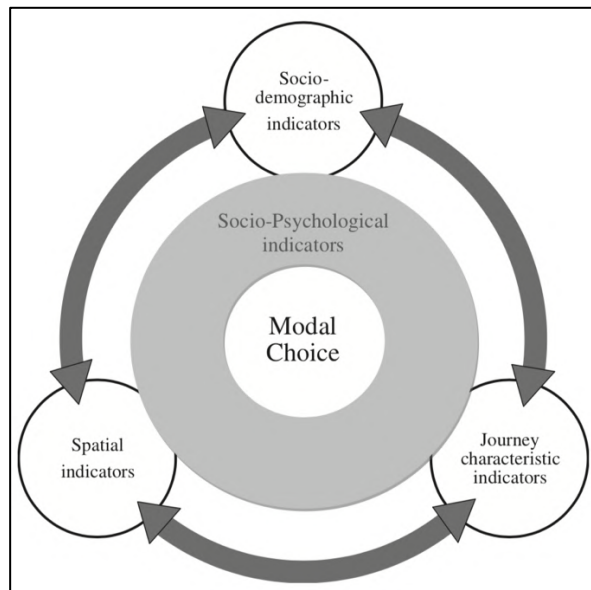


Figure 8 - Illustration of the interaction of indicators in the modal choice process (De Witte et al. 2013)

So, the modal choice is defined as the result of interaction between socio-demographic, journey characteristics and spatial indicators mixed with subjective indicators through socio-psychological factors. This modal choice structure can be applied to different means of transport, notably bicycle. Many researches have been made on the use of bicycle, and many of them devote a part to the study of these determinants. The next parts will focus on the results found in the literature. For this purpose, articles reviewing the literature, such as (De Witte et al. 2013) and (Heinen, van Wee, and Maat 2010), were used.

3.4.1 Socio-demographics factors

Socio-demographics indicators allow to have a description of the traveller through information like age, education, etc.

Gender and age seem to have an effect on bicycle use. However, this effect depends on the average use of bicycle in the country/city studied. For instance, in a country with a low cycling level, men and young people are more likely to cycle (Aldred, Woodcock, and Goodman 2016). In a comparison of bicycle use in Stockholm and Copenhagen, the gender effect is observed as women are more likely to cycle in Copenhagen (Haustein et al. 2019). A survey conducted in Texas shows that socio-demographics characteristics, such as gender and age, are related to the perception of safety and quality of bicycle use: men and young people are likely to perceive it better (Sener, Eluru, and Bhat, n.d.). According to many other studies, the gender effect seems to depend on countries cycling level as described above, whereas the relation between cycling and age is not clear for some

studies but is in accordance with previous results for other studies (Heinen, van Wee, and Maat 2010).

Several studies show that other socio-demographics characteristics such as household incomes, household size, or car ownership have an effect too. For instance, in Portland, Oregon it appears that cycling level increases with incomes (Dill and Voros 2007). However, the relation between income and cycling is not clear, and some studies show that cycling is inversely proportional or simply not related to income (Heinen, van Wee, and Maat 2010). An increase of the number of cars in the household leads to the fall of the bicycle used (Parkin, Wardman, and Page 2007). Moreover, it appears that education level is linked to bicycle use. Indeed, a higher education level increase propensity to cycle (Handy, Xing, and Buehler 2010). According to studies made on adolescent's population in Germany and the Netherlands, socioeconomic status and parents working status affect the modal choice: for instance, having working parents seem to increase bicycle use for adolescent from Rotterdam, while having a lower socioeconomic status seem to decrease bicycle for German adolescents (Bere et al. 2008; Reimers et al. 2013; Debruijn et al. 2005).

So far, numerous studies were conducted on the effect of socio-demographics factors on the use of bicycle. However, not all results seem to converge and the way some factors influence cycling appear to be depending on level of cycling in the country or the city.

3.4.2 Spatial indicators

Spatial indicators are defined as "elements characterizing the spatial environment in which the journey and thus modal choice takes place", and it refers to different factors such as population density, land-use diversity, or parking, that can have effect modal choice (De Witte et al. 2013).

It appears that cycling propensity increased with urbanized areas and land-use mixture (Harms, Bertolini, and te Brömmelstroet 2014; Heinen, van Wee, and Maat 2010). It can be linked with the fact that more shops, workplaces, etc. are accessible on a small distance. The size of the city can also be an element influencing the probability to use bicycle. Two studies show that small- and medium-sized cities have the highest bicycle share probability in the Netherlands (Heinen, van Wee, and Maat 2010). In the same article, it appears that denser road structure can have a positive influence on bicycle use, but it is not clear as other studies show that there is no significant relation.

In addition to urbanization status, bicycle facilities can be considered as determinants too. For instance, safe parking possibilities is perceived as a good point for cyclists (Hunt and Abraham 2007). Bicycle paths are taken into account by potential cyclists, and comparative analyses show the link between cycling facilities and the modal share of cycling, as well as traffic lights that require

cyclists to stop and accelerate (Heinen, van Wee, and Maat 2010). Then, the way car parking facilities are located in the street can have an influence on safety but results are not clear about that (Heinen, van Wee, and Maat 2010).

Hilliness is also expected to be an important factor, but studies show that the perception and preference to flat or hilly area depends on the motives of the trip (daily commuting or sport, for instance) and the cyclist's level of experience (Heinen, van Wee, and Maat 2010). One explanation can be that unexperienced cyclists prefer flat area, compared to experiences ones. However, a lot of determinants and factors have to be taken into account.

Various spatial indicators seem to have an effect on the use of bicycle, but a significant part of these spatial characteristics might be related to the perception of each cyclist.

3.4.3 Journey characteristics

Journey can be described through several characteristics such as the weather, the distance, information, etc. All these characteristics have potentially an effect on modal choice, thus on bicycle use.

About weather condition, it appears that temperatures and precipitations have a negative effect on commute bicycling (Nielsen, Mulalic, and Christiansen 2016; Nankervis 1999; Bergström and Magnusson 2003; Parkin, Wardman, and Page 2007). Precipitation and chance of rain would be the most negative weather aspect, but the way it is measured can conduct to different results (Heinen, van Wee, and Maat 2010). Temperature is also a significative factor but depending on characteristics of cyclists. It appears that commuters are less influenced by temperature than other cyclists (Heinen, van Wee, and Maat 2010).

Distance is a factor that impacts the use of bicycle (Handy, Xing, and Buehler 2010; Heinen, van Wee, and Maat 2010; Parkin, Wardman, and Page 2007). Indeed, the distance is often related with time and effort, two aspects that seek to be minimized.

Other journey characteristics also play a role in the use of bicycle. For instance, travel costs (not only cycling costs but other means of transport too) is related to cycling, and having free public transport tends to decrease cycling modal share. As an opposite effect, it can be expected that paying people to commute by bicycle would have a positive effect. It can be illustrated by the "bicycle kilometric allowance" that exists in France.

Journey characteristics can have significant effects on the use of bicycle. But once again, the perception of each cyclists is taken into account.

3.4.4 Socio-psychological indicators

As de Witte points out, socio-psychological factors are part of the modal choice process in the sense that they influence the traveller's final decision. This aspect of socio-psychological factors is linked to the theory of planned behaviour, which is combined with the effect of socio-demographic determinants and trip characteristics. The theory of planned behaviour has been constructed by Icek Ajzen and is composed of three main aspects (Milković and Štambuk 2015; Heinen, van Wee, and Maat 2010): (i) **attitude** that corresponds to the traveller's perception and evaluation of the use of the mode of transport, (ii) **perceived social norms** that are linked with the modal choice process by the pressure that is felt by the traveller about the mode of transport used, and (iii) **perceived behavioural control** that refers to the way people perceive if it is easy or difficult for them to perform a behaviour.

However, these three aspects from the theory planned behaviour do not seem to cover all the elements related to the socio-psychological indicators. Thus, while the theory of planned behaviour assumes that decisions are based on rational choices, it seems that other elements such as **habits** can put this assumption into question (Heinen, van Wee, and Maat 2010).

Different studies show that modal choice is not only linked to socio-demographic and instrumental attributes but also to hedonic, symbolic and affective attributes (Steg 2005; Schuitema et al. 2013; Hunecke et al. 2007). These studies, which focus on different modes of transport, underline that policy makers must consider all these elements if they want to effectively promote one mode of transport over others.

The **attitude** towards car use is generally more positive than that towards bicycle use (Heinen, van Wee, and Maat 2010). In that way, the use of bicycle depends on the evaluation people make of cycling, but also of other vehicles. For instance, if someone considers car use negatively, he/she is more likely to use another means of transport that can be bicycle. Moreover, attitude is related to symbolic and affective motives, that have an effect on the use of certain transport modes (Steg 2005). Then, the pressure related to **social norms** seems to have a strong effect on the use of a specific mean of transport (Heinen, Maat, and Wee 2011). For instance, non-cyclists surrounded by a high number of cyclists are more likely to consider cycling (Aldred and Jungnickel 2014). One study combines social norms and personal norms into ecological norm and is related with the use of environmental friendly means of transport (Hunecke et al. 2007). In the case of bicycles in particular, it appears that social norms are important in the modal choice process, including the perception of better support (Heinen, van Wee, and Maat 2010). The aspect of **perceived behavioural control** is also strongly linked to bicycle use, as cyclists and non-cyclists perceive

differently possibilities and barriers to cycle (Heinen, van Wee, and Maat 2010). It appears that it is an important factor in the choice of using a bicycle (Milković and Štambuk 2015). However, these three aspects rely on rational choices, whereas other element can be taken into consideration. **Habits** need to be break, and bicycle use seems to be related to that. Indeed, the propensity to use a bicycle increases with the fact that cycling is often practiced (Heinen, van Wee, and Maat 2010). On the other hand, it can be assumed that the habit of using another means of transport requires an additional effort to be transformed into cycling.

This literature review highlights the many factors that seem to be linked to the modal choice process. While some individual indicators but also spatial and trips characteristics are linked to modal choice, socio-psychological elements influence the traveller's final decision. The influence of factors differs according to the means of transport studied. In the case of cycling, the results in the literature sometimes converge but also often diverge. It seems that the results depend on certain elements such as the study areas or the way the data are considered. However, some articles dealing with the effect of different factors on modal choice highlight that not only infrastructural or socio-demographics attributes are related to that choice, but socio-psychological factors, such as symbolic and affective motives, also play a significant role in this process, thus, these articles indicate that policy makers should rely not only on socio-demographic elements, but also on the influence of these socio-psychological factors . In the end, this literature review can give a first idea of the determinants that could be revealed in the case of Copenhagen and Lyon. The following studies will confirm or refute these results.

3.5 Research questions

As presented previously, the modal choice process refers to many factors and the objective of this study is to determine the different factors that influence the use of bicycle in a city with a high cycling level and in a city with a low one in order to answer to the general question: How can different factors influence modal choice by favouring cycling? As reminder, the modal choice process can be described as being relative to several factors: (i) socio-demographic, spatial and journey indicators, and (ii) socio-psychological indicators. The broad objective of this work is to study the influence of different factors on the use of bicycle in two cities in order to provide information on how to promote cycling. It appears interesting to these determinants cannot be studied according to the same methodology, and it is therefore proposed to conduct the entire study in two parts described below.

The first part of this thesis aims at identifying and comparing the effects of the first (i) kind of factors between the cities of Copenhagen and Lyon. As illustrated in previous papers, it appears that in high cycling cities and low cycling cities these factors could have different effects. For instance, gender and age affect the use of the bicycle differently depending on the cycling level of the city. For factors like income and education, the effects are less clear. The main research questions are: How socio-demographic, spatial and journey characteristics affect bicycle use in Copenhagen and Lyon? Do they have the same effects in the two cities? As quantitative data are available for both cities, it seems valuable to carry out a statistical analysis to determine the influence of factors, and to compare them. According to the literature and the classification of Lyon and Copenhagen in low cycling cities and high cycling cities respectively, some results can already be expected. It is the case of gender and age influences that might be significant in Lyon but not in Copenhagen.

The second objective is to focus on the cycling culture in Copenhagen and its perception. As several papers show, socio-psychological aspects are a part of the modal choice process. These socio-psychological factors are composed of attitudes, social norms, etc. It seems interesting to study this aspect in the case of Copenhagen, a capital city where many international students and workers come, and where the cycling culture is strongly established. The main research questions are: How do Copenhagen newcomers perceive this culture? What are the main aspects that encourage or discourage them to use bicycles? Would it be a benefit for low cycling countries to implement aspects of the Danish cycling culture? In this context, it seems appropriate to study how foreigners living in Copenhagen, as they are residents with an external point of view, about their perception of the cycling culture, and their behaviour and thoughts about this means of transport. It can be expected that the short-term residents' perception depends on the place where they used to live before, and the experiences they had. As cycling infrastructures are highly developed, it can encourage people to bike, but crowded cycle lanes and excessive speed of some cyclists may be discouraging. It can also be expected that bicycle use is related to alternatives in the cities: for example, high public transport prices may encourage people to choose or switch to another transport mode.

4. Methodology

In order to answer the various research questions asked previously, a general methodology has been put in place. In this section, the organization of the methodology will be presented before describing more precisely each important aspect of it.

4.1 Overall methodology of the thesis

The purpose of this thesis is to answer the problem proposed in the introduction. So, the aim is to identify the elements that influence bicycle use in urban areas. As noted in the literature review, there are many factors involved in the modal choice process. These may be characteristics specific to the individual, as well as perceptions of the environment or characteristics related to the journey being considered. As mentioned above, this paper seeks to analyse two aspects of bicycle use: the differences that can emerge in the determinants of bicycle use between two different cities, and those that explain why use is so important in Copenhagen. To this end, the work has been divided into two main parts: (i) statistical analysis of surveys carried out in Copenhagen and Lyon in order to reveal the determinants and compare them with each other, and (ii) study of the perception of bicycle use in Copenhagen. The two analyses carried out required a certain methodology, which will be described in the following sections and can be summarised through the Figure 9.

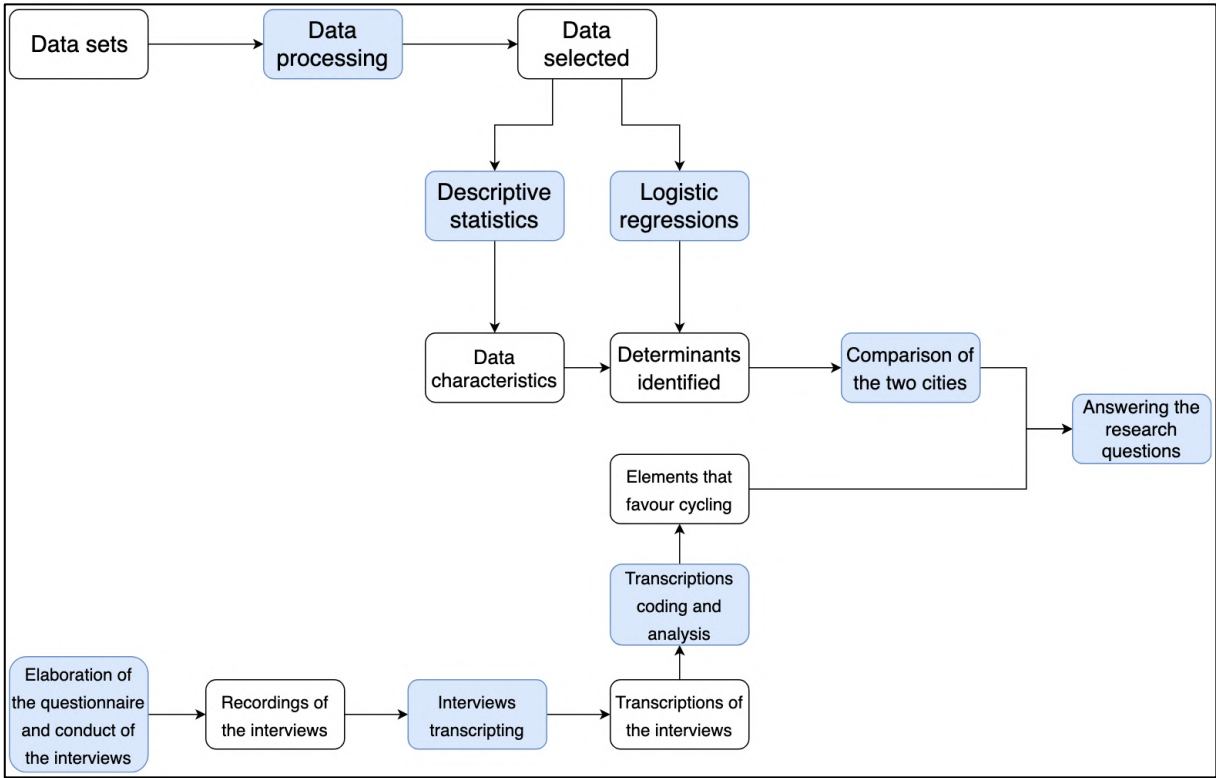


Figure 9 - General methodology used to answer the research question

The white boxes correspond to the different elements, whereas the blue ones correspond to the operations made during all the studies. This general methodology will be detailed in the following parts, first about the data analysis and comparison, and then about the interviews.

4.2 Analysis of the two data sets

As described above, two studies are carried out in this paper. The first consists of the statistical study of two surveys conducted in Copenhagen and Lyon. As the two surveys have been made differently, the first step in this study is to present the origins of the data and what make them different. Once the main differences have been revealed, and in order to compare these data statistically, it is necessary to select comparable data and construct variables with similar structures. Finally, the statistical study is carried out using different tools that will be presented later.

4.2.1 Two data sets, two different origins

As mentioned above, the two surveys were conducted independently, by different entities, and using different methods. It is therefore interesting to present the origin of these two surveys in order to highlight their differences.

4.2.1.1 TU data

The *Transportvaneundersøgelsen* (TU) is the Danish National Travel Survey. Its history is composed of three temporal parts. The first one starts in 1976 with a first survey, then followed by two other surveys in 1981 and 1986. The second generation of the surveys lasts from 1992 to 2003, and a lot of changes were made during this period. After two years without survey, due to withdrawal of financing, the current and third generation of the survey has been launched in May 2006 and is still running now (Christiansen and Skougaard 2015). These data were provided by the *Danmarks Tekniske Universitet* (Technical University of Denmark - DTU), through DTU Transport¹⁶.

Concerning the survey process, the target population is Danish residents from 9 to 84 years old, and the respondents are selected through the Danish Civil Registry (CPR) which provides a registration number to all Danes and people living in Denmark. The CPR allows to have access to information on gender, age, address, etc. In general, the travel survey is expected to have 1,000 respondents per month which corresponds to 60% answer rate compared to the initial target of

¹⁶ Data source: DTU Transport, <https://doi.org/10.11581/dtu:00000034>

20,000 respondents per year. Then, the final information come from web and telephones interviews. These interviews are conducted on a continued time period which means that for almost each day of the year there are corresponding interviews.

Then, data are structured in 6 tables which are: Session, journey, *Tur* (Trip), *Deltur* (Trip stage), Household and *Bil* (Car). All these tables allow to have numerous information about respondents, but also household situations and trips characteristics.

4.2.1.2 EMD data

The *Enquête Ménage Déplacement* (EMD) is a survey conducted in different French cities. It is conducted by cities with the help of the French State and the CEREMA (*Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement* - Centre of studies and expertise on risks, environment, mobility and development). A common method has been created during the 1970s and is still updated. The use of this common method allows to have comparable results through space and time. Data of this thesis were provided by the Laboratoire Aménagement Économie Transports (Transport, Urban Planning and Economics Laboratory – LAET).¹⁷

The survey was conducted through face-to-face or phone interviews from the 7th October 2014 to 11th April 2015 and there were 27,000 respondents¹⁸. The information collected can be classified into 4 groups: *Ménage* (Household), *Personne* (Respondent), *Déplacement* (Journey) and *Trajet* (Trip).

In addition of this data from two surveys, it has been decided to use weather data¹⁹ to enrich the analysis considered. These weather data are composed of different elements for each day of the year, such as amount of rain (in millimetre) or the coldest temperature of the day.

As the two methods are different, there are inconsistencies between the data. For example, data from Lyon were collected on a specific time period, from October 2014 to April 2015, whereas data from Copenhagen are collected every day. In addition, tables do not match exactly as names given do not reflect the same meaning in the two datasets as it is explained in Table 2, and some variables in one dataset are not present in the other, and inversely. It is the same problem with modalities of each variable that can be completely different between the two datasets. Moreover, the data are collected on different scopes. While EMD data come from a precise area that corresponds to

¹⁷ Data source: Laboratoire Aménagement Économie Transports, <http://www.laet.science/>

¹⁸ Source: www.sytral.fr/359-enquete-grand-territoire.htm

¹⁹ Data source : WorldWeatherOnline, through the website <http://www.historique-meteo.net/>

Lyon metropolitan area (more than 500 towns compose this area), TU data are collected throughout Denmark, not only the Copenhagen area. As it is not useful to compare the mobility within a country and within an urban area, it is necessary to select proper area from the two datasets. The step of selecting proper similar variables and proper scopes will be defined in the next part.

4.2.2 Data selection

As explained in the previous part, data from the two surveys have different characteristics. These differences result in the need to select data to make the comparison consistent.

Each data set is composed of different tables where elements are linked by "id" variables such as SessionId or JourneyId for TU data, and id_menage or id_personne for EMD data. Each table contains different information related to a specific topic. Tables from TU and EMD data have approximatively the same names, except that they do not always refer to the same kind of variables.

TU data from Copenhagen	EMD data from Lyon	Comments
"Journey": it is the entire journey of a day, from home and return to home. Each journey is divided into 2 or more trips.		
"Trip" (<i>Tur</i>): it is a trip from one stay/activity to another. Each trip is divided into 1 or more stages.	"Journey" (<i>Déplacement</i>): it is a trip from one stay/activity to another. If 2 or more modes of transport (all except walking), it is divided into "trips".	A primary mode is determined following two different rules: - Copenhagen: the primary mode is defined as the mode which has the largest length sum during the trip - Lyon: the primary mode is the one that is the highest in the hierarchical

		classification of modes established by CEREMA
"Trip stage" (<i>Deltur</i>): it is one usage of a mode of transport on the trip.	"Trip" (<i>Trajet</i>): it is one usage of a mode of transport on the "journey".	

Table 2 - Different tables from the two data sets

The fact of travelling can be defined in different ways. The use of one mode of transport can be used as a definition (it corresponds to Trip stage and Trip for TU and EMD data), as well as the transition from one activity to another, or a loop whose starting and ending point is the home. It has been decided to focus on trips defined as transition from one activity to another, so the two tables used are *Trip* from TU data and *Journey* from EMD data.

As the two surveys were conducted on different spatial and temporal scales, the data must be sorted in order to obtain comparable information. Thus, the selected TU data are from October to March for the couples of years 2013-2014, 2014-2015 and 2015-2016 in order to match Lyon's survey that had been conducted from October 2014 to March 2015 (even if some interviews were conducted in April 2015, the latest data remaining are from March 2015). It has been decided to use three couples of years for TU data, as it allows to have more trips, in addition on a similar time of year (October-March).

Similarly, the spatial scales are different as the TU data cover trips throughout Denmark, while EMD data covered the trips on 500 cities within Lyon region. The two study areas selected are: Greater Lyon (*Grand Lyon*) and Greater Copenhagen (*Storkøbenhavn*). These two areas have approximatively the same population (about 1.3 million inhabitants) and close area size (530km² for Greater Lyon and 615km² for Greater Copenhagen) which lead to a similar density (2,587 inhabitants/km² and 2,148 inhabitants/km² respectively).

Other criteria are used to get samples with similar characteristics. For instance, the age ranges of people surveyed are not the same between the two data sets. It has been decided to select the data to match the two ranges. Thus, as the age range of the data from Copenhagen is the most restrictive one (the lowest age is higher than the lowest age from EMD, and the highest age is lower than the highest age from EMD), it has been decided to keep from EMD data only the trips where the user was between 9 and 84 years old.

At this point, the data from Lyon and Copenhagen areas are composed of 53,268 and 9,501 trips respectively.

The next step is the selection of interesting variables to analyse. They have been selected according to literature review, but also and above all, on the basis of the possibility of matching the variables between the two data sets. In addition to the selection of variables, it is necessary to check if modalities match between variables of the two datasets. Some of the variables have completely different modalities (notably variables related to education level or transport modes) and required to create similar modalities. After having selected the proper data and made modalities to match between variables, the statistical analysis can be done. The next part will present the methodology used to conduct the statistical analysis of the data.

4.2.3 Methodology used for statistical analysis of the data

The data available for this first study make it possible to consider carrying out statistical analyses. The data considered here correspond to the data that has been previously selected. The first part of the method is therefore based on the production of univariate descriptive statistics of the two samples, in order to have a first overview of the differences between the two surveys. Among the selected variables, some can be considered quantitative, i.e. corresponding to a scale of measurement (e.g. age), while others are categorial (e.g. level of education). For the first category, the quantitative variables, the descriptive statistics used correspond to certain simple indicators such as the average, minimum value, median, etc. For the second category, the description is based on the distribution of users of each trip in the different categories of variables. The distribution is expressed in percentage in order to have an idea of representativeness. This description makes it possible to identify the similar characteristics of the two surveys, and those on which they differ.

Then, it seems interesting to look at the relationship between the variables and the mode of transport used. Thus, the production of bivariate descriptive statistics makes it possible to illustrate the potential links between variables and modal choice. It is also a way to provide a kind of typical profile for some categories of users. Although the significance of the observed links cannot be verified by descriptive statistics alone, they provide an overview of the different categories of individuals and their modes of transport, as well as the link between the characteristics of the journeys and the mode of transport used.

As a reminder, the purpose of this study is to determine the different factors that influence bicycle use, and to compare them between Copenhagen and Lyon. Many articles in the field of transport, but also in any other field where statistical studies are carried out, analyse survey data using logistic regression. Here, the objective is the identification of determinants that make it possible to differentiate between two groups of trips: (i) those made by bicycle, (ii) those made with another means of transport. An interesting working paper from the French National Institute of Statistics

and Economic Studies presents a statistical analysis method for this type of context: the Logit model seems to be very suitable for this type of study (Afsa 2016). Concerning our basic problem, a variable Y (corresponding to the use of the bicycle) can be defined according to two values: 1 if the trip is made by bicycle, 0 otherwise. The trips also have characteristics represented by variables X . The variable Y only takes two values, so it is not possible to perform a linear regression on it correctly. Therefore, it is the probability that Y is equal to 0 or 1 that is used. The assumption is that the probability for Y to be equal to one of the values is a function of the characteristics X , through a linear combination. The function used to link the linear combination to the probability of having a certain value of Y is based on an exponential form. After several simplifications in the notation and variables used, the following probability formula is obtained:

$$P(Y_i = 1|X_i) = \frac{1}{1+e^{-X_i\beta}}, \text{ with } i \text{ referring to the different trips.}$$

In order to analyse the two data sets through this modal, the software R with the package GLM has been used by specifying as a link function, the logit function. Then, interpretation of the results is based on the sign of coefficients for each variable. For example, if the sign of the variable *Age* is negative, it seems that by increasing, the effect on the probability to use bicycle is negative, so older people are less likely to cycle. However, the sign is not the only indicator to be taken into account in the model. Variables need to be statistically significant and the GLM function gives this information for each variable. Finally, it is important not only to rely on the results provided by the regression, but also to step back and question the causality that links the variable with cycling.

The three previous sub-sections describe the method used for the statistical study of the two surveys conducted in Copenhagen and Lyon. This statistical study therefore makes it possible to describe the use of cycling in these two cities but also to identify the determinants specific to the two territories. The following part presents the methodology related to the analysis of cycling culture in Copenhagen.

4.3 Qualitative interviews

The second part of this thesis is based on the study of cycling culture in Copenhagen. For this type of study, it seemed relevant to analyse qualitative elements. In order to obtain the data in line with the desired study, it was therefore decided to carry out a survey with qualitative interviews. The methodology presents the design of the questionnaire, the elements that made it possible to organise, conduct and make the interviews usable, and finally how the analysis of the interviews was carried out.

4.3.1 Design of the questionnaire and conduct of the interviews

As the purpose of this study is to analyse the Danish cycling culture, it was considered to conduct qualitative interviews with people living in Copenhagen area. The aim is to identify elements that encourage and discourage people to cycle, and to get an external point of view of the cycling culture in this city. That is why, the idea of interviewing foreigners came out and it has been decided to focus on foreigners who are staying in Copenhagen area from several months to several years. As a result, tourists or very short-term residents (from days to few weeks) were not considered. It is related to the fact that tourists do not have enough experience and do not consider travelling in the same way than residents. In order to facilitate the search for volunteers, international students were targeted. Indeed, it has been assumed that they would be more likely to participate in interviews, could be easier to contact and form a homogeneous group. As a reminder, the final objective of this study is to identify the socio-psychological factors that determine bicycle use in Copenhagen by foreign residents, and in particular to highlight elements that could be introduced in other cities.

In this way, the questionnaire was designed on the basis of the work of Mayara Moraes Monteiro, PhD student at DTU, who interviewed short-term foreign residents in Portugal about their mobility. Her questionnaire was used as a basis for the development of a more bicycle-oriented questionnaire. The idea of this questionnaire was to make the respondent reflect on his or her mobility in previous cities and in Copenhagen, by guiding the discussion on the use of the bicycle in the end. Thus, the questionnaire was designed according to five parts:

- Socio-demographics: this part mainly tends to describe the interviewees' backgrounds. It is also useful to make respondents feel confident with simple questions.
- Experiences in the former city: several questions about mobility habits in former city and opinion about the mobility there.
- Mobility in Copenhagen: several questions about place of residence, mobility habits in Copenhagen area and opinion about mobility here.
- Focus on cycling: this part aims at asking the interviewees on their perception about cycling in Copenhagen and other cities.
- Comparison with former city: different questions which tend to make the interviewees compare mobility in Copenhagen and their former cities in order to highlight potential points for improvement that are important.

First drafts of the questionnaire were discussed with Mayara Moraes Monteiro, Sonja Haustein and Michael Bruhn Barfod, and then final versions were tested on volunteers in order to identify

unclear questions and to measure the interview duration. The final version of the questionnaire used for conducting interviews is in Appendix 4.

4.3.2 Research of volunteer, conduct and transcription

The search of students to interview has been carried out on social media (Facebook) by posting message on students' groups from different universities in the Copenhagen area, and by sending e-mail to some research departments. People who wanted to participate in the interview could register through an online form (Google Form), which allowed them to choose the date and the hour of the interview. In order to get more participants, I asked students working in my host department as well.

The interviews were conducted by me, in English and recorded with a voice-recorder device provided by DTU Library. Participants had to sign a declaration of consent where it was specified that the interview would be recorded, and the information got would be used for research only and through an anonymous form.

In order to make the analysis possible, each interview was transcribed into word processing software, sometimes with the help of "Voice typing" function from Google Doc to understand some unclear sentences.

4.3.3 Analysing the interviews

The interviews conducted provide qualitative information on the perception of cycling culture in Copenhagen. They must be analysed in order to provide useful information. Analysis of qualitative interviews requires specific methods and one of them is related to 'coding' the transcriptions got from interviews (Saldaña 2009). The aim is to identify significant elements by focusing on a certain way to *code* the document. In this way, several codes are obtained for an interview and lead to code categories, which in turn allow themes/concepts to be expressed.

The method actually used is based on this inverted principle. Instead of identifying elements and constructing concepts with them, it was attempted to start from the themes already present in the literature and to have a reading of the transcripts in order to recognize responses similar to these themes.

Although the methodology is divided into two parts, an attempt has been made to maintain a certain complementarity and coherence between the two studies, particularly with regard to the elements analysed but also to the links that they share.

5. Results from the two studies

The previously detailed methodology has been applied and has produced results that will be presented in this section. Although the first study consists of a statistical study of two mobility surveys conducted in Copenhagen and Lyon, and the second study is based on qualitative data obtained in a different context, a certain complementarity of the analysis is being pursued here.

5.1 Results from the analysis of the two data sets

The goal of this part is to compare the different determinants constituting the options to cycle in the two cities of Copenhagen and Lyon. As described in the methodology, the difference in the source of the two datasets required some data processing, which led to the selection of some data and variables. A description of the data obtained after this treatment, as well as the results obtained from the statistical analyses, will be described below.

5.1.1 Overview of the selected data

The variables selected as a result of the process are presented in Table 3. The names in the two data sets are given as information, but a general name will be used for each variable in the rest of the thesis. As stated in the methodology, it was necessary to match the modalities of each variable between the two data sets. Some variables containing many different modalities between the two given sets have been simplified to present the same structures. The variables for which the most significant changes have occurred are described in Appendix 2. Some other variables needed modifications as well, but they were minor, and it is not relevant to describe them here. For instance, due to missing distance values in TU data, it has been decided to delete the trips concerned, which lead to a total number of 9,061 trips instead of 9,501. The different modalities related to **Occupation** have been selected following 5 main groups that tend to represent a potential constraint on mobility: (i) Pupil, (ii) Student, (iii) Work, (iv) Do not work, and (v) Other. The latter is used to assign missing variables (NA) to a group. For the variables **Driving license** and **Public transport pass**, it has been decided to convert them into kind of binary variable with two modalities "Yes" and "No". The transformation of the variable **Education level** was complicated in the sense that the initial modalities were very different and also in the sense that the education systems are different between France and Denmark. Finally, five **Transport modes** were kept: (i) bicycle, (ii) private car, (iii) public transports, (iv) walk, and (v) other. The following analyses will be made with these new modalities or some derived variables.

Themes	TU data	EMD data	Qualitative or quantitative?	Orderable?	Comment
Id variables	SessionId, JourneyId...	HouseholdId, TripId...	--	--	These variables are used to link trips with respondents and households.
Date	DiaryDate, DiaryYear, DiaryMonth, DiaryWeekday	date	Qualitative	Yes	These variables describe traveller, household and trip. Here are presented the variables obtained directly from the databases, but later they can be derived into other variables, especially for regressions.
Age	RespAgeCorrect	age	Quantitative	Yes	
Gender	RespSex	sexe	Qualitative	No	
Education level	RespEduLevel	niveau_etudes	Qualitative	No	
Occupation	RespPrimOcc	occupation	Qualitative	No	
Driving license	ResphasDrivlic	permis	Qualitative	No	
Household size	HousehNumPers	taille_menage	Quantitative	Yes	
Household cars	HousehNumcars	nombre_VP	Quantitative	Yes	
Public transport subscription	RespHasSeasonticket	Abonnement_TC	Qualitative	No	
Trip distance as the crow flies	GISdist	doib	Quantitative	Yes	
Trip duration	SumMin	duree	Quantitative	Yes	
Temperature minimal	TempMin	TempMin	Quantitative	Yes	
Temperature maximal	TempMax	TempMax	Quantitative	Yes	
Precipitation	Precip	Precip	Quantitative	Yes	
Transport mode	PrimMode	modp	Qualitative	No	This variable gives the primary transport mode as describe before.

Table 3 - Variables selected for the study on Lyon and Copenhagen data

5.1.2 Results from the statistical tools

As explained previously, this part aims at highlighting the different factors that influence bicycle use in the two cities, and to compare them. The modalities modifications and the selection of data allow to get comparable data, which have specific characteristics such as described in Table 4. The two cities areas have similar characteristics in terms of population and size area, and therefore population density. Regarding data characteristics, some variables, such as **Age**, **Household size** or **Public transport subscription**, are quite similar between the two data sets. However, it appears that there are significant differences for some variables, and more precisely some modalities. For instance, in the case of **Occupation**, the proportions of students and pupils are really close in the two data sets, but work share is higher in TU data. In the case of **Education level**, except for people currently studying, each modality is greatly different between TU and EMD data. Then, the results for **Distance** and **Duration** are interesting in that the average distance is very different between the two surveys, while the average durations are very close. These differences have to be taken into consideration and kept in mind while analysing other results. Subsequently, the means of transport used for the different trips within the cities do not have the same modal shares between Lyon and Copenhagen. The breakdown of the means of transport are illustrated in Figure 10.

These results were expected according to the previous reports on mobility in the two cities. The figures show that private car is the main transportation mode in the two cities with more than 40% of all the trips. Although the three main alternative modes, namely public transport, walking and cycling, account for around 54% of all the trips (54.5% and 53.7% for Copenhagen and Lyon respectively), they are shared differently according to the two cities. The biggest difference comes in particular from the use of bicycles, which have a marginal role in Lyon, while it is the second most important means of transport in Copenhagen after car. There is also a significant difference in walking, since it is the second most common way to travel according to EMD data. Finally, although public transport is used more in Lyon than in Copenhagen, the modal shares remain close between the two data sets.

After these descriptive statistics about the two samples, it seems interesting to calculate bivariate statistics to obtain an overview of the potential links between variables and modal choice.

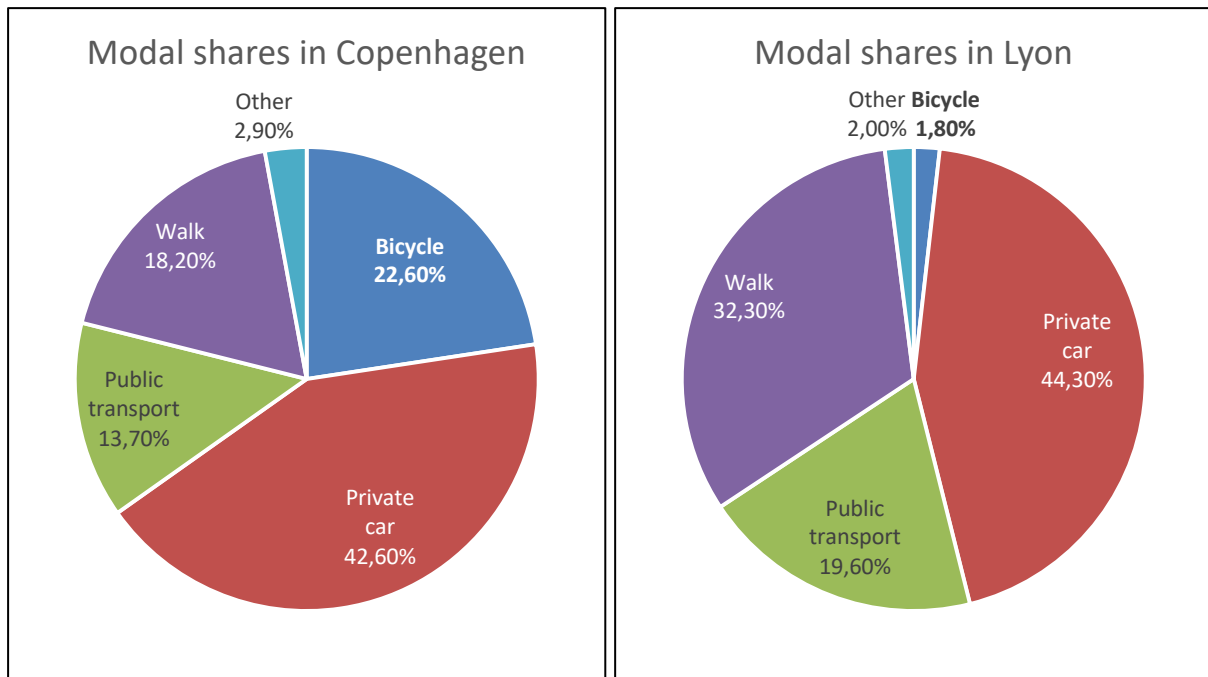


Figure 10 - Comparison of the modal shares in the cities of Copenhagen and Lyon

In order to calculate bivariate statistics, it has been decided to change some variables. For example, instead of studying the number of household members and household cars and education levels, three new variables have been introduced: (i) Household size higher than 1, (ii) Number of cars in the household higher than 0, and (iii) Higher education. The variable related to higher education is used as it is complicated to compare different education levels as they do not have an explicit order. The two other variables allow to focus on car availability and a change in household structure. The calculations were made in the two ways for each variable, i.e. the figures represent variable X according to the mode of transport, then the modes of transport according to variable X.

The different bivariate statistics calculated allow to observe the link between variables and also potentially typical profile for cycling. Even if only some figures are presented here, all the figures are in the Appendix 3 for readability purpose. The first observation come from the variable **Gender** in Figure 11. It appears that the use of bicycle is highly different between females and males in Lyon. Although in Copenhagen almost as many females as males use bicycles, in Lyon females are clearly under-represented, which is not the case in the overall sample, which may indicate that females are clearly less using this means of transport. At the same time, it is quite similar for the other transport modes. This difference between males and females for the use of bicycle is in line with what is told in literature.

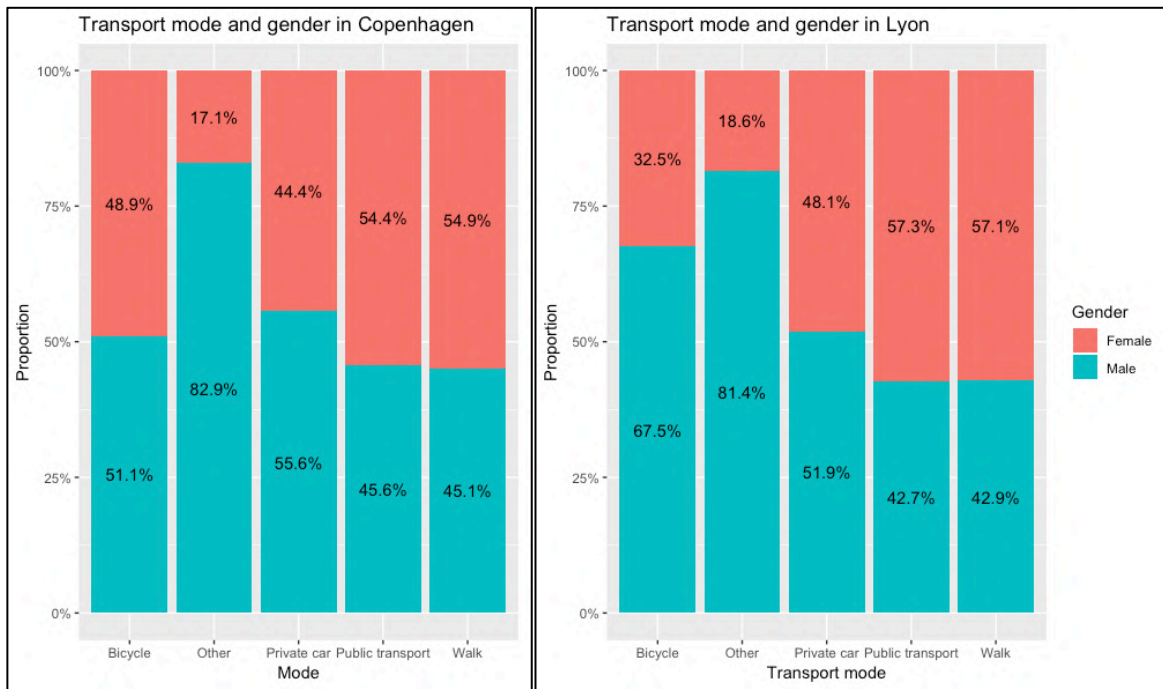


Figure 11 - Proportion of each gender for the different modes of transport

Concerning the variable **Occupation**, it is again possible to observe a significant difference between the two cities in Figure 12. Indeed, the use of public transport is very much represented among pupils and students. While public transport journeys represent 19.6% of all journeys in the Lyon sample, they have a modal share of 32.8% and 44.5% for pupils and students respectively. While the share of public transport varies less in Copenhagen, the share of bicycles also increases very strongly with pupils (31%) and students (38%), while the overall share stands at 22.60%.

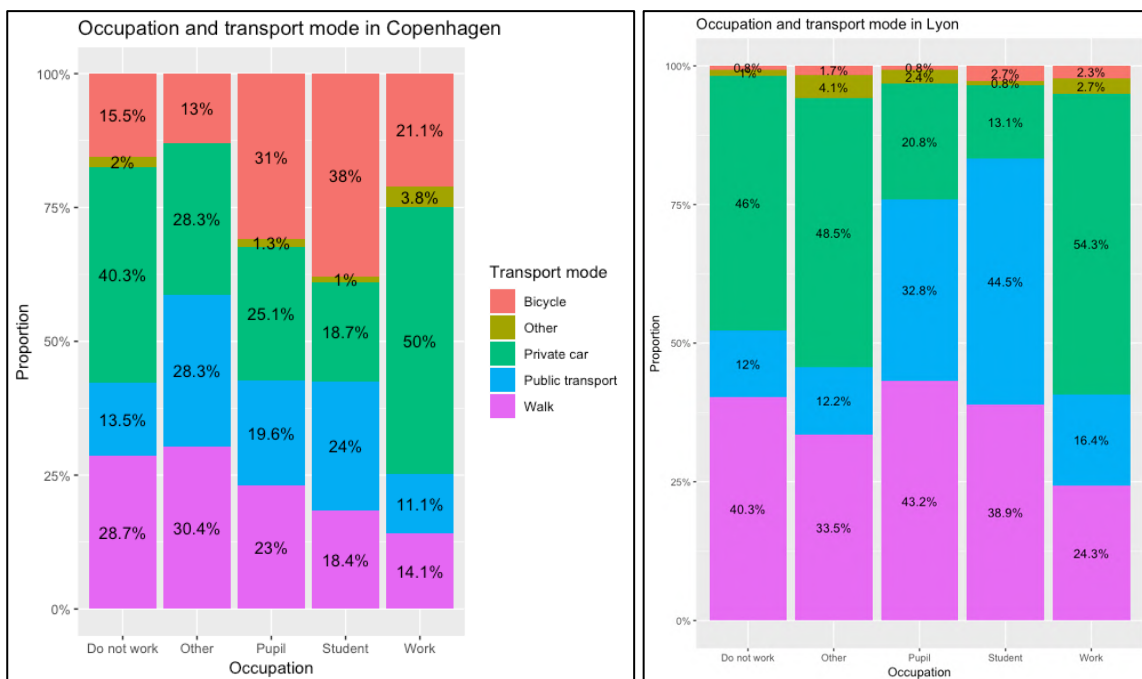


Figure 12 - Proportion of each transport mode for the different occupations

For the **Education level** variable, 62.2% of those who use bicycles in Lyon have a higher level of education, which is higher than the average of the sample. There is therefore an over-representation of people with a higher level of education. The fact of having a **driving license** is related to a huge car modal share. At the same time, in Copenhagen the proportion of bicycle users having a driving license is 71.1% which is a bit than the sample average, whereas in Lyon it is 85.1%, so it is under-represented in Copenhagen and over-represented in Lyon. However, it does not seem possible to identify any causality between the use of bicycle and having a driving license. The same kind of observation can be made with the variable **Public transport subscription** which is linked with a significant use of public transport, mainly in the case of Lyon where, for people with public transport pass, the modal share exceeds 50%. Once again, it is possible to examine the causality in that case. It can be assumed that people who pay for a subscription plan to use it. For the variable **living in a single-person household**, the results obtained in the two cities are pretty similar. For instance, the use of car increase when people are not living alone. It can be assumed that it is linked to the fact that people living with children are more likely to use car to bring them at different places. About **having at least one car available**, the results are really close in the two cities. Of course, having a car is related with a higher use of car, but here again the causality can be discussed: do people buy a car because they plan to use it? Or do people use a car because they have it? It is a topic of discussion as it is possible to buy a car without thinking about how it will be used. Then, trips with higher **distances** are mainly made by car in the two cities, while active mode such as bike and walking are highly represented for trips with distance lower than 2 km.

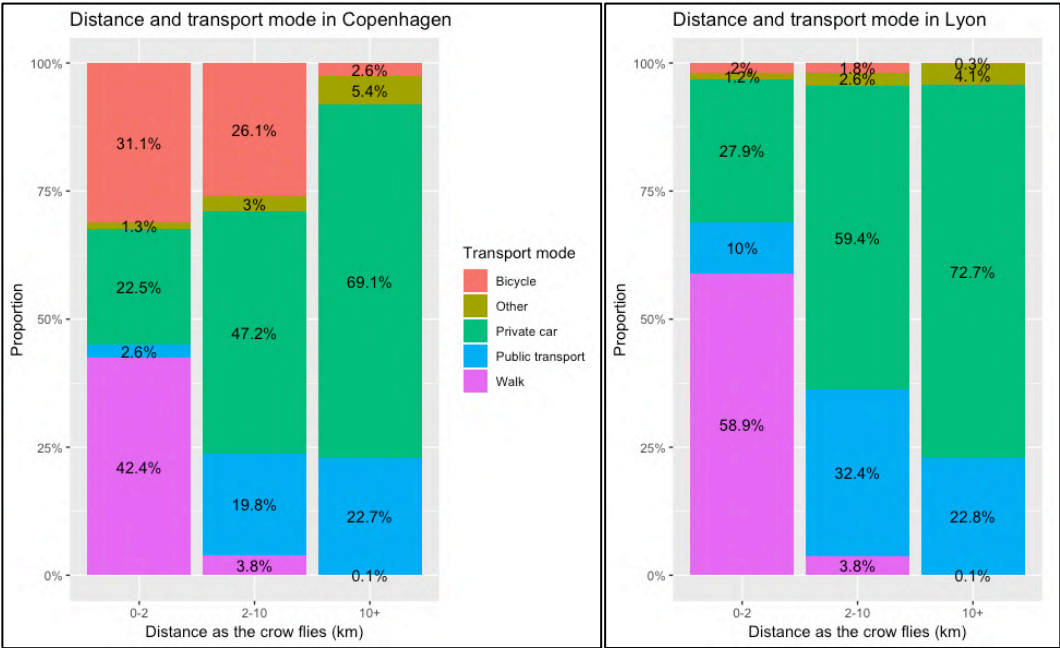


Figure 13 - Proportion of each transport mode for the different distances

The different modal share for each distance range are illustrated in Figure 13. It is possible to see that the use of public transport increases between 2-10 km and 10+ km in Copenhagen, while it is decreasing in Lyon. It can be assumed that for distance between 2 and 10 km, people in Copenhagen use more bicycle and do not have to use public transport, but for 10+ km, it is complicated and needs to much effort to use bicycle, so they switch to car and public transport. About the weather, for higher **minimum** and **maximum temperatures**, the modal share of cycling also increases, especially in Copenhagen. These are expected results since bicycles are an external means of transport and users are therefore confronted with weather conditions. For the variable **Precipitation**, even if the modal share decreased a bit in the two cities, it is not significant.

These bivariate statistics provide a first overview of the potential relations between mobility and other variables related to travellers or trips. However, sample sizes do not always allow meaningful conclusions to be drawn from existing relations. It is mainly the case for bicycle use in Lyon as it is a small sample compared to the other transport modes. Moreover, causality needs to be taken into account before concluding on the possible effect of a variable on modal choice.

Variables	Copenhagen (Storkøbenhavn)	Lyon (Grand Lyon)
Population	1,321,000 inhabitants (2015)	1,371,000 inhabitants (2015)
Area size	615 km ²	530 km ²
Density	2,148 inhabitants/km ²	2,587 inhabitants/km ²
Period	October 2013 – March 2014 October 2014 – March 2015 October 2015 – March 2016	October 2014 – March 2015
Number of trips recorded	9,061	53,268
Gender	Male: 52.1 % Female: 47.9 %	Male: 48.1 % Female: 51.9 %
Age	-Minimum: 9 -Median: 41 -Mean: 41.6 -Maximum: 84	-Minimum: 9 -Median: 40 -Mean: 41.3 -Maximum: 84
Average age by transport modes	-Bicycle: 37.2 -Private car: 44.9 -Public transports: 37.5 -Walk: 41.4 -Other: 42.5	-Bicycle: 39.8 -Private car: 45.9 -Public transports: 33.3 -Walk: 40.2 -Other: 37.9
Education level	-Primary: 0.7% -Secondary: 12.2% -Higher: 50.3% -Apprenticeship: 15.4 % -Studies in progress: 19.6% -Other: 1.8%	-Primary: 3.0% -Secondary: 35.3% -Higher: 39.7% -Apprenticeship: 0.4% -Studies in progress: 21.3% -Other: 0.3%

Occupation	-Do not work: 18.8% -Pupil: 10.6% -Student: 9% -Work: 61.1% -Other: 0.5%	-Do not work: 27.5% -Pupil: 11.7% -Student: 8.9% -Work: 50.8% -Other: 1.1%
Driving license	-Yes: 78.5% -No: 21.5%	-Yes: 74.3% -No: 25.7%
Household size	-Minimum: 1 -Median: 2 -Mean: 2.8 -Maximum: 11	-Minimum: 1 -Median: 2 -Mean: 2.9 -Maximum: 10
Household cars	-Minimum: 0 -Median: 1 -Mean: 1.007 -Maximum: 7	-Minimum: 0 -Median: 1 -Mean: 1.297 -Maximum: 9
Public transport subscription	-Yes: 28.3% -No: 71.7%	-Yes: 30.8% -No: 69.2%
Trip distance as the crow flies (km)	-Minimum: 0 -Median: 3.06 -Mean: 10.42 -Maximum: 273.07	-Minimum: 0 -Median: 1.74 -Mean: 5.44 -Maximum: 989.21
Trip duration (min)	-Minimum: 1 -Median: 15 -Mean: 23.05 -Maximum: 386	-Minimum: 1 -Median: 15 -Mean: 22.25 -Maximum: 715

Table 4 - Comparison of the variables and characteristics from the two cities

In order to focus on the use of bicycle and to compare the factors influencing its use in the two cities, two binary logistic regressions were done, using the variables selected before or derived variables. The results got from the regressions and for the two cities are summarised in Table 5. The column “Estimate” is related to the coefficient for each modality. Here, it has been decided to keep the sign only. Then, the column “Significance” says if the modality is significant or not in that regression. To read it, the rule is to remind that more stars “*” indicate a better significance. Statistically speaking, when the number of stars decreases, the probability of being false with the estimation increases. Here, are considered significant all the modalities with at least one star. Then, the numbers and shares are here to give an idea of the proportions each modality represents.

The variables used can be classified using the different categories from (De Witte et al. 2013). Thus, there are three primary categories: (i) socio-demographics indicators, (ii) journey characteristics, and (iii) spatial indicators. The different variables available in the two data sets are from the two first categories. We can group them in order to make the analysis clearer Figure 14 - Categories and variables used for the study

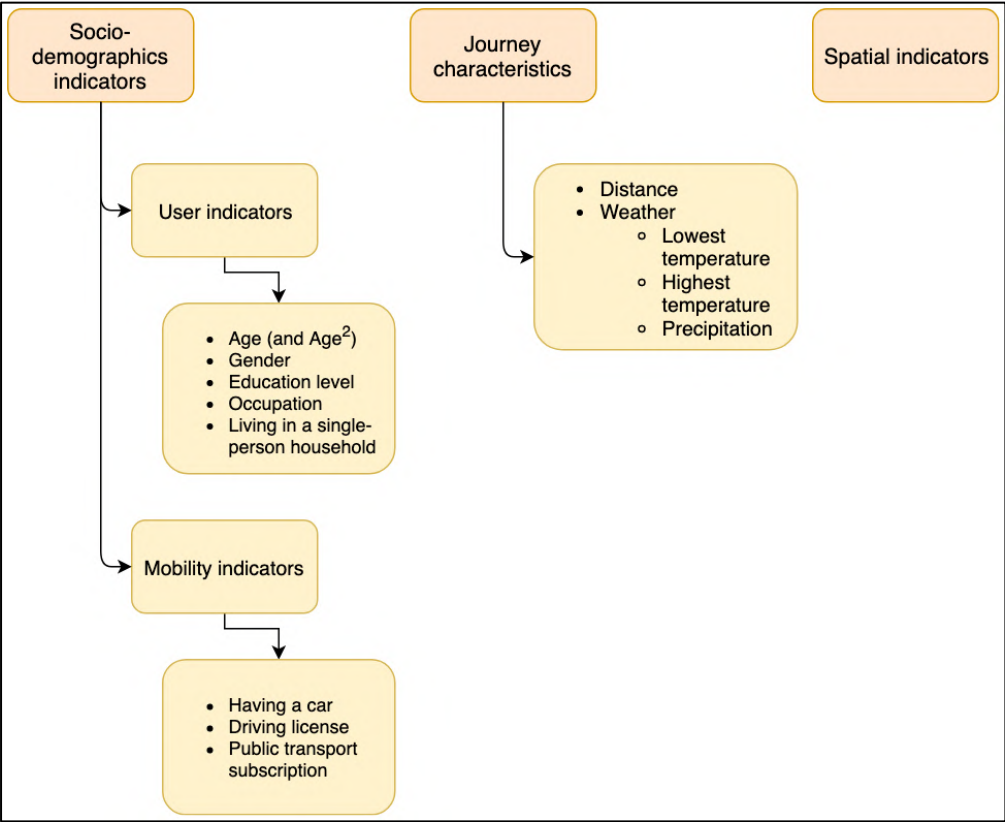


Figure 14 - Categories and variables used for the study

There is no variable related to the spatial factors, but regarding to the literature review, it can be assumed that the results got from the interviews will give information about these factors. For

instance, hilliness, bicycle infrastructure, etc. are elements that can be found in qualitative interviews through the perception and evaluation by respondents.

5.1.2.1 Socio-demographics indicators

The socio-demographics indicators allow to know the situation of the traveller and his/her individual and social characteristics.

User indicators

The **age**, such as its derived variable **age²**, is not a significant in the case of Copenhagen, whereas the two variables are significant in the case of Lyon. The first variable has a positive sign while the second one has a negative sign. It can be interpreted as when people are young, they are more likely to cycle with the age, while it is the opposite for people older. Some articles do not give a definitive result about age it seems to depend on other variables. For some studies, the use of bicycle decreases with the age, while for other studies, age is not a significant factor (Heinen, van Wee, and Maat 2010).

The **gender** is not significant in the case of Copenhagen while it is for Lyon with a positive sign for male travellers. It is in accordance with the literature as some results are that in countries with a low cycling level, male travellers are more likely to cycle than female ones (Aldred, Woodcock, and Goodman 2016).

For the variables related to the **occupation**, the results are quite similar in the two cities. As the reference modality is "Do not work", it appears that the fact of being active is a significant determinant to use bicycle. By using the "Work" mode as a reference, perhaps "Studies in progress" would also have had a significant positive coefficient given the observations made earlier, which showed that pupils and students used the bicycle a lot. Here causality could hardly be explained in the sense that using a means of transport determines the occupation. It seems more relevant to say that having an occupation (or not) determines the means of transport used. This may be related in particular to the value of time, which tends to increase with the fact of being constrained by work, and cycling can often be faster than other means of transport. However, this statement does not apply all the time.

The same kind of results are got for the variable **higher education**. Indeed, the fact of having a higher education level is a factor that positively influence the use of bicycle. However, in the literature, this result is still ambiguous as studies show that the higher education level, the less likely people are to cycle, while other studies show the opposite result (Ton et al. 2019).

The fact of **living in a single-person household** has a negative effect on the use of bicycle in Copenhagen, while it is not a significant variable in the case of Lyon, which is a city with a low cycle level, literature tend to say that the use of bicycle decreases with the number of children and therefore the size of the household. The result is surprising considering what has been observed in bivariate statistics.

Mobility

For the variable **driving license**, the two cities have different results. In the case of Copenhagen, this variable is not significant, whereas in the case of Lyon, it is significant, and it has a positive effect on the use of bicycle. At the same time, **having a car** is significant and has a negative effect in the two cities. It is surprising for the case of Lyon where the fact of having a driving license has a positive effect. Anyway, it appears that access to a car is a significant determinant of non-use of bicycle. It can be assumed that, as having a car is often a considerable investment, people who have one plan to use it. However, the causality between the variables and modal choice can be discussed as the results are surprising and not really complementary. According to the literature, it appears that **car availability** is a significant variable for the use of car, and consequently for the use of bicycle but in a negative way.

The same kind of results appears for the variable **public transport subscription** in the two cities. It is possible to have the same assumption than with the previous variable.

5.1.2.2 Journey characteristics

As it can be expected, higher **distances** have a negative effect on the use of bicycle. It can be explained by the range of the trips which reach hundreds of kilometres in the two cities. By taking only short distances (e.g. less than 10km), the continued variable could appear as an insignificant variable or with another effect. An interesting point is that when a trip is less than 2 km, people are less likely to cycle compared to a trip with a distance between 2 and 10 km. It can be assumed that this result comes from the higher propensity to walk for short distances. However, this result about distance below 2 km is not really in line with bivariate statistics calculated before.

Concerning the **trip duration**, it has been decided to not keep this variable. Indeed, the results were not significant, and it was thought after that it was directly linked with distance and transport mode.

The **weather** is composed of three variables here. The **minimum temperature** is divided into 4 parts, and the reference is temperatures below 0°C. In the case of Copenhagen, only the group of

temperatures above 10°C has a significant and positive effect on the use of bicycle. At the same time, it is the same for the group of temperatures between 0°C and 5°C in the case of Lyon. It is surprising as higher minimum temperatures do not have significant effect on the use of bicycle in Lyon. The variable **maximum temperature** is divided into 4 parts as well with the group of temperatures below 5°C as reference. The variable is not significant in the case of Copenhagen, but for Lyon, the groups “10-15°C” and “15+°C” are significant and have a positive effect on the use of bicycle compare to a maximum temperature below 5°C. The **precipitation** variable is divided into two groups: 0-5 mm (reference) and 5+ mm. In the two cities, this variable is not significant. It can be assumed that when it is raining, people are less likely to cycle. It can be assumed that this lack of significance is related to the way rain is presented here. Perhaps, more than rain itself, a weather forecast announcing rain has a real effect on cycling.

5.1.3 Conclusions of the statistical analyses

Previous analyses are carried out using data from two surveys conducted using different methodologies and on different territories. In order to optimally compare these data, it was necessary to process them to ensure not only the spatial and temporal consistency of the samples, but also the similarity of the structures of the variables in the data sets. Descriptive statistics allow a general comparison of the two samples obtained, and their consistency. Although some baseline characteristics are chosen to be similar in both samples (e.g., population size of the study area, months of the year), other variables differ in their values. This is particularly the case for gender distribution, level of education, etc.

The selected variables correspond to passenger and trip characteristics, which are part of the modal choice process according to (De Witte et al. 2013). Thus, the analysis of these indicators makes it possible to highlight the determinants of bicycle use in both cities. Logistical regressions allow to compare the effect and significance of the different variables on bicycle use. The study of the variables Age and Gender allowed to highlight the difference between Lyon and Copenhagen. At the same time, Lyon is considered as a low-cycling level city, while Copenhagen is considered as low-cycling level city. In the case of Lyon, Gender and Age variables have a significant effect as younger males are more likely to use bicycle. It can be expected that this result is related with the perception of safety in a city where infrastructures and behaviours are not as adapted to bicycles as in Copenhagen. Other variables give interesting results which are sometimes surprising. It can be expected that some results obtained with the regressions and other tools will be explained in the following part. The method used and the data may lead to limitations that must be taken into account in the analysis of the results. A discussion section will be devoted to these elements.

Variable		Copenhagen (n=9,061)				Lyon (n=53,268)			
		Estimate	Significance	Number	Share	Estimate	Significance	Number	Share
Age	<i>Continued variable</i>	-	0.55197	--	--	+	**	--	--
Age ²	<i>Continued variable</i>	+	0.39976	--	--	-	*	--	--
Sex	Female	Ref.		4,562	47.9%	Ref.		27,668	51.9%
	Male	+	0.13223	4,939	52.1%	+	***	25,600	48.1%
Occupation	Do not work	Ref.		1,821	18.8%	Ref.		14,669	27.5%
	Other	+	0.096	46	0.5%	+	*	582	1.1%
	Pupil	+	***	1,031	10.6%	+	***	6,217	11.7%
	Student	+	***	847	9.0%	+	***	4,761	8.9%
	Work	+	***	5,756	61.1%	+	***	27,039	50.8%
Higher education	No	Ref.		4,749	50.3%	Ref.		32,139	60.3%
	Yes	+	***	4,752	49.7%	+	***	21,129	39.7%
Drive license	No	Ref.		2,056	21.5%	Ref.		13,673	25.7%
	Yes	-	0.62728	7,445	78.5%	+	*	39,595	74.3%
Household size = 1	No	Ref.		7,728	81.2%	Ref.		43,096	80.9%
	Yes	-	**	1,773	18.8%	-	0.42105	10,172	19.1%
Number of cars > 0	No	Ref.		2,438	26.2%	Ref.		9,582	18%
	Yes	-	***	7,063	73.8%	-	***	43,686	82%
Public transport subscription	No	Ref.		6,812	71.7%	Ref.		36,857	69.2%
	Yes	-	***	2,689	28.3%	-	***	16,411	30.8%
Distance (km)	0-2	-	***	3,585	39.6%	+	0.05634	27,954	52.5%
	2-10	Ref.		3,351	37%	Ref.		19,521	36.6%
	10+	-	***	2,125	23.4%	-	***	5,793	10.9%
Minimum temperature (°C)	<0	Ref.		493	5.1%	Ref.		1,155	2.2%
	0-5	-	0.97987	2,689	28%	+	*	19,159	36%
	5-10	+	0.35444	4,124	43.9%	+	0.11912	24,165	45.3%
	10+	+	**	2,195	23%	+	0.05702	8,789	16.5%
Maximum temperature (°C)	<5	Ref.		1,632	16.9%	Ref.		8,688	16.3%
	5-10	-	0.55417	4,602	48.7%	+	0.24082	14,060	26.4%
	10-15	+	0.95403	2,325	24.6%	+	*	17,983	33.8%
	15+	+	0.90180	942	9.9%	+	**	12,537	23.5%
Precipitation (mm)	0-5	Ref.		8,097	85.1%	Ref.		43,497	81.7%
	5+	-	0.15105	1,404	14.9%	-	0.08528	9,771	18.3%
R ² McFadden		0.1704				0.0920			
Pr(> z) - Significance code		0 < '***' < 0.001 < '**' < 0.01 < '*' < 0.05 < '.' < 0.1 < '' < 1							

Table 5 - Results of the logistic regressions for the two cities

5.2 Identifying which aspects encourage or discourage people to cycle through qualitative interviews

As described above, the determinants of the use of a mode of transport can be divided into several categories. In the statistical study carried out in the previous section, socio-demographic factors and trip characteristics were analysed. The aim here is to investigate the perception of Danish cycling culture by resident and the influence of different factors such as socio-psychological but also environmental (infrastructures, facilities, etc.) aspects. As Copenhagen is a city with a high cycling level, this mean of transport is a part of its culture. In contrast, the use of bicycle in Lyon is not significant and it is not one of the main transport modes of the city. The analysis of these factors therefore completes the identification of the determinants of bicycle use. This section could lead to identify the elements that are directly influenced by the policies put in place and therefore to propose prescriptions on how to promote the use of the bicycle.

5.2.1 Respondents characteristics

In total, ten interviews have been conducted between June and July 2019 and the average length is 37 minutes. All the interviews have been recorded and transcribed in order to analyse them. Due to the intention to keep each interview anonymous, it was decided to replace the name of the participants. Thus, for interview's citations the alternative name, as well as age and gender will be given.

The 10 participants volunteered to be interviewed in response to the various announcements. They represent a sample of people with different characteristics. Their main characteristics are described in Table 6, which gives an overview of the panel of respondents.

The total duration of the interviews is between 27 and 57 minutes with an average of 36 minutes, which shows some variety in the amount of comments collected for each interview. In terms of educational level, the number of PhD students (n=5) is close to that of master's students (n=4), while one respondent is at the bachelor's level. The total length of time the respondents have lived in Denmark varies widely from a few months to several years. For instance, 40% of the interviewees have been in Denmark for less than 1 year. Then, there are as many male participants as there are female participants, and the average age is 24.2 years (age range of 21-27). So, the panel is gender balanced, and the average age is young, which is explained by the focus on university students. However, despite having contacted people from different universities, 9 participants come from DTU, while only one participant comes from Copenhagen Business School (CBS).

Name	Age	Gender	Nationality	Place of residence	Driving license	Occupation	Time so far in Copenhagen	Interview date	Total time of interview
Martin	23	M	French-Danish	Nærum	Yes	Master student	9 months	10 th June	32min21
Sven	27	M	Swedish	Lyngby	Yes	PhD student	18 months	12 th June	38min40
Fang	25	F	Chinese	Nærum	Yes	PhD student	5 months	14 th June	33min42
Chang	22	M	Chinese	Nærum	Yes (but not valid in Denmark)	Bachelor student	9 months	16 th June	31min43
Pablo	25	M	Spanish	Copenhagen (North-East)	Yes	PhD student	4 years	18 th June	27min38
Emma	24	F	French	Østerbro	No	Master student	6 years	18 th June	30min24
Charlotte	26	F	German	Bagsværd	Yes	PhD student	4 years	26 th June	33min26
Anna	26	F	Icelandic	Lundtofte	Yes	PhD student	5 years	28 th June	44min07
Gabriel	21	M	French	Lyngby	Yes	Master student	3 months	11 th July	57min08
Camille	23	F	French	Gentofte	Yes	Master student	2 years	12 th July	33min

Table 6 - Main characteristics of the participants and interviews

5.2.2 Analysis of the interviews

As mentioned previously, several socio-psychological and environmental factors can be taken into account in the analysis of the modal choice process. All the elements collected during the interviews will be presented in three parts: (i) past experiences in terms of mobility, (ii) mobility in Copenhagen, and (iii) improving bicycle use. This presentation will highlight the results obtained for each interview and identify trends based on a parallel with the elements developed in the literature.

5.2.2.1 Past experiences

Different questions have been asked to interviewees about their past mobility experiences, in general and about cycling. The purpose of this section is to identify the means of transport used by the respondents in their former cities as well as the evaluation they make of them, and finally their potential experiences with the use of the bicycle.

The first thing that can be deduced from the interviews is the diversity of origins. Indeed, the people surveyed come from countries and cities where the use of bicycles differs (4 from France, 2 from China, 1 from Germany, 1 from Iceland, 1 from Spain, 1 from Sweden). Even for people from the same country, the cities of origin vary. In addition, many of the respondents had other stays abroad in addition to Denmark, which adds to their experiences.

For most of participants, the means of transport used were cars, public transport and walking. These transport modes (car and public transport) are often considered as being more convenient in terms of comfort and speed:

*"It was the tramway all the time. It was the most **convenient**."* (Martin, 23, M)

*"So, in general I think organisation of the transport system is very **convenient** in Hong Kong. [...] In general, people have access to most of public transport modes. [...] So, I think, probably, **most people take public transports**. [...] I would say that car is **faster**, and, let's say, more **convenient** than the public transport, in some occasions."* (Fang, 25, F)

However, a proportion of respondents do not consider mobility in their former city to be a good thing and highlight points leading to a poor assessment:

*"I had to go to downtown first, and transfer bus over there and another bus going to my Uni. So... it's a **long way**, it's 24 km in total, every day and it's only one way. [...] If 5 points scale, I would **only rate 1 or 2**, probably. It's pretty **bad**."* (Chang, 22, M)

*"I would say...in the city close to Paris I was living in, **no super well**, like it **could be better**. [...] For instance, there was **no option really for biking** and the public transport in general is just...it could be better. **It's not very well connected**"* (Emma, 24, M)

*"[About the evaluation of the transport system] A bit **inefficient**, I would say. I mean there is **not so much capacity** for all the demand that is currently in the island. So, in peak hours it's really **easy to get a lot of traffic**, a lot of **congestions**."* (Pablo, 25, M)

*"[...] I did not have a car which is very uncommon in Iceland, most people have a car, because the **public transport isn't really that great**, there is not frequent trips, and also if you have to walk maybe 5 minutes to the bus, you can be soaking wet or very cold [...]"* (Anna, 26, F)

These testimonies emphasize the fact that some people used means of transport that did not satisfy them. It can be assumed that this is related to the effect of habits that reduce travellers' propensity to learn about other modes of transportation or to take other factors into account (Heinen, van Wee, and Maat 2010). It may also be related to the inability to use another means of transportation, for personal reasons or because there is no other offer.

In addition to questions about daily mobility, participants were asked if they had any particular experiences with cycling. Only one respondent used the bicycle almost every day, while another participant used to ride the bike once a week or once every two weeks. It appears that for other interviewees, this means of transport was more considered as a leisure activity by respondents:

*"[About past experiences with bicycle] Yes, but just the **normal childhood biking** I experienced."*
(Pablo, 25, M)

*"Well, the bike was more kind of a **leisure activity**, how I used a bike was to **go long trips, in the mountains and in nature, off-road.**"* (Charlotte, 26, F).

*It's more likely to be **a sport**, and more likely to be **an adventure**, because it's not **safe.**"* (Chang, 22, M)

The last quote refers to the fact that some have had significant experiences or attitudes towards cycling. Therefore, it appears that the respondents had experiences or feelings of insecurity:

*"But for instance, the **bike lanes**, like, close to where I lived, just **stop at some points**, so it's just like roads, and it's...you don't even have walking path on the side of the road, it's just like [...] **a gap in the side**, so it's **pretty dangerous**, and in the city **people just don't pay attention.**"* (Camille, 23, F)

*"Using bicycle in Sydney is **dangerous**, because they don't have bicycle lane, but you can ride a bicycle in Sydney but not on the pavement, because it's dangerous for the pedestrians. So, the only thing, the only way you can ride a bicycle is on extra roads as the cars. And the rule to ride a bicycle in Sydney is to do what a car do. It's very dangerous for bicycle riders [...]. I did [cycle] in Sydney before, but it's dangerous, and I **almost get a car hit, so that was panic.**"* (Chang, 22, M)

It therefore appears that the people surveyed had very different experiences with their former mobility, both in terms of the means of transport used and their satisfaction. It also seems that people had experienced cycling as leisure and an unsafe mean of transport, more than a way to commute. Therefore, the former daily use of bicycle is really low in the sample and only one respondent can be considered as a cyclist in his former city. This may be related to several elements, such as the absence of social support on bicycle use, the habit of using other means of transport, and the lack of good alternatives. Indeed, a study shows that people with a co-worker who cycle to work are more likely to cycle as well, and people accustomed to using another mode of transport are less likely to use the bicycle (Heinen, van Wee, and Maat 2010). It also seems that the perception of bicycle use plays a role, particularly in terms of effort required and dangerousness. Finally, it can be assumed that the use of bicycle was not promoted by cycling infrastructures planning or other incentive policies in their cities.

5.2.2.2 Current mobility in Copenhagen

As cities are often very different, and the context too, the means of transport used by the respondents changed when they arrived in Copenhagen. While only one respondent used bicycles regularly in his former city, most of respondents converted to this mode of transport (7

respondents indicated that they use bicycle regularly). It can be related to the fact that habits can be broken by particular events, such as moving and different environment. Thus, people have tended to rethink their mobility in a new context (Copenhagen area) with new references.

One of the main changes is car use that is perceived differently here, and there seems to be a willingness to manage without a car for different reasons such as perceived constraints or simply the fact that they don't think they need a car at the moment:

*"It's **not restrictive not to have a car** for me, just for these 4 months. [...] I didn't feel like I had to bring my car from France to here."* (Gabriel, 21, M)

However, as said in the previous quote, staying more or less long in Copenhagen can have an effect on considering getting a car or not. In addition, it appears that car-sharing systems or other are used in some cases:

*"No, I don't have a car. My fiancé has an account with DriveNow, the electric cars that we have here [...] we have used it on some vacations, for example **to get all our luggage to the airport**. And then, I have some friends that have a car, so when they are on vacations, we have access to their car."* (Anna, 26, F)

*"I don't have my car but, I used **twice the green mobility** thing, you know the electric cars you can rent. [...] Sometimes when I come home like too late and **there is no train** anymore, I just take **this car**."* (Camille, 23, F)

It seems that the use of the car does not completely disappear and that it remains a backup solution in some situations.

Respondents were asked about their first impression of cycling in Copenhagen, and the answers converge towards a common perception of a great democratisation of this means of transport:

*"There are **lots of them**. And there are **everywhere**. I also come from a city where people bike a lot, so it's not like let's say completely shocking that sense, but it's way **more structured** [...]"* (Sven, 27, M)

This quote above shows that even when someone is used to seeing a lot of bicycles, the way in which use is managed can still be surprising. Then, the main element that emerges from the answers is the astonishment at the omnipresence of bicycles:

*"I think **many people are using bicycles** here, that's my first impression yes."* (Fang, 25, F)

*"Oh, **there are pretty much!** And I think there are **even more than people**. And yes, I saw more bicycles than people."* (Chang, 22, M)

"I didn't expect to this, such a big thing, when I arrived. So, I was really surprised that everybody was using that and that was so common." (Pablo, 25, M)

"The fact that it is really developed. Everybody has a bicycle. And yes, you can do everything by bicycle, limited by the fact 'what if far or not' [...]" (Gabriel, 21, M)

In general, most respondents' first impressions converge on the fact that the number of bicycles in Copenhagen is significant and that its use is very widespread, and it was mainly a surprise for them, even if they had heard about the Danish cycling culture:

"I heard about it [Danish cycling culture], but you don't really realise before you see it for real, yes it was still surprising." (Pablo, 25, M)

"I have heard of it [Danish cycling culture], but I think I did not measure the extent of it. I was just thinking maybe some people bike, but not literally everyone." (Emma, 24, F)

This framework results in a perception of social support on bicycle use that encourage people to use a bicycle:

"I think it just motivates you to bike when everyone around you is also biking. So, I think it positively influences how often I bike. [...] When you meet your friends, and other people then, they are also more likely to bike just because they live this bike culture." (Charlotte, 26, F)

"[About buying a bicycle] You know, everyone was looking for a bike, and so 'Okay, I'm looking for a bike too'." (Camille, 23, F)

This result points to the importance of cycling in Copenhagen, but above all its effect on people who are foreign to this culture and who arrive in this city. The social norms seem to play a significant role for these people, which is in line with the results found in the literature.

Moreover, participants were asked about their evaluation and attitudes towards bicycle use, more precisely about the advantages and disadvantages they consider for cycling:

"Well, it's good for my health, just doing a bit of sport every day like that, it's good for the mental just to be outside and in the nature [...], and well it's good for the planet yes. I tried to avoid emissions." (Martin, 23, M)

"Well, it's a green mode of transport, and it also helps for health, you can do the exercising and other things. So, I think, generally, for environment, for individuals, it's quite...also...somehow, it's also convenient to travel." (Fang, 25, F)

"It's environmentally friendly. It's cheap. It's fast. And it's an outdoor mean of transportation." (Emma, 24, F)

*"It's **fast**, it's **cheap**, and **easy access to parking slots** [...] and of course it's **healthy**, to bike and get some **exercise** [...]" (Charlotte, 26, F)*

The previous quotes highlight the fact that answers tend to converge toward main elements, such as health, sport, ecological beliefs, etc. These points are mainly related to attitudes, which tend to have a positive effect on bicycle use, and also different reasons that are often taken into consideration by travellers (Heinen, van Wee, and Maat 2010).

However, some aspects of cycling use are also evaluated as negative and can be interpreted as barriers to cycling. In that way, interviewees were asked to indicate the disadvantages of cycling they perceive:

*"So, for example, if you meet up with a group of people that do not have a bike, then you get this kind of...troubles. And if you have a bike that you **care about**, you don't want to put it outside for a long period of time. So, it's also all these considerations. And of course, in Denmark when it **rains** and it **snows**, it's not the most comfortable..." (Sven, 27, M)*

*"[...] I think...for **long distance** it may takes quite **longer time**. Most of time it's not applicable, I think. Perhaps, that's a disadvantage. [In the case of Copenhagen] Probably the **weather**, because the **cold** period is quite long. And in that case, it's gonna be a little bit difficult to cycle." (Fang, 25, F)*

*"It's depending on the **season**, like sometimes it's not super practical. I'm not that kind of person that has all the **rain** gear yet, like some Danes do, with the pants and everything." (Emma, 24, F)*

*"A bit of **discomfort** because, when it's **raining**, it's not very pleasant. And yes, you get to work all **sweaty**, so, you have to take a **shower or bring change**." (Camille, 23, F)*

Once again, and as with the perceived advantages, it appears that some of the disadvantages mentioned stand out more and thus show a generalized trend. This is particularly the case for the weather and the effort required, that are can be considered as functional aspects. The latter is linked to different points: the environment in which the cyclist operates, i.e. whether it is a hilly or flat environment, but also the distance to be covered.

It can be concluded from these two questions that interviewees tend to converge toward the same elements when it comes to elements that are perceived positively and negatively with regard to bicycle use. This is particularly relevant as the majority of them were not used to cycling on a daily basis before. In addition, the various elements cited by respondents correspond to those often found in the literature (Heinen, van Wee, and Maat 2010).

Then, it appears that experience can also play a role in the way people consider bicycle use. The fact of having used bicycle in Copenhagen can have an effect on how this transport mode will be considered in the future.

"[About getting use to Danish cycling culture] Yes, because I plan next year to go by bicycle to my university, so I will have like 10 minutes of bicycle instead of using the car or using the public transportation, it's the same time, cheaper and faster than public transportation. [...] ... Yes, I think I wouldn't have considered the option of going by bicycle and taking my bicycle to Paris, if I haven't been to Copenhagen just before." (Gabriel, 21, M)

This quote highlights the result found in some other studies that people that tried to cycle to work are more likely to use it as a daily way to commute (Heinen, van Wee, and Maat 2010).

As already seen in a previous quote, spatial indicators are perceived as important elements by travellers. As a result, people consider the cycling infrastructures in Copenhagen as a part of what make cycling better:

"[...] I think the lanes are in good condition and they are wide enough there are enough of them, so easy to get around." (Sven, 27, M)

"[About bicycle infrastructures in Copenhagen] I am not quite sure because I do not have too much experience this yet, but...what I see is that most of the roads has bicycle lanes, and I think it's also a good way to promote this kind of transport mode." (Fang, 25, F)

"I think that, overall, the infrastructures are really good" (Pablo, 25, M)

"And in my mind, also the infrastructure plays a big role in helping citizens here to practice the culture and move the culture forward. So, having a good bike racks, and also very good maintenance facilities for your bike, that helps a lot." (Charlotte, 26, F)

The part about mobility in Copenhagen allows to notice that many respondents changed their mobility habits and switched to bicycle when they arrived in Copenhagen. Many reasons can be related to this change of behaviour. One of them is the support linked to social norms. It appears that being surrounded by bicycles and cyclists gives an impression of pressure that encourages the use of bicycles. However, this incentive does not seem to be perceived as negative, as no respondent express an impression of being forced to ride a bike so as not to feel rejected. Then, as interviewees were asked to evaluate this mean of transport, many advantages and disadvantages were cited. An interesting point and that regardless of the origins of the respondents, the elements mentioned seem to converge towards similar points. These elements are mainly related to attitudes towards cycling, perceived behavioural control, and also the

perception of spatial indicators. These aspects can be related to the theory of planned behaviour. While these results are rather consistent with those in the literature, one aspect could not be confirmed with the interviews conducted. Indeed, there does not seem to be any difference in the perceived advantages and disadvantages between those who use bicycles here and those who do not, whereas the literature tends to say that people who cycle perceive more positively this behaviour, and people who does not cycle are more likely to perceive barriers to cycling. Finally,

5.2.2.3 What could be improved and comparison with former city

In this final part, interviewees' opinions about cycling and mobility within the different cities they lived in are analysed in order to reveal the way it could be improved. In that way, two main questions were asked to interviewees:

- What could be improved in the use of bicycles in Copenhagen?
- What about the improvement points in bicycle use in the former cities?

The main goal of these questions is to identify the elements, such as psychological factors or environmental factors, that would make cycling easier and better for people.

As a continuation of the disadvantages mentioned above, the elements that emerge from the respondents' answers mainly deal with effort and weather. However, it appears that people are already quite satisfied with their cycling experience in Copenhagen and it is mainly a matter of details:

*"Maybe switching to an **electric bike**. To go **faster** and go **further** way with the bike instead of using the bus."* (Martin, 23, M)

*"Better **weather**...? No, there are, for example, a lot of nice **initiatives**, such as the ones which **countdowns to greenlight**... those things are of course very pleasant on your bike, right? So, on all, I think it's all good."* (Sven, 27, M)

*"I don't have any idea, for now. [...] For me, it's such **an improvement to be here**."* (Gabriel, 21, M)

*"I would like...For example **I would prefer electric bike** than a normal one. We can also **save some energy**, save some individual energy I mean."* (Fang, 25, F)

The answers are in some ways part of the solution to the disadvantages of using a bicycle obtained previously.

Then, respondents were asked to give some elements that could improve their cycling conditions in their former cities:

*"[About Copenhagen infrastructures] And bike lanes are amazing. It's a biking city, so **there are cities where you could build out bike lanes.** [...] **Better bike lanes** would be nice. And then of course, you always want a **metro**, right? That's the most efficient system but I think it's just too small to make it reasonable." (Sven, 27, M)*

*"Clearly **the bike lanes** having a different asphalt very soft, and **different height so cars don't get in...yes, all this great cycling environment.** So clearly the design of the bike lanes." (Martin, 23, M)*

*"The **bike lanes**, definitely. And not just...I mean proper bike lanes, that are **separated from the roads**, and not just bike lanes that are drawn on top of bus lanes. And, like traffic lights for the bikes. [About being more likely to cycle in the case there were all cycling infrastructures in former cities] **Definitely, definitely, yes.**" (Emma, 24, F)*

The last quote highlights the fact that the sense of security can be linked to infrastructure, and in particular to being separated from cars.

*"The **cycleways**, everywhere in the cities [...] You can't really cycle in Paris, you don't have...I mean in Denmark you have...every road you have a cycleway with it. In Paris, not at all. So, I think, yes, **definitely all the cycleways should be, really...if it was established in France, it would be really cool.**" (Gabriel, 21, M)*

*"Maybe also the infrastructures of **being able to put the bike in the train or in the metro**, or in something, because as it is now, it would be very like inconvenient to try [...] yes that would be nice." (Camille, 23, F)*

*"**Bike lanes**, and... the stable **timetable**, because people don't want to get, like...get a fake timetable, I would have to wait at the station for a long time. And... yes... less strikes." (Chang, 22, M)*

These quotes highlight some answers given in previous parts about the importance of infrastructures to encourage cycling. However, the last quote shows that other modes of transport can interfere with the use of bicycles, as they can be more attractive for some people. In addition, for some respondents, the environment in their city is not adapted to the use of bicycle:

*"I think it still depends...because of the **geography** that...the **road is not as flat as in Copenhagen, in Hong Kong.** Another thing is also about the convenience, because the convenience of the other transport modes is already very good, so there are, actually, kind of **competing transport modes** for that, so I think it depends." (Fang, 25, F)*

"I mean, even if there were like bicycle infrastructures, it has to be, like, really adapted...I mean I'm speaking about a difference of 1,000 meters in altitude from one town to another. So... biking over it might be, like, really complicated." (Pablo, 25, M)

As the main barriers seem to be related to the effort needed to use a bicycle, the e-bike solution was proposed in order to analyse which other barriers could appear in that case:

*"We have a lot of **ups and downs** in Iceland. [About using e-bike] Yes, I think that's actually why it's becoming more popular in Iceland. [...] but I think the **climate is still a big issue**. [About combining bike and public transports] I think that would definitely help."* (Anna, 26, F)

All the answers got from this part make possible to evaluate the situation about cycling in Copenhagen and other cities in the world. Whereas in Copenhagen cycling conditions are already perceived as being good, some points of improvement mainly about the weather and effort come out. These elements are in line with the disadvantages identified previously. In the same time, for improving cycling conditions in respondents' former cities, infrastructure is the main lever on which to act, particularly to improve the perception of safety. Most of the elements collected in the responses to the interviews are consistent with what is present in the literature. This is particularly the case for the support of social norms, attitudes towards cycling, but also spatial factors that play an important role, such as cycling infrastructure and hilliness. However, it appears that other cities characteristics such as competition from other transport modes or topography do not seem to facilitate the improvement of bicycle use.

While some solutions can be considered at an individual level, others require specific policies. These elements make it possible to consider some ways to improve the promotion of bicycle use in cities where it is low.

6. Discussion

As the studies have been conducted in order to highlight the elements that encourage or discourage the use of bicycle, it is interesting to extract from these results the relevant and useful elements. This section will first present the lessons learned from these studies, including qualitative interviews, before proposing ideas for promoting cycling. Finally, the limitations of the studies conducted will be presented in order to take a step back on the results.

6.1 Lessons learned from the studies

This section aims to highlight the results obtained in the previous sections, and in particular to highlight the elements that have a significant effect on bicycle use. Thus, it is then possible to propose ways to develop the use of bicycles through the implementation of policies and/or facilities that encourage their use.

The two studies previously conducted highlight the factors that influence bicycle use. However, some influencing factors, such as socio-demographic factors, are not potential levers for action. The main focus here is therefore on what is related to the characteristics of a journey, the environment and user perception. Among the most important elements in the choice of bicycle use, safety feeling was often mentioned in the previous study. Indeed, it appears to be one of the negative aspects that can discourage the use of a bicycle if the facilities are not designed to protect the user. The effort due to distance or hilliness is also perceived negatively by cyclists as non-cyclists. By the influence of the subscription to public transport in the regressions, and the perception of these public transport as being in competition with cycling in the interviews, it appears that there is also a risk and an effect of competition between the modes of transport. Then, cost is an important factor in the choice of a means of transport, but it is not always perceived in the same way. Thus, it has been shown that even if the cost of a bicycle is lower than that of a car, it is more efficient to pay bicycle users to encourage people to switch to this mode of transport. With these lessons learned, it is possible to make proposals on policies to be put in place to encourage cycling.

6.2 Propositions

The aim of this part is to answer to the previous highlighted points with ideas to improve bicycle use.

For instance, in order to improve safety feeling, the development of proper infrastructures can be a solution. The Dutch approach called “Sustainable Safety” proposes to follow 5 rules when designing roads²⁰:

- Functionality of roads: to be sure that roads have only one purpose
- Homogeneity of mass, speed, and direction of the users: to try to avoid huge difference in speed, mass or direction. Speed is a significant factor during crash.
- Predictability of road course/road user behaviour: roads must be designed to be easily understood by users. Users also need to know how other users will move.
- Forgivingness of the roads: the environment must be designed as if one user makes an error, it does not result in a serious crash. An example is the separation between two roads at different levels which should not be too abrupt for cyclists not to fall if they accidentally pass on the other road.
- State of awareness by the road user: it is mainly related to education and consists of the ability to judge which behaviour is appropriate.

These different rules seem to be really interesting as they aim at reducing risks on roads and can make people feel safer.

Another aspect of cycling is the economic aspect. Indeed, interviews have shown that it is a means of transport considered cheap. Nevertheless, in order to motivate more people to turn to cycling, it may be relevant to focus on financial incentives. In France, there is a bicycle mileage allowance that allows companies to cover part of the costs associated with bicycle use. The allowance is 0.25 €/km multiplied by the number of kilometres between the employee's home and place of work²¹. However, this system is not implemented everywhere, and even in France it remains limited since companies can choose not to grant the allowance, just as public sector employees have access to it only in certain organizations and on an experimental basis. Another financial support could be

²⁰ Source: Bicycle Dutch, <https://bicycledutch.wordpress.com/2012/01/02/sustainable-safety/>

²¹ Source: URSSAF, <https://www.urssaf.fr/portail/home/employeur/calculer-les-cotisations/les-elements-a-prendre-en-compte/les-frais-professionnels/les-frais-de-transport/trajet-domicilelieu-de-travail/prise-en-charge-facultative-des/indemnite-kilometriques-velo.html>

for the purchase of e-bikes. Indeed, as noted above, the perception of effort related to distance and hilliness is a major obstacle to regular bicycle use. The use of e-bikes could help to reduce this bad perception and thus encourage more people to use bicycles more often and for longer distances, thus reducing the use of other means of transport. In the same way, encouraging the combination of public transport with cycling would make it possible to consider cycling for many trips. The possibilities offered to cyclists still seem very limited and do not allow full consideration to be given to using both modes of transport together. In addition, in most major cities, public transit is saturated during rush hours, so it seems difficult to consider adding bicycles. An innovative solution should therefore be explored so that buses, metros, etc. can contain bicycles, without reducing the space available to users.

Here are some proposals that could be tried to improve bicycle use in cities. It may be interesting to note that in some countries, there are associations working on bicycle use improvement. This is particularly the case for Dutch Cycling Embassy, Cycling Embassy of Denmark or the French Federation of Bicycle Users.

6.3 Limitations of the studies

The principle of this section is to present the limitations of previous studies and provide some perspective on the results obtained.

The first study of survey data has limitations that are interesting to present here. First of all, these data come from two different surveys, which implies that they were conducted differently. One consequence is that the two surveys are not initially similar. Although some aspects are similar, the procedure followed to carry them out may vary and therefore lead to inconsistencies between the two surveys. In addition, in order to ensure a sufficiently large number of data, it was decided to extend the period of the data selected in the Copenhagen survey over several years. This results in a risk of a punctual event that would only affect one of the two samples. A solution to avoid these limitations could be to set up a survey method at European level, for example. Thus, a certain homogeneity of the surveys carried out would make it easier to compare them. Then, about the regressions, the R^2 of McFadden calculated are not really good with low values, especially for Lyon. This must be taken into account when interpreting the results. Finally, it would have been interesting to be able to study more variables, such as daylight, spatial factors (hilliness, bicycle infrastructures, etc.) or income.

Nevertheless, the results obtained are not completely in disagreement with the results in the literature and they allow to have a comparison of two cities with completely different cycling levels.

About the second study, the sample used is not really representative as it is composed only with students (mainly from DTU) and young people (between 21 and 27). It may be interesting to collect the perceptions and opinions of people of different ages. Similarly, diversifying the background of participants could also provide access to more information. Nevertheless, having a sample with similar individuals allowed the effects of certain factors to be erased and a set of responses representing a particular group to be obtained. Another limitation of this study is related to the analysis and interpretation of interviews. Indeed, the interviews were analysed by only one person. A cross-referenced look at the transcripts could have allowed for different interpretations and thus improved the elements retained.

7. Conclusion

In a context where issues related to climate change and urban pollution are increasingly appearing in the media, mobility as it is today is being questioned. In cities, the place given to the car for several decades is now being questioned and alternatives to this individual means of transport are being sought. Cycling therefore often appears in proposals for alternatives to the car because it takes up less space and does not emit greenhouse gases or pollutants. However, the place of cycling is still very unequal in the world, and even already in European countries. In this thesis, a comparison of bicycle use in Copenhagen and Lyon was carried out on the basis of two independent surveys. The modal share of bicycle in trips made in these cities varies greatly: whereas in Copenhagen, 22.60% of journeys are made by bicycle, this figure reaches only 1.80% in Lyon. These are therefore two cities which, despite the fact that they have close areas and populations, have a great disparity in their use of the bicycle. The statistical analyses carried out on these two surveys made it possible to identify the determinants of bicycle use and compare them between the two study areas. Age and gender are two characteristics that have a significant influence on the choice of cycling in Lyon. Other factors such as car availability, public transport subscription, or weather conditions affect modal choice in the two cities. This study was subsequently supplemented by qualitative interviews with international students in Copenhagen. The interviews made it possible to analyse how the Danish cycling culture is perceived by foreigners, and to identify the elements that encourage or discourage the use of a bicycle. The different elements interpreted in these interviews come from the theory of planned behaviour, such as attitudes, social norms and perceived control behaviour. It was therefore possible to highlight that being surrounded by people cycling is really motivating to choose this mode. In addition, the perception of some positive or negative aspects of bicycle use may be accentuated or moderated by the environment. For example, Copenhagen's cycling infrastructure allows cyclists to be separated from cars, thus increasing safety feeling. Cycling infrastructure is one of the things that foreigners seem to miss the most in their former cities. Finally, other elements from the interviews and the statistical study made it possible to suggest ways to improve bicycle use conditions in many cities and encourage people to switch to this mode. These proposals mainly concern the feeling of safety, through compliance with rules in road design, the economic aspect, with a financial incentive in the form of a kilometric allowance for the use of bicycles or subsidies for the purchase of electric bicycles, as well as competition between modes of transport with improved combinations of public transport with bicycles, in particular the ease of using public transport with a bicycle.

This thesis is part of a subject that is becoming increasingly important given the current challenges. The search for alternatives to polluting modes of transport is very present in policies. Understanding what encourages people to use one mode of transportation over another is a key step in providing effective promotional campaigns in the future. This thesis proposed to identify a part of these determinants in the cities of Lyon and Copenhagen. Some limitations have been raised in this thesis and it is therefore possible to propose perspectives on this research. The two data sets have been modified to match the different variables and modalities to each other. It would therefore be possible to extend the research carried out, particularly on other modes of transport, in order to increase knowledge in this field. Finally, this thesis made it possible for the comparison of two cities to be made, which has not been found in the literature. It is therefore a gain of knowledge. In addition, other articles highlight the influence of the level of cycling in a city on the determinants of cycling use, and here it has been possible to highlight this difference between low and high level. In the future, if survey data were easily accessible, it would be relevant to make further comparisons between cities of the same size.

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Appendices

9. Appendix 1 – The different goals established by UNO

THE WAY FORWARD UNECE SUSTAINABLE TRANSPORT DIVISION CONTRIBUTION TO SUSTAINABLE DEVELOPMENT GOALS through servicing the ITC, ECOSOC Committee, THE PEP and the Special Envoy for Road Safety

SDGs Targets		Sustainable Transport Division				
		Analytical work	Capacity Building	Regulatory Work		
1	1.4 ... ensure that all men and women, have access to basic services. 1.5 ... reduce their exposure and vulnerability to climate-related extreme events	1	Transport for Sustainable Development: The case of inland transport		WP.5	
2	2.1 ... access to food all year round 2.a ... increase investment ... in rural infrastructure	2	Benchmarking transport infrastructure construction costs	Ⓢ Perishable Foodstuffs (ATP)	WP.5, WP.11	
3	3.6 ... halve the number of global deaths and injuries from road traffic accidents 3.9 ... reduce the number of deaths from ... hazardous chemicals and air pollution	3	Ⓢ a. Diesel Engine Exhausts Ⓢ b. Intelligent Transport Systems Strategy Ⓢ c. THE PEP Ⓢ d. R.S. papers	Ⓢ a. Support to Special Envoy on Road Safety Ⓢ b. Promoting R.S. Ⓢ c. R.S. Items Ⓢ d. SAFEFTS Ⓢ e. UNDA Road Safety Mgt Project	Ⓢ a. Road signs and signals Ⓢ b. Road Traffic rules Ⓢ c. Drink-Drive Ⓢ d. UN Vehicle Agreements Ⓢ e. Dangerous goods Ⓢ f. GHS recommendations Ⓢ g. CTU Code	WP.1, WP.29, WP.5, WP.15, WP.6, WP.24, SC.1
4	4.3 ... ensure equal access for all women and men to ... education	4	Ⓢ a. Transport for Sustainable Development Ⓢ b. Sustainable Urban Mobility and Public Transport			WP.5
6	6.1 ... achieve universal and equitable access to safe and affordable drinking water for all	6				WP.5
7	7.3 ... improvement in energy efficiency	7	Ⓢ a. Diesel Engine Exhausts	Ⓢ a. Promoting Vehicles Regulations Ⓢ b. Periodical technical inspections	Ⓢ a. UN Vehicle Agreements Ⓢ b. Intermodal Transport & Logistics	WP.23, WP.5, WP.24
8	8.8. Protect labour rights and promote safe and secure working environments for all workers	8	a. Mutual recognition of boat masters certificates b. Work of Crews of Vehicles Engaged in Int Road Transport	Harmonization of professional requirements in inland navigation	a. Work of Crews of Vehicles engaged in International Road Transport (ACRTR) b. Code of Practice on the Packing of Containers	WP.24, SC.3, SC.1
9	9.1. Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure	9	Ⓢ a. ITS Strategy Ⓢ b. Border Crossing Facilitation Papers Ⓢ c. C.C. Adaptation	Ⓢ a. Financing Infrastructure Ⓢ b. TEM & TER and EATL projects Ⓢ c. BIC Facilitation	Ⓢ a. Border crossings facilitation (TIR, Harmonization etc.) Ⓢ b. Infrastructure (RGR, AGC etc.) Ⓢ c. UN Vehicle Agreements	WP.30, WP.6, SC.1, SC.2, SC.3, WP.24, WP.5, WP.29
11	11.2 Provide access to safe, affordable, accessible and sustainable transport systems for all	11	Ⓢ a. Sustainable Urban Mobility and Public Transport Ⓢ b. Transport for Sustainable Development Ⓢ c. ITS Strategy	Ⓢ a. Urban Mobility and Public Transport Ⓢ b. ForFITS Ⓢ c. SAFEFTS Ⓢ d. THE PEP	Ⓢ a. UN Vehicle Agreements Ⓢ b. Dangerous Goods Conventions (ADR, ADN) Ⓢ c. GHS Recommendations Ⓢ d. UNRS Conventions	WP.29, WP.15, WP.1, WP.5, SC.1, SC.2, WP.24
12	12.3 ... reduce food losses along production and supply chains... 12.c ... fuel subsidies 12.4 ... achieve the environmentally sound management of chemicals ...	12	a. EATL, TEM, TER projects b. ATP Roadmap c. Border Crossing Facilitation Papers	Ⓢ a. Transport Corridors Ⓢ b. promoting Vehicles Regulations	Ⓢ a. UN Vehicle Agreements Ⓢ b. Perishable Foodstuffs Ⓢ c. Transport of Dangerous Goods Ⓢ d. GHS Recommendations Ⓢ e. UNRS Conventions	WP.29, WP.5, WP.15, WP.11, WP.1, WP.30
13	13.1. Strengthen resilience and adaptive capacity to climate-related hazards 13.3 / 13.a Climate Change Mitigation	13	Ⓢ a. C.C. Adaptation Ⓢ b. C.C. adaptation & Transport	Ⓢ a. ForFITS Ⓢ b. Non road mobile machinery project	Ⓢ a. UN Vehicle Agreements	WP.29, WP.5, WP.24
14	14.1 ... prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities.....	14	Ⓢ a. Ports Hinterland Connections	Ⓢ a. Inland Waterways and coastal shipping	Ⓢ a. Transport of Dangerous Goods / ECOSOC recommendations	SC.3, WP.15, ECOSOC, WP.5
17	17.5 Adopt and implement investment promotion regimes; 17.11 Significantly increase the exports of developing countries 17.17 Encourage and promote public-private partnerships	17	Ⓢ a. EATL, TEM, TER projects Ⓢ b. Transport for Sustainable Development	Ⓢ a. Innovative ways to finance Transport infrastructure Ⓢ b. PPPs and Rail	Ⓢ a. Work on Unified Railway Law Ⓢ b. Infrastructure Ⓢ c. BIC Facilitation	SC.1, SC.2, SC.3, WP.24, WP.5, WP.30

10. Appendix 2 – Modalities modification in different variables

10.1 Occupation

Occupation – Initial modalities	
TU data	EMD data
<ul style="list-style-type: none"> • Pupil from primary • Pupil from high school • Student at university or other further education • Apprentice, trainee • Employee • Self-employed • Unemployed, unemployment benefit • Social assistance, rehabilitation, long-term ill • Non-age pensioner • Receiver of pre-retirement pay • Old age pensioner • Full-time housewife, otherwise out of work • NA 	<ul style="list-style-type: none"> • Full-time work • Part-time work • Apprenticeship, trainee • Student from university and other further education • Pupil • Unemployed • Retired • Full-time housewife • Other

Occupation regrouped in 5 categories	
TU data	EMD data
<ul style="list-style-type: none"> • Pupil <ul style="list-style-type: none"> ○ Pupil from primary ○ Pupil from high school • Student at university or other further education • Work <ul style="list-style-type: none"> ○ Apprentice, trainee ○ Employee ○ Self-employed • Do not work <ul style="list-style-type: none"> ○ Unemployed, unemployment benefit ○ Social assistance, rehabilitation, long-term ill ○ Non-age pensioner ○ Receiver of pre-retirement pay ○ Old age pensioner ○ Full-time housewife, otherwise out of work • Other <ul style="list-style-type: none"> ○ NA 	<ul style="list-style-type: none"> • Pupil • Student from university and other further education • Work <ul style="list-style-type: none"> ○ Full-time work ○ Part-time work ○ Apprenticeship, trainee • Do not work <ul style="list-style-type: none"> ○ Unemployed ○ Retired ○ Full-time housewife • Other

The modalities have been grouped into 5 categories (Pupil, Student, Work, Do not work, Other) as follows:

10.2 Driving license

Driving license - Initial modalities	
TU data	EMD data
<ul style="list-style-type: none"> • Person under 18 years • Yes • No, has never had • Has had 	<ul style="list-style-type: none"> • Yes • No • Learning

In the same way, modalities of the variable "Driving license" can be regrouped as binary variable Yes and No:

Driving license	
TU data	EMD data
<ul style="list-style-type: none"> • Yes • No <ul style="list-style-type: none"> ○ Person under 18 years ○ No has never had ○ Has had 	<ul style="list-style-type: none"> • Yes • No <ul style="list-style-type: none"> ○ No ○ Learning

10.3 Public transport pass

Public transport pass - Initial modalities	
TU data	EMD data
<ul style="list-style-type: none"> • Yes • No 	<ul style="list-style-type: none"> • Yes, free • Yes, paid with partial employer support • Yes, paid without any employer support • No

The variable related to public transport pass is also modified into a binary variable:

Public transport pass	
TU data	EMD data
<ul style="list-style-type: none"> • Yes • No 	<ul style="list-style-type: none"> • Yes <ul style="list-style-type: none"> ○ Yes, free ○ Yes, paid with partial employer support ○ Yes, paid without any employer support • No

10.4 Transport mode

These two variables are not going to be used as model variables, but they can be useful to make descriptive statistics.

Transport mode - Initial modalities	
TU data	EMD data
<ul style="list-style-type: none"> • Walk • Bicycle • Moped 30 • Moped 45 • Skateboard/roller/scooter • Passenger car • Van (vehicles for goods transport <3.5t) • Lorry (vehicles for goods transport >3.5t) • Motorcycle • Taxi cab 	<ul style="list-style-type: none"> • Walk • Bicycle driver • Bicycle passenger • Moped driver <50cm³ • Moped passenger <50cm³ • Moped driver >50cm³ • Moped passenger >50cm³ • Shared bicycle driver • Shared bicycle passenger • Private car driver • Private car passenger • Public bus

<ul style="list-style-type: none"> • Tourist coach, rented bus • Public bus • S-train • Other train • Metro train • Ferry, water bus • Pleasure boat • Airplane 	<ul style="list-style-type: none"> • Public tramway • Public metro • Train to airport • Department public transport • Tourist coach, rented bus • Regional train • Regional coach • National train • Taxi cab • Employer transport • Van/Lorry driver • Van/lorry passenger • Inland or maritime transport • Airplane • Skateboard/ roller/ scooter • Wheelchair • Other modes
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<ul style="list-style-type: none"> ○ Van (vehicles for goods transport <3.5t) ○ Lorry (vehicles for goods transport >3.5t) ○ Taxi cab ○ Tourist coach, rented bus ○ Pleasure boat ○ Airplane • Private car <ul style="list-style-type: none"> ○ Passenger car • Public transport <ul style="list-style-type: none"> ○ Public bus ○ S-train ○ Other train ○ Metro train ○ Ferry, water bus 	<ul style="list-style-type: none"> • Public transport <ul style="list-style-type: none"> ○ Public bus ○ Public tramway ○ Public metro ○ Train to airport ○ Department public transport ○ Regional train ○ Regional coach ○ National train • Other <ul style="list-style-type: none"> ○ Two+ motorized wheels driver <50cm³ ○ Two+ motorized wheels passenger <50cm³ ○ Two+ motorized wheels driver >50cm³ ○ Two+ motorized wheels passenger >50cm³ ○ Tourist coach, rented bus ○ Taxi cab ○ Employer transport ○ Van/Lorry driver ○ Van/lorry passenger ○ Inland or maritime transport ○ Airplane ○ Skateboard, roller, scooter ○ Wheelchair ○ Other modes
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As some categories represent only few trips, more general categories (Walk, Bicycle, Two+ motorized wheels, Private car, Public transport, Other) are created to group the modalities:

Transport mode	
TU data	EMD data
<ul style="list-style-type: none"> • Walk • Bicycle • Other <ul style="list-style-type: none"> ○ Moped 30 ○ Moped 45 ○ Motorcycle ○ Skateboard, roller, scooter 	<ul style="list-style-type: none"> • Walk • Bicycle <ul style="list-style-type: none"> ○ Bicycle driver ○ Bicycle passenger ○ Shared bicycle driver ○ Shared bicycle passenger • Private car <ul style="list-style-type: none"> ○ Private car driver ○ Private car passenger

10.5 Education level

Education level – Initial modalities	
TU data	EMD data
<ul style="list-style-type: none"> • 1st-7th form • 8th form • 9th form • 10th form • Upper secondary certificate/higher preparatory certificate • Higher commercial/technical certificate – Business college • Other schooling • Vocational (certificate of apprenticeship) • Short-term further education (1.5-2 years) • Medium-term further education (2-5 years) • Long-term further education (more than 5 years) 	<ul style="list-style-type: none"> • Studies in progress • Primary school • Secondary to 3rd • Secondary to baccalaureat • Secondary to baccalaureat success • Higher +2years • Higher with at least 3 years • Apprenticeship primary and secondary • Apprenticeship higher • No study background

<ul style="list-style-type: none"> • Secondary: <ul style="list-style-type: none"> ○ 8th form ○ 9th form ○ 10th form ○ Upper secondary certificate/higher preparatory certificate ○ Higher commercial / technical certificate – Business college • Apprenticeship <ul style="list-style-type: none"> ○ Vocational (certificate of apprenticeship) • Higher <ul style="list-style-type: none"> ○ Short-term further education (1.5-2 years) ○ Medium-term further education (2-5 years) ○ Long-term further education (more than 5 years) • Other <ul style="list-style-type: none"> ○ Other schooling 	<ul style="list-style-type: none"> • Secondary <ul style="list-style-type: none"> ○ Secondary to 3rd ○ Secondary to baccalaureat ○ Secondary to baccalaureat success • Higher <ul style="list-style-type: none"> ○ Higher +2years ○ Higher with at least 3 years • Apprenticeship <ul style="list-style-type: none"> ○ Apprenticeship primary and secondary ○ Apprenticeship higher • Other <ul style="list-style-type: none"> ○ No study backgrounds ○ Studies in progress
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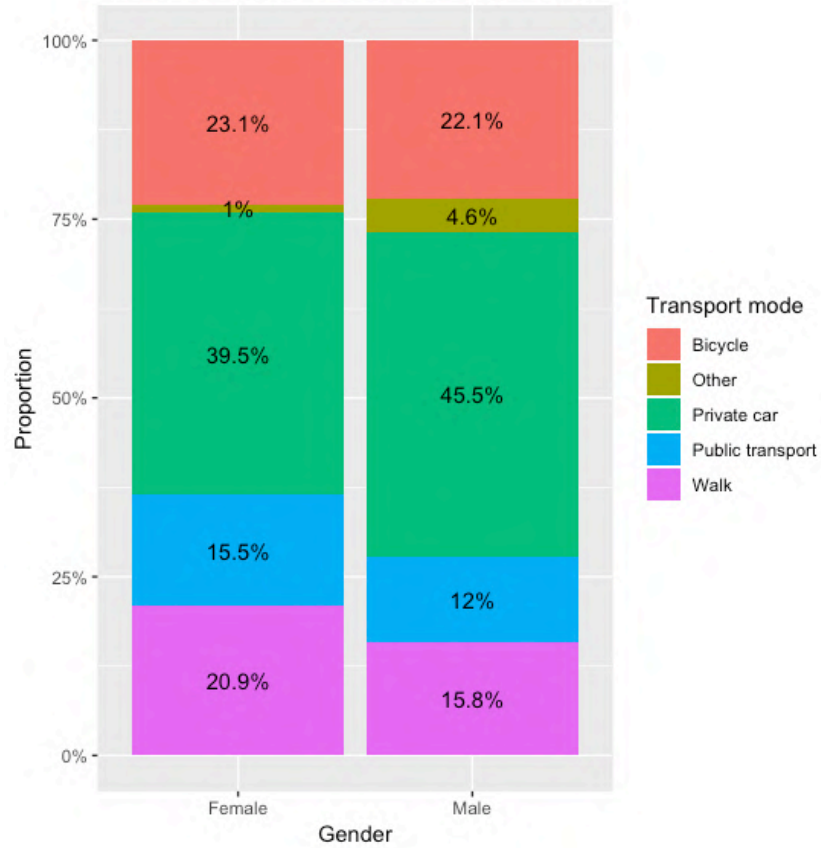
These variables have been grouped into 5 categories:

Education level	
TU data	EMD data
<ul style="list-style-type: none"> • Primary: <ul style="list-style-type: none"> ○ 1st-7th form 	<ul style="list-style-type: none"> • Primary: <ul style="list-style-type: none"> ○ Primary school

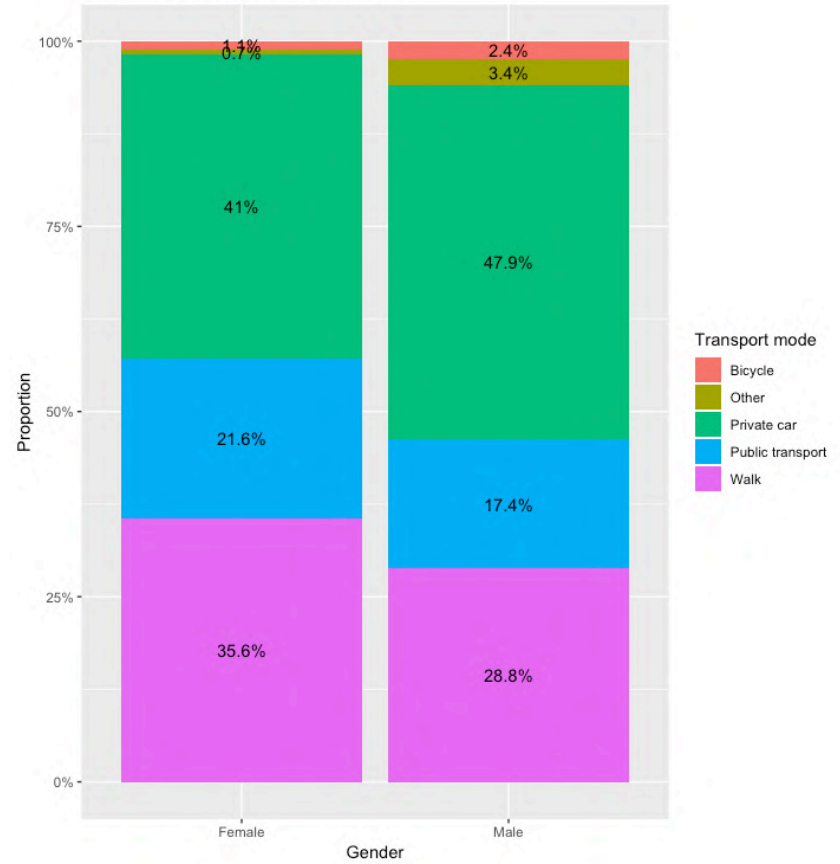
11. Appendix 3 – Bivariate statistics

11.1 Gender

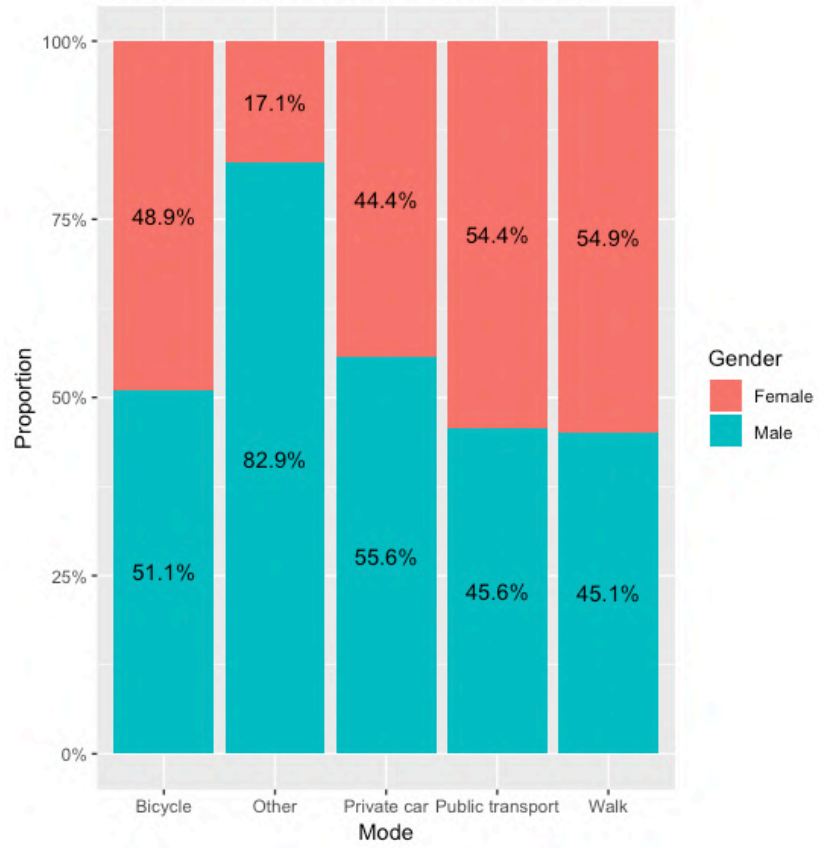
Gender and transport mode in Copenhagen



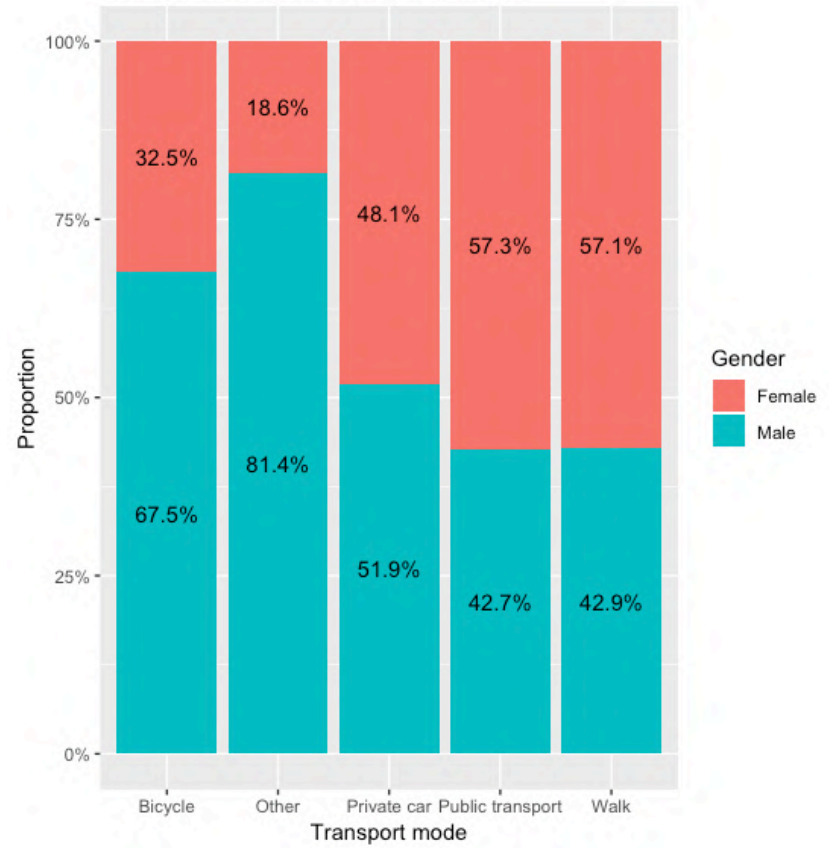
Gender and transport mode in Lyon



Transport mode and gender in Copenhagen

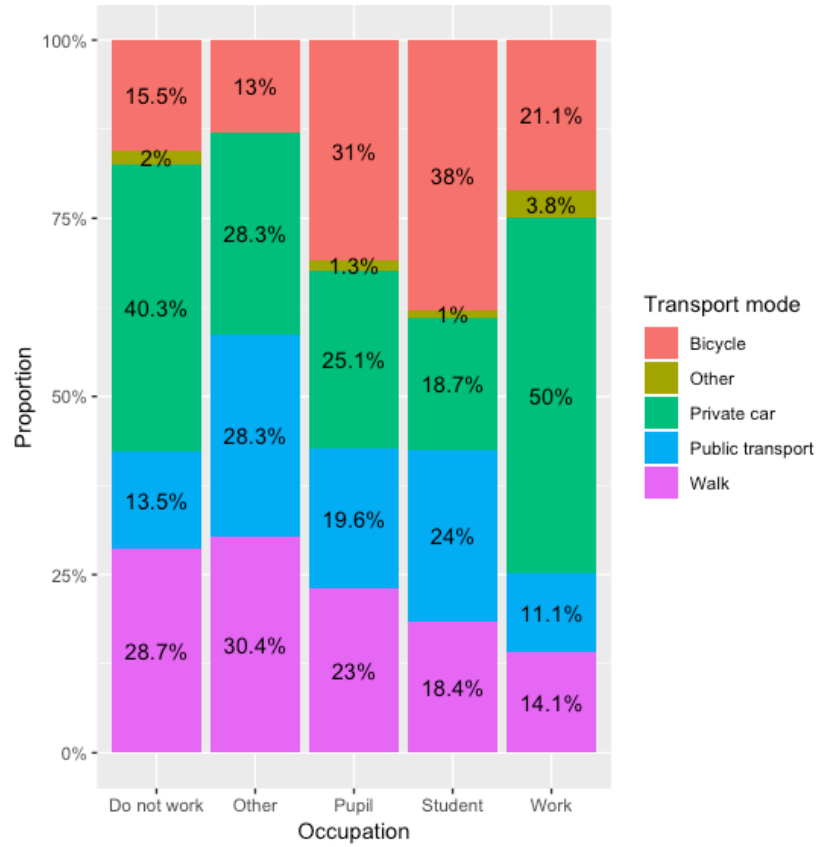


Transport mode and gender in Lyon

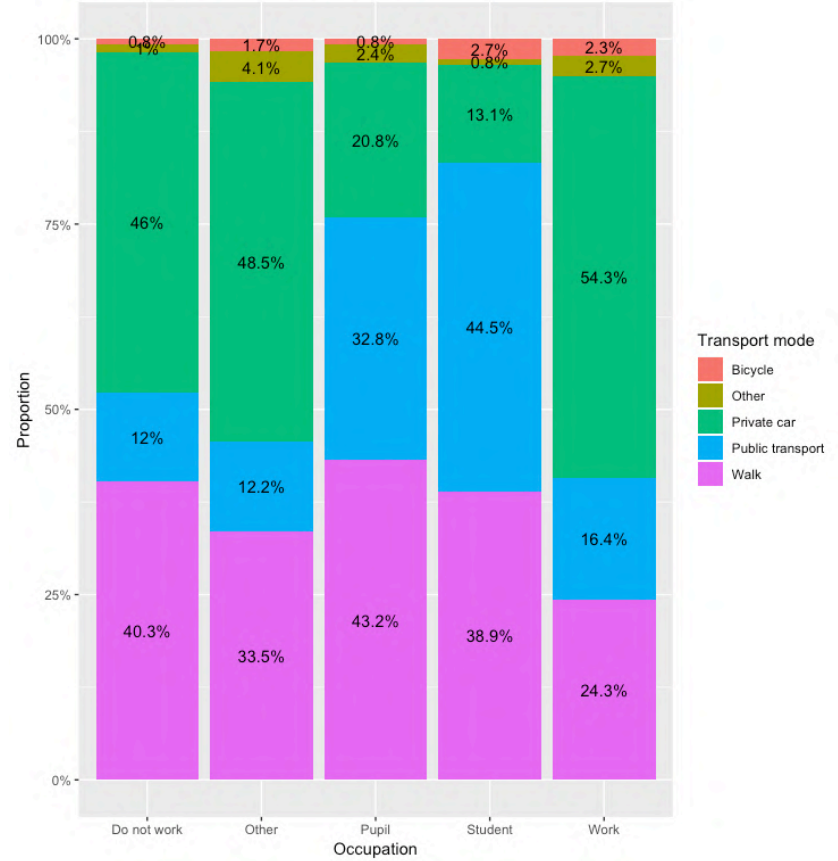


11.2 Occupation

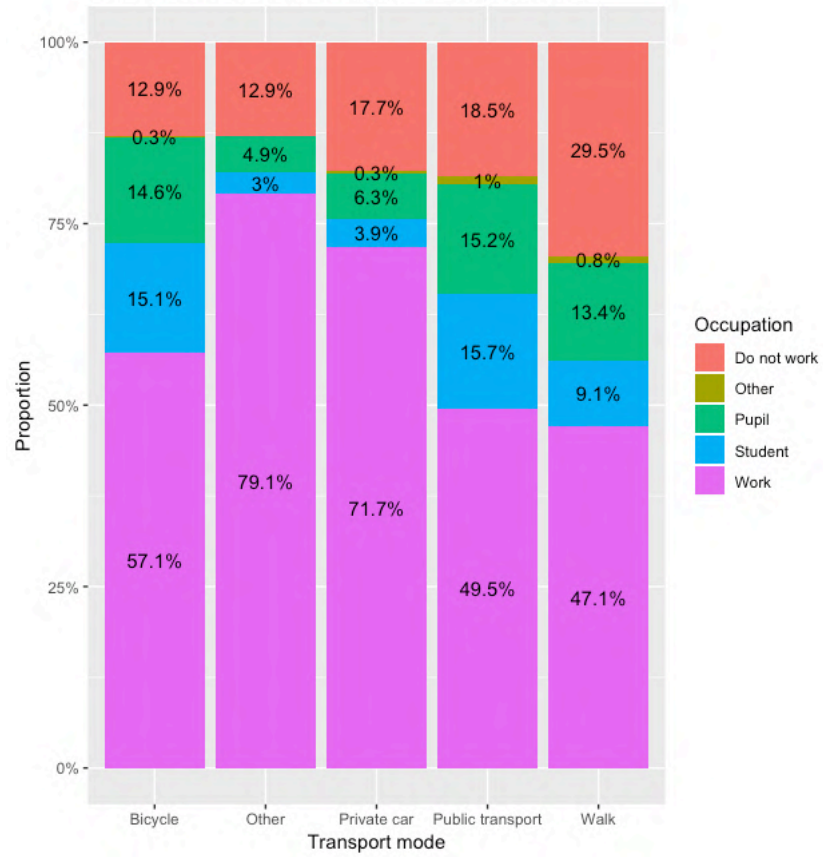
Occupation and transport mode in Copenhagen



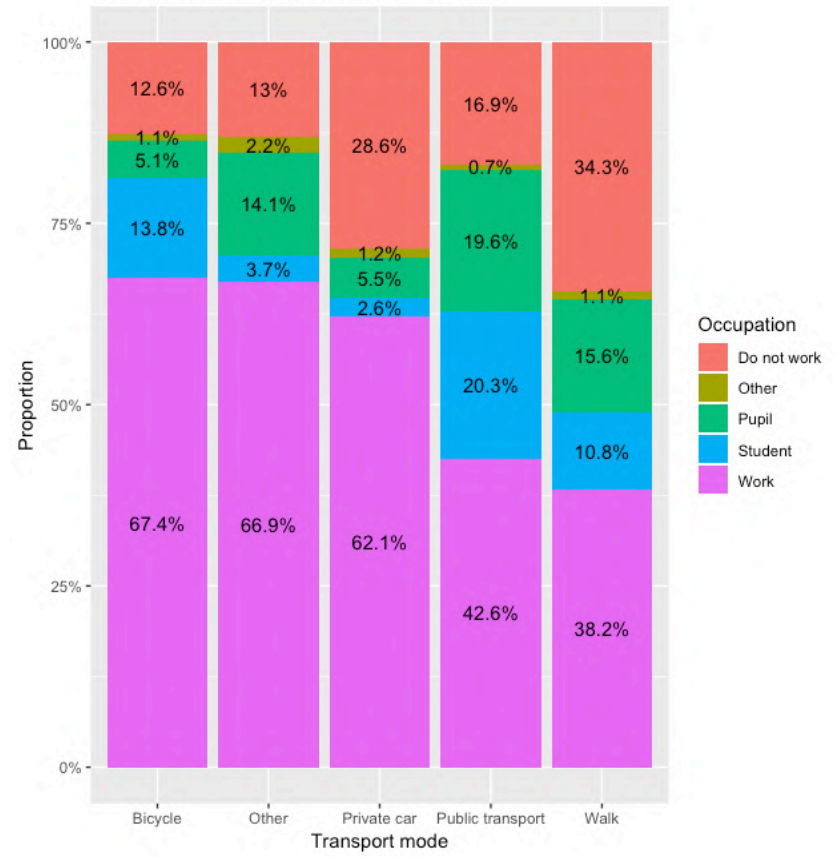
Occupation and transport mode in Lyon



Transport mode and occupation in Copenhagen

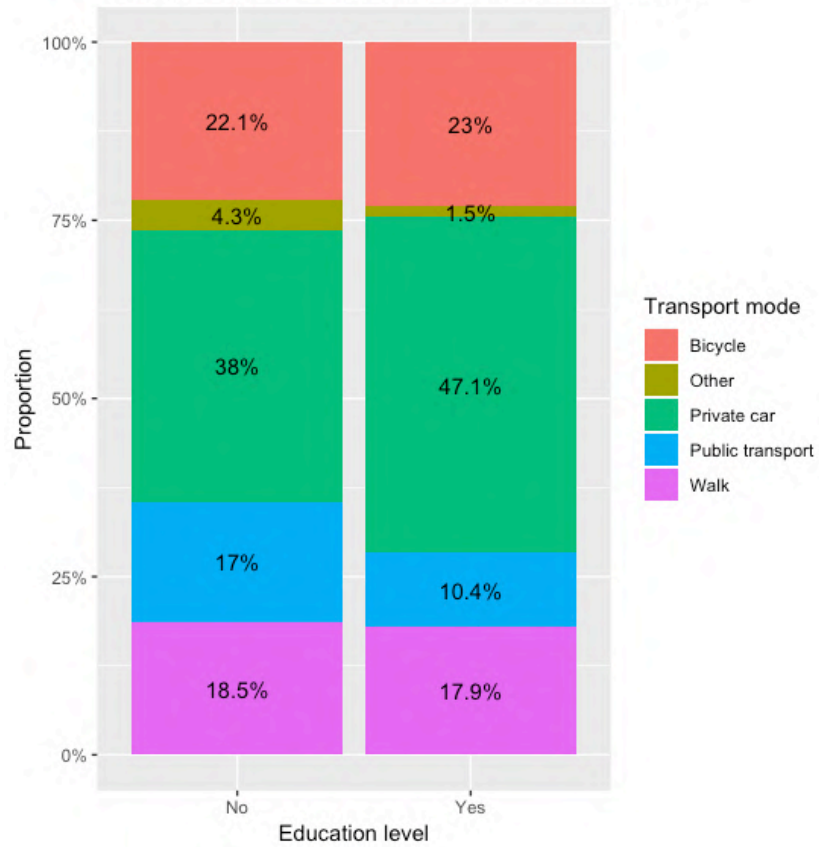


Transport mode and occupation in Lyon

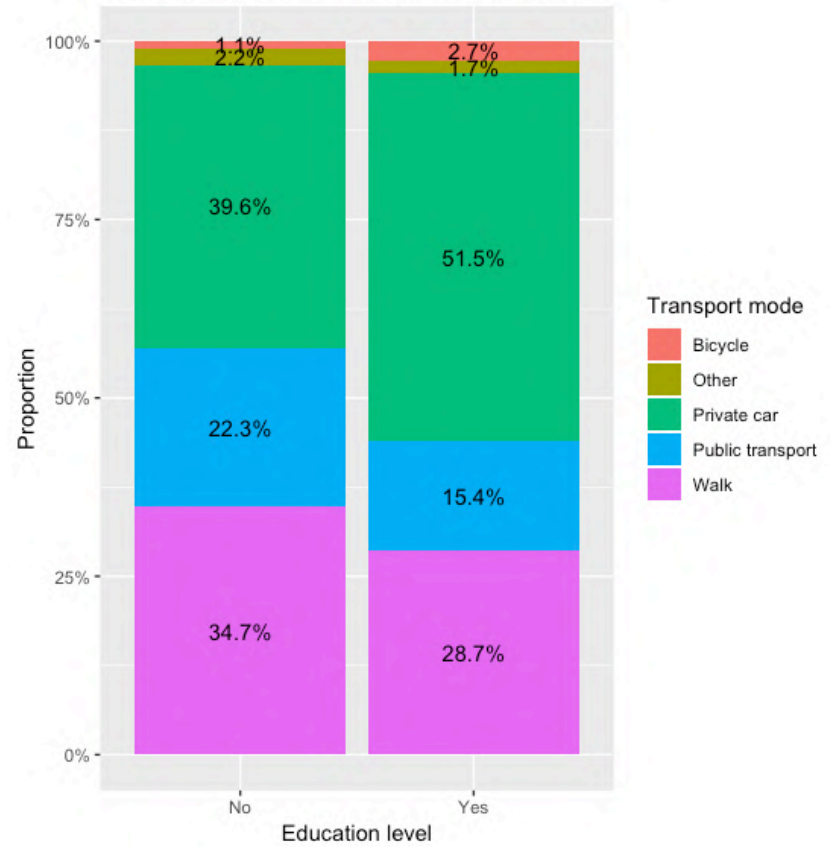


11.3 Education

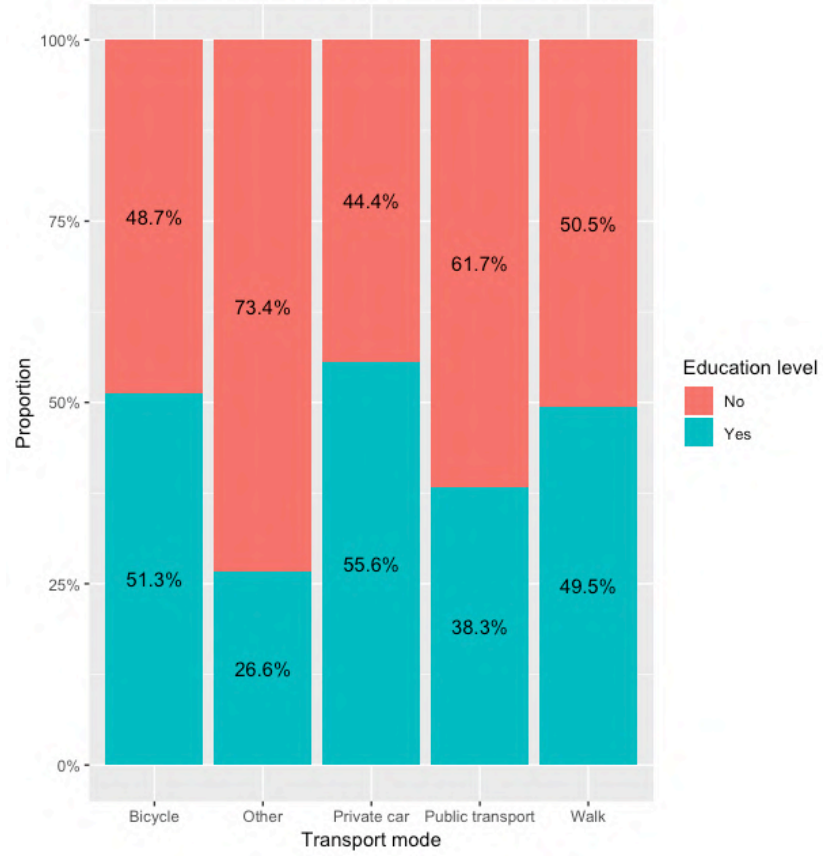
Education level and transport mode in Copenhagen



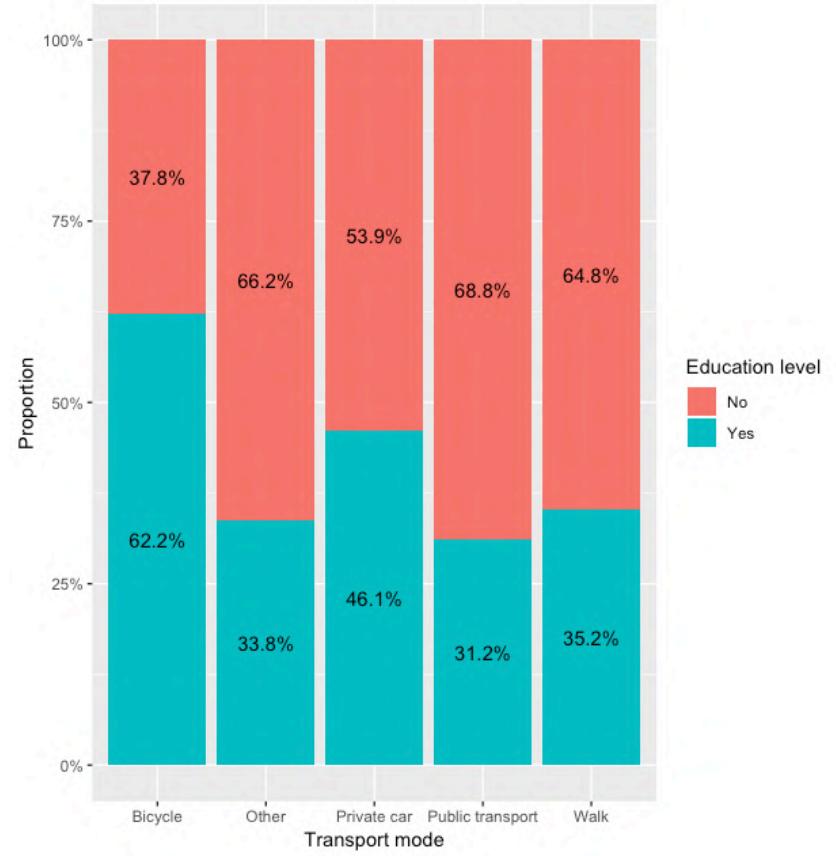
Education level and transport mode in Lyon



Transport mode and education level in Copenhagen

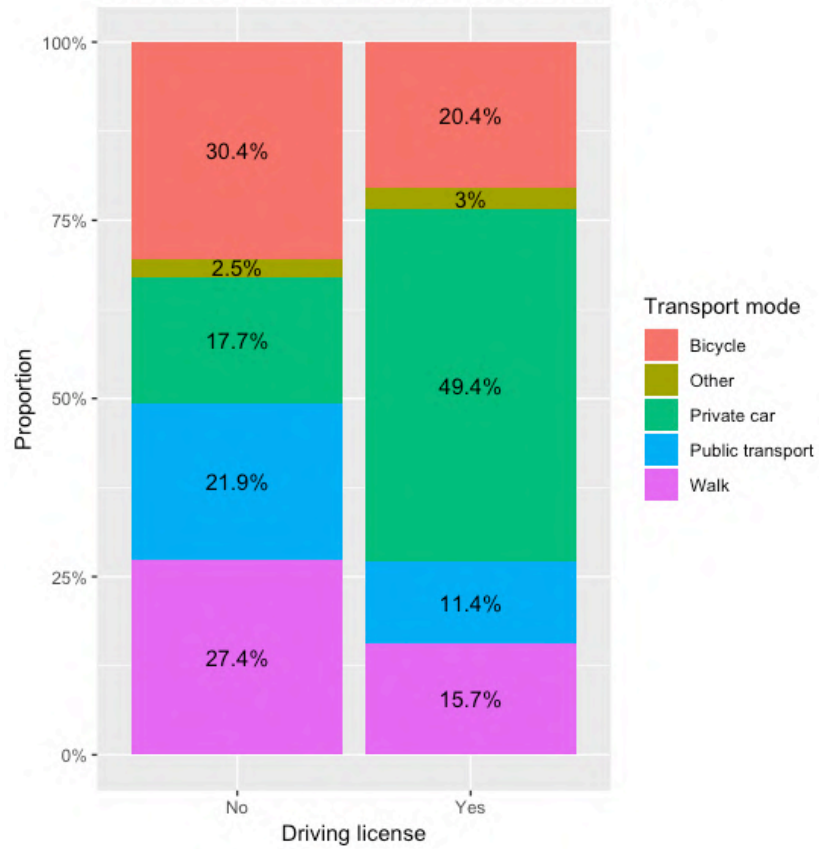


Transport mode and education level in Lyon

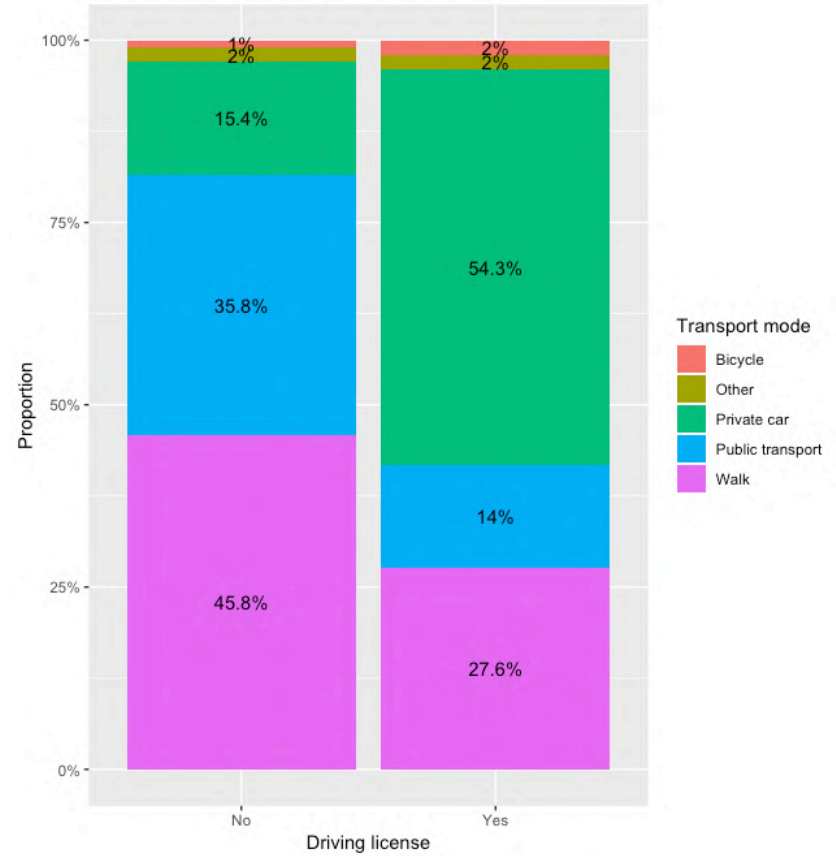


11.4 Driving license

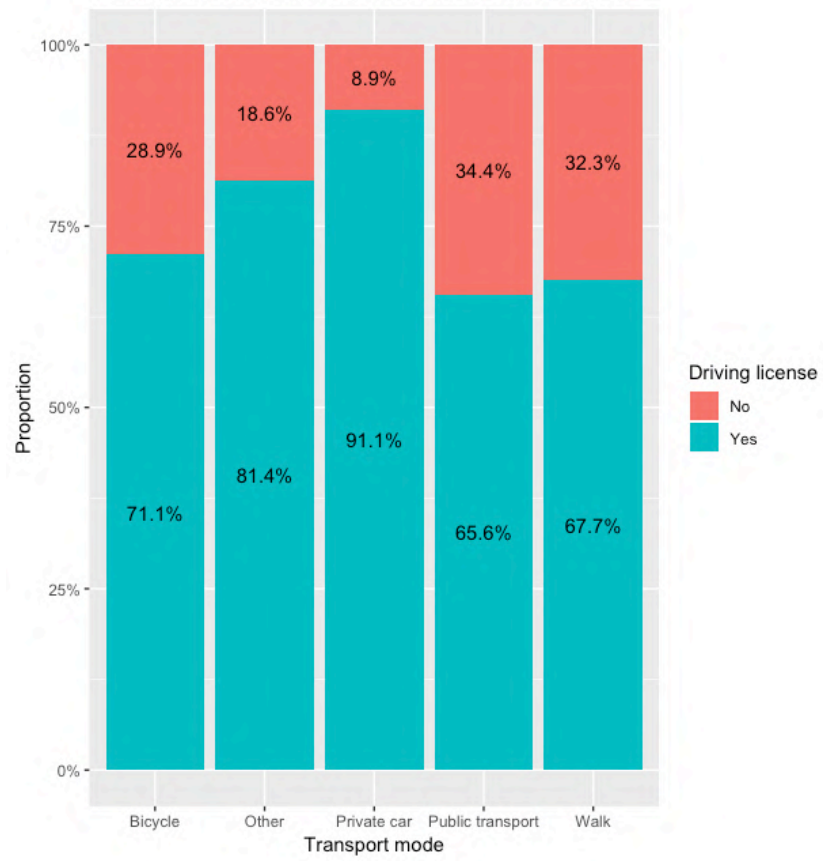
Transport mode and driving license in Copenhagen



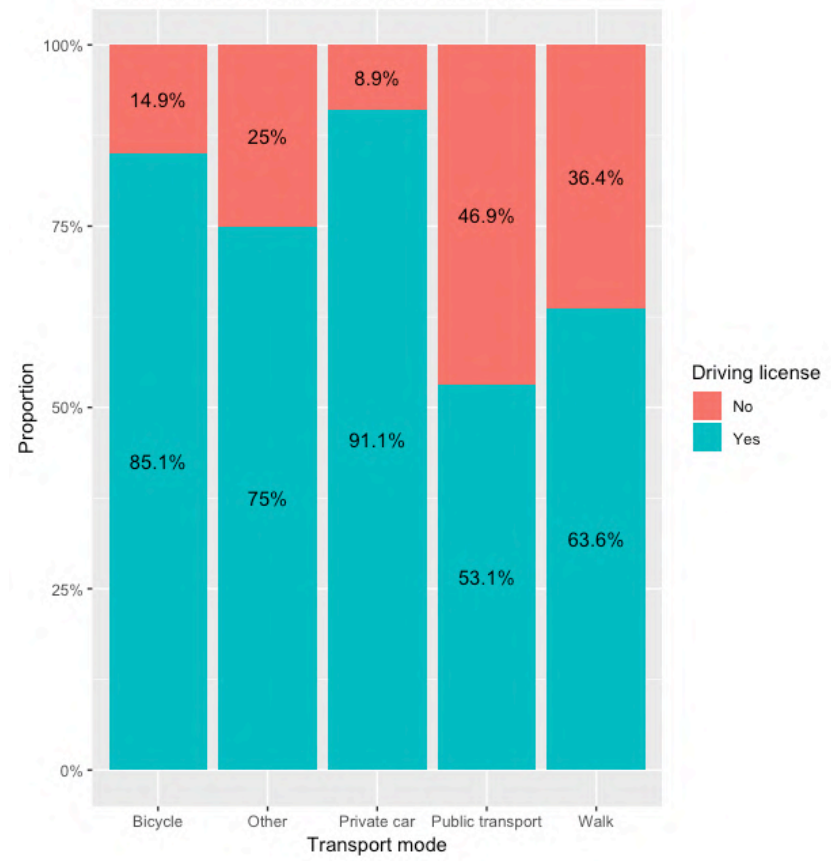
Transport mode and driving license in Lyon



Driving license and transport mode in Copenhagen

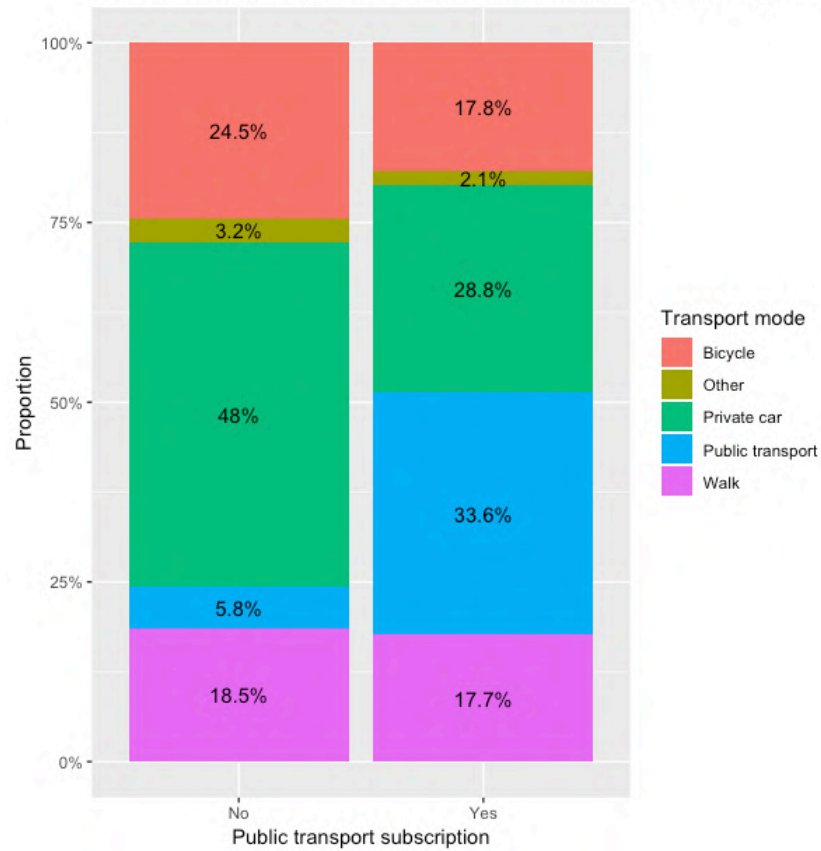


Driving license and transport mode in Lyon

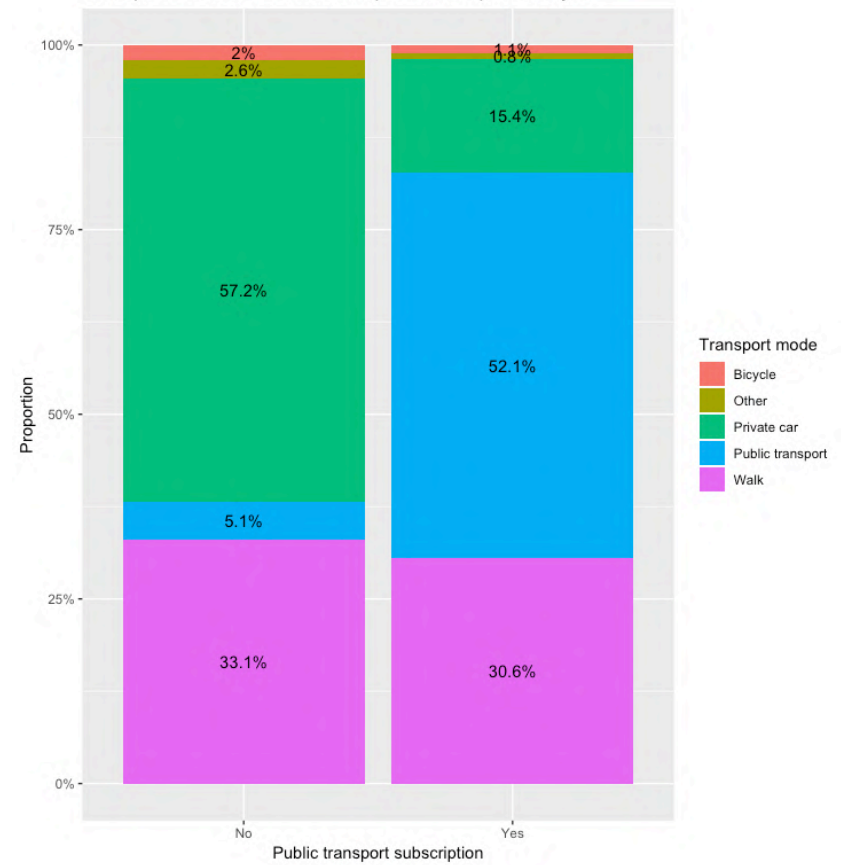


11.5 Public transport subscription

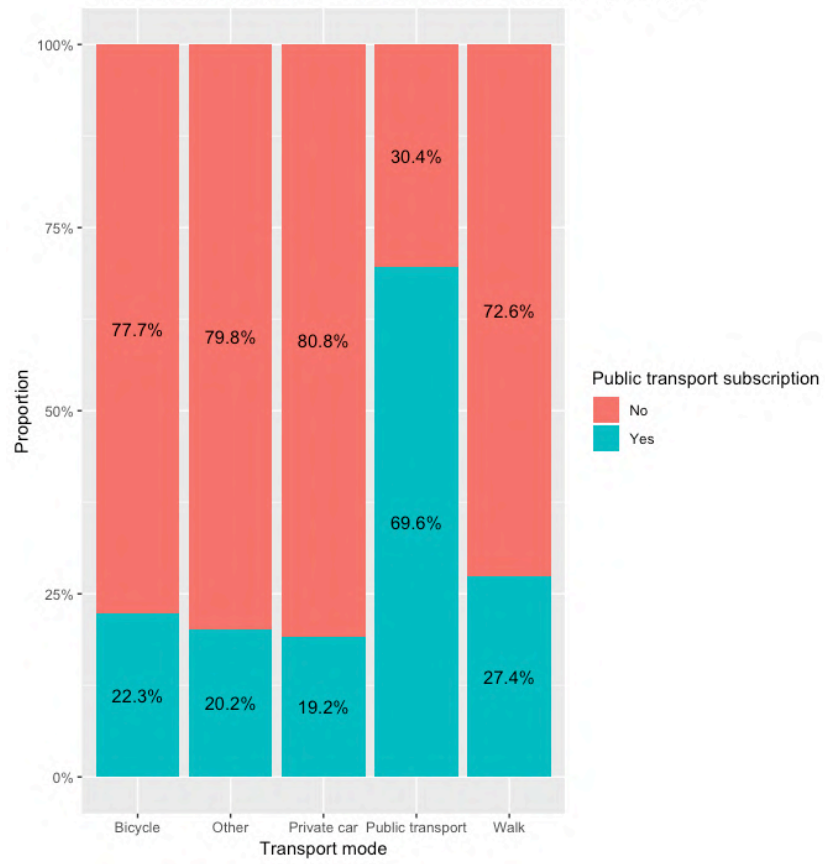
Transport mode and Public transport subscription in Copenhagen



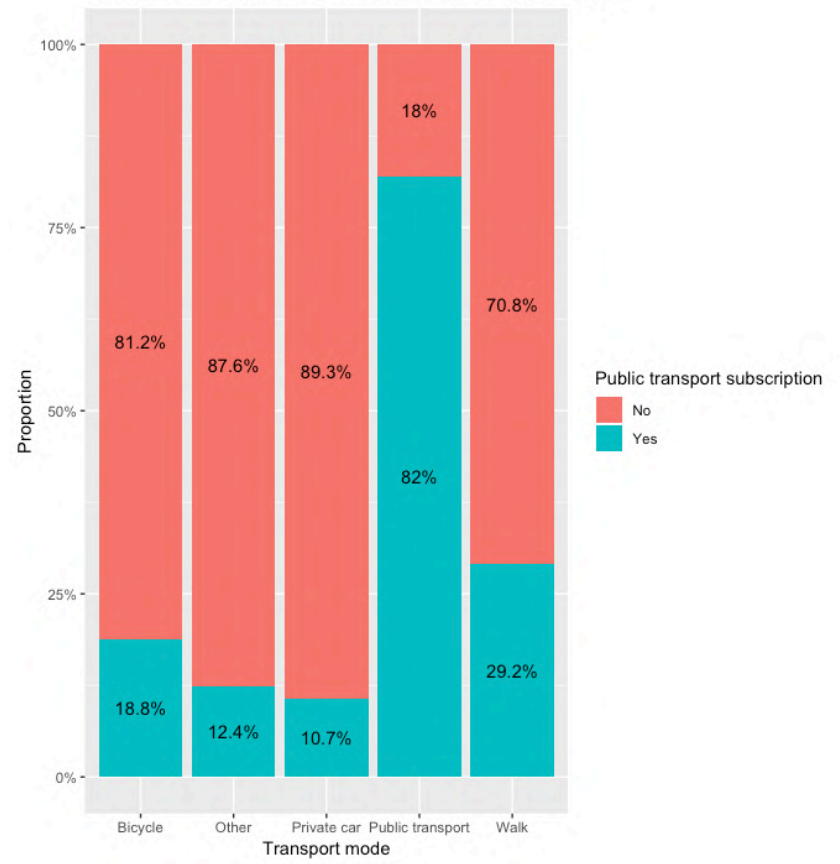
Transport mode and Public transport subscription in Lyon



Public transport subscription and transport mode in Copenhagen

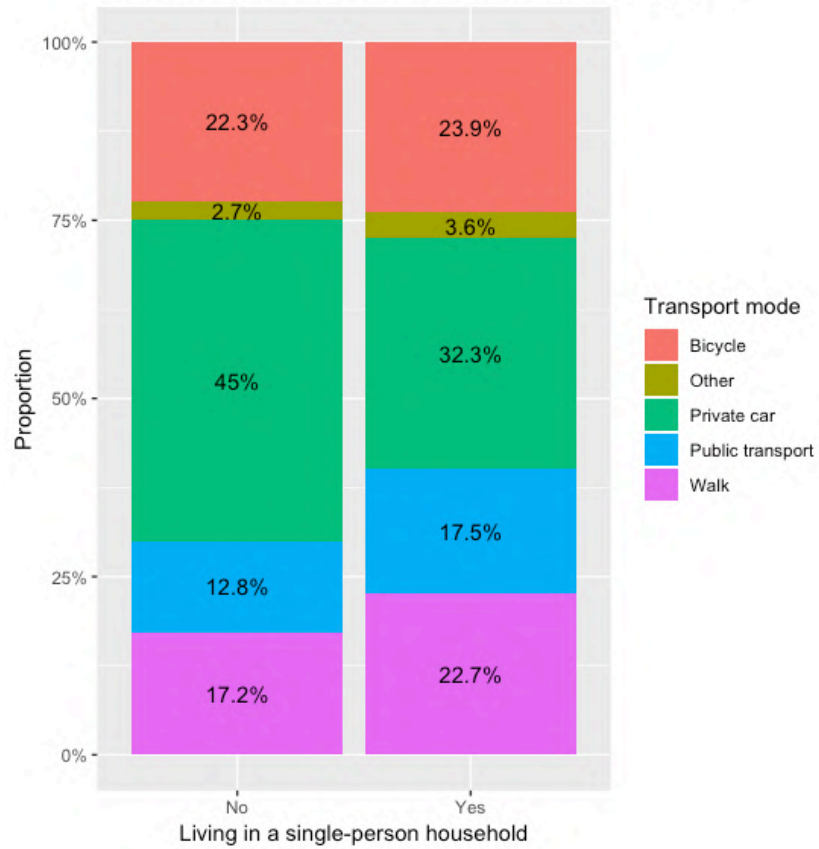


Public transport subscription and transport mode in Lyon

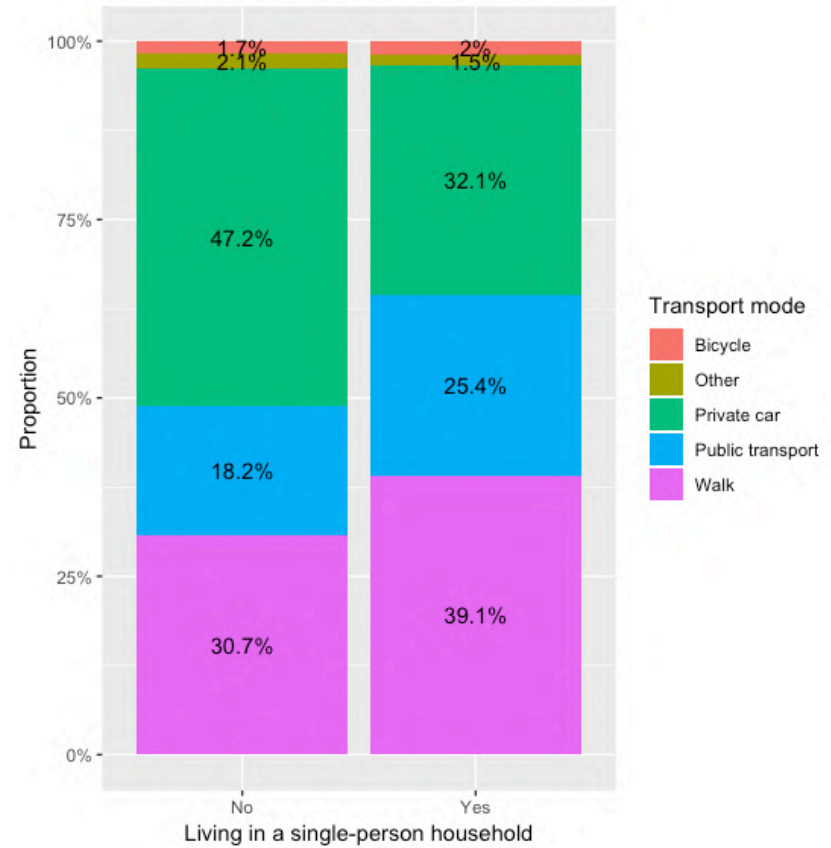


11.6 Living in a single-person household

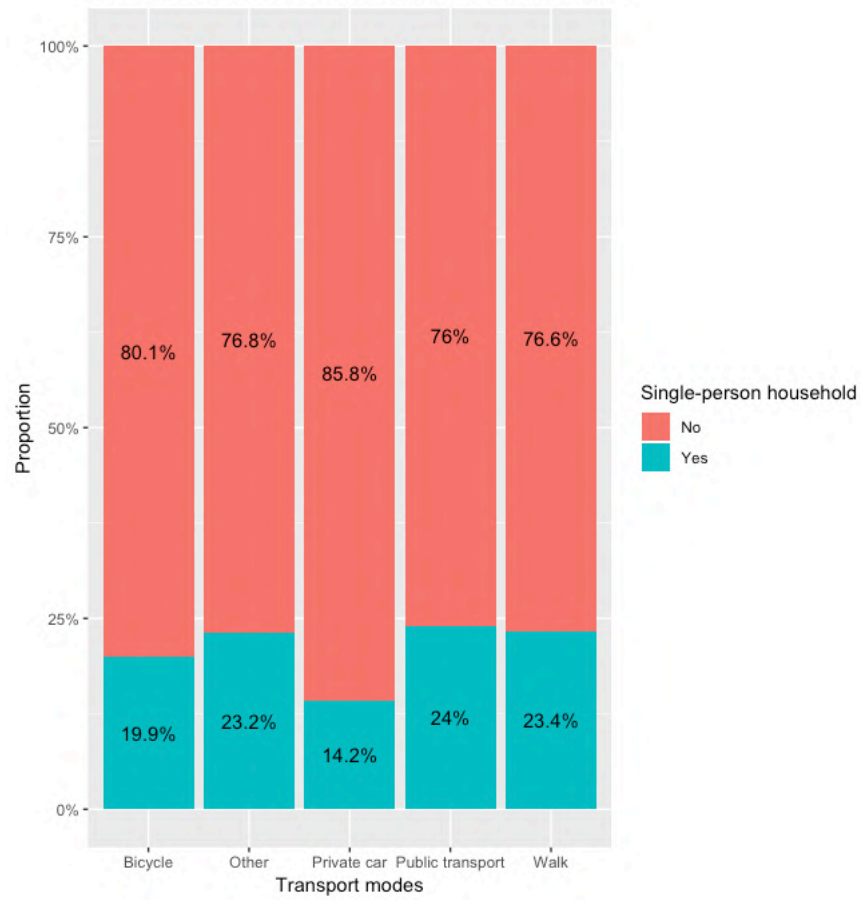
Household size and transport mode in Copenhagen



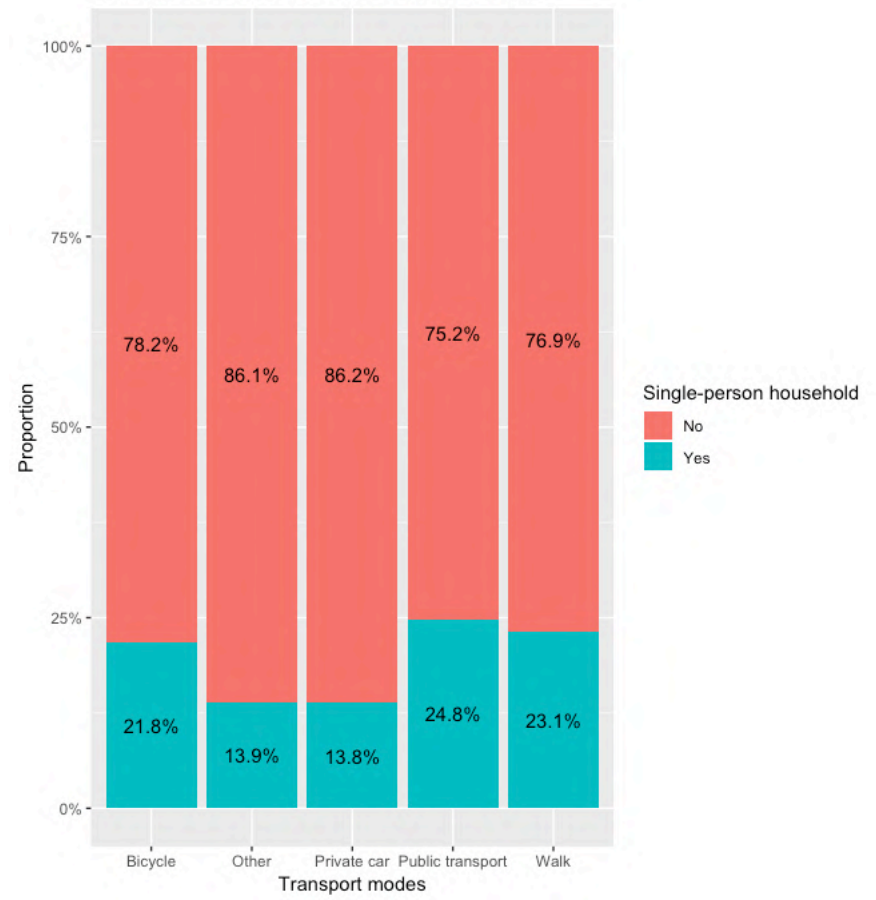
Household size and transport mode in Lyon



Transport mode and household size in Copenhagen

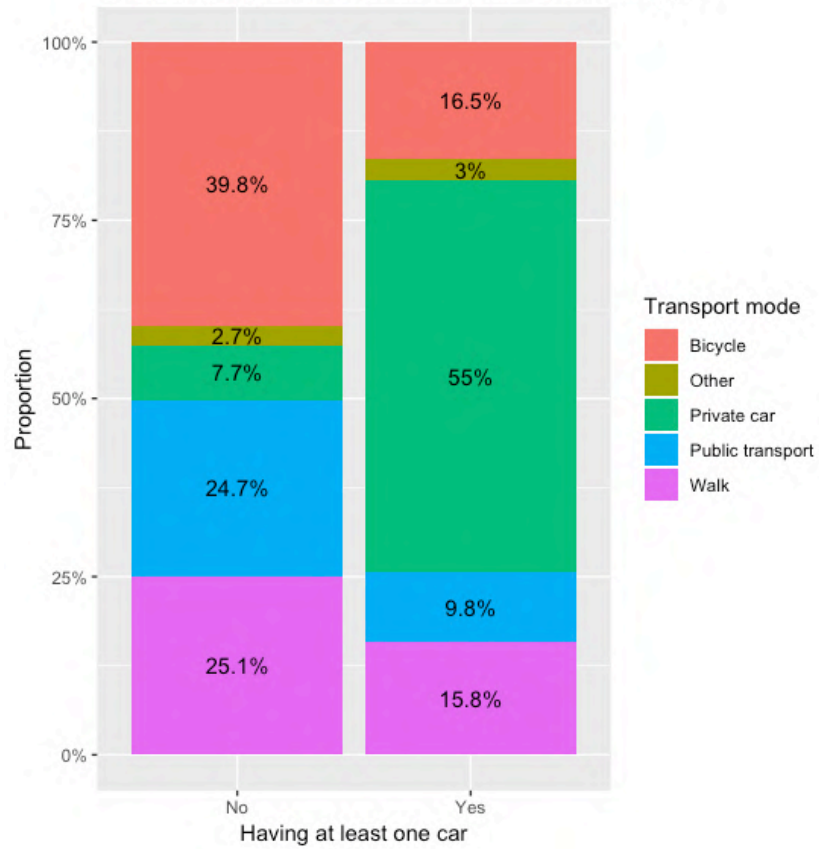


Transport mode and household size in Lyon

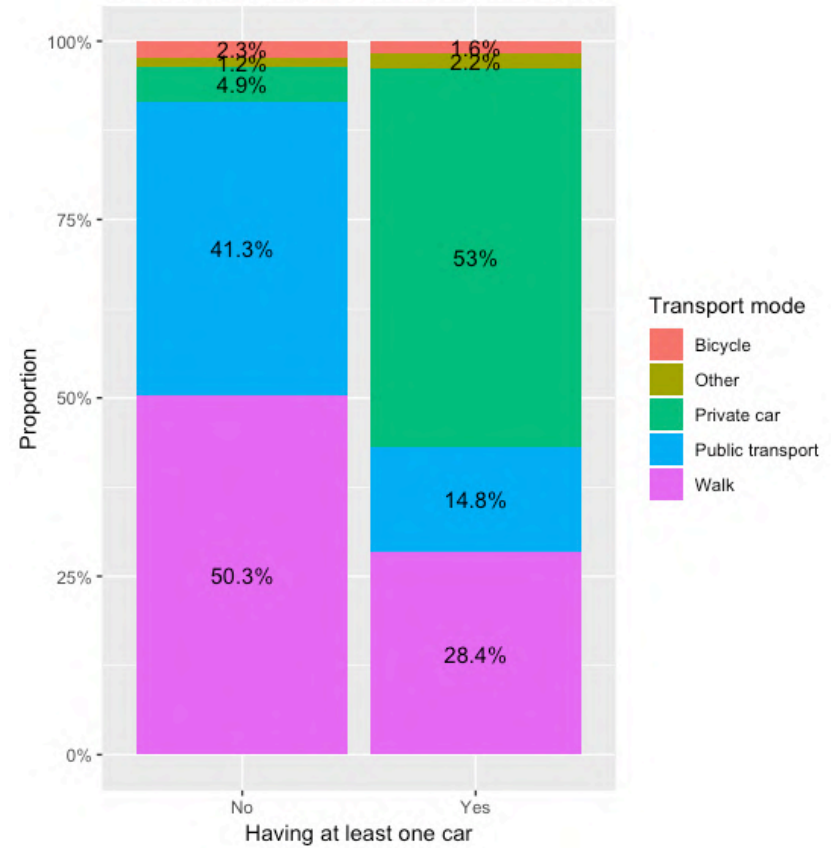


11.7 Car availability

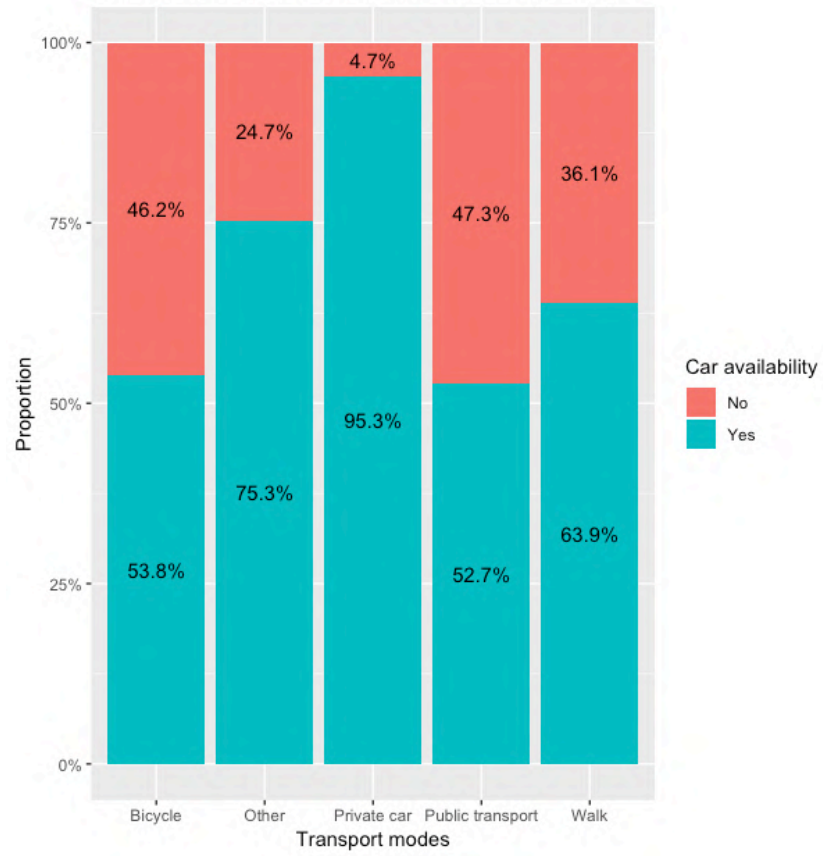
Car availability and transport mode in Copenhagen



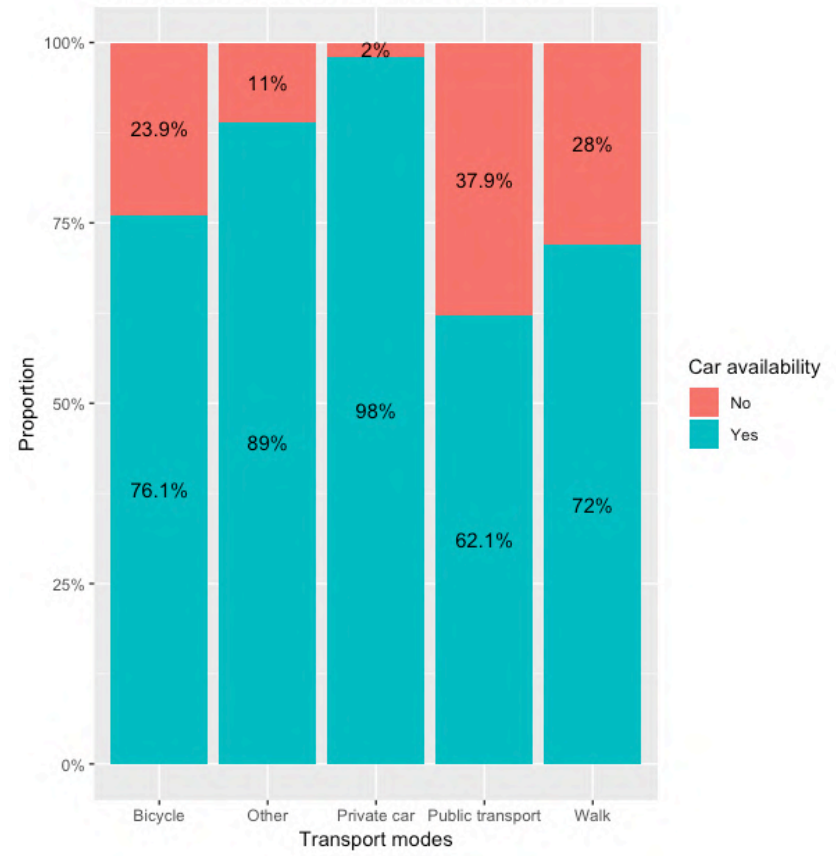
Car availability and transport mode in Lyon



Transport mode and car availability in Copenhagen

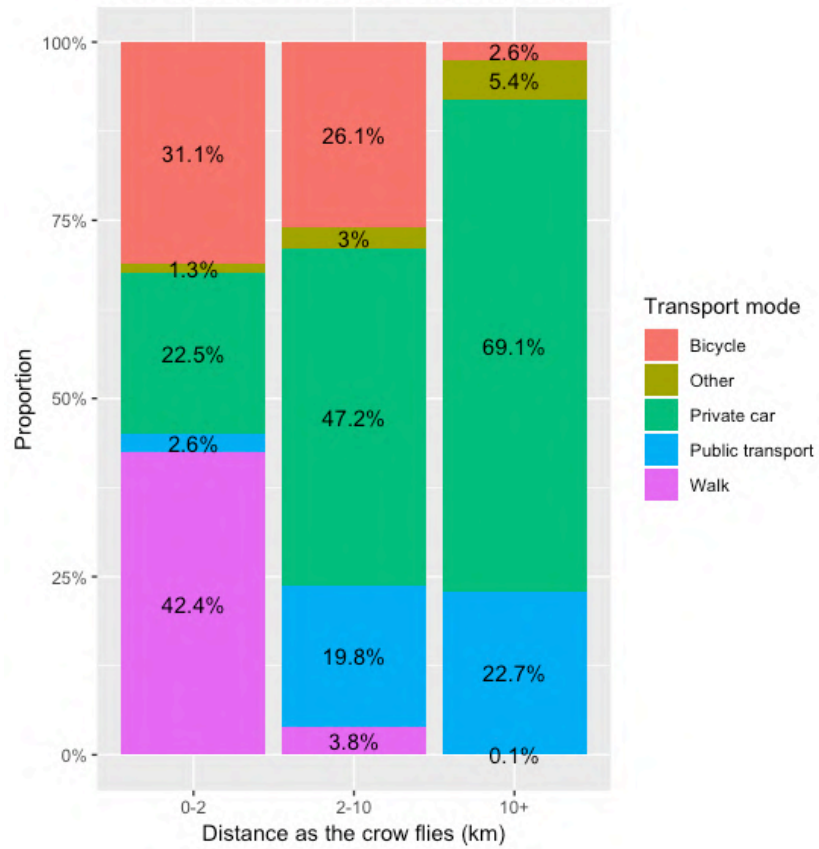


Transport mode and car availability in Lyon

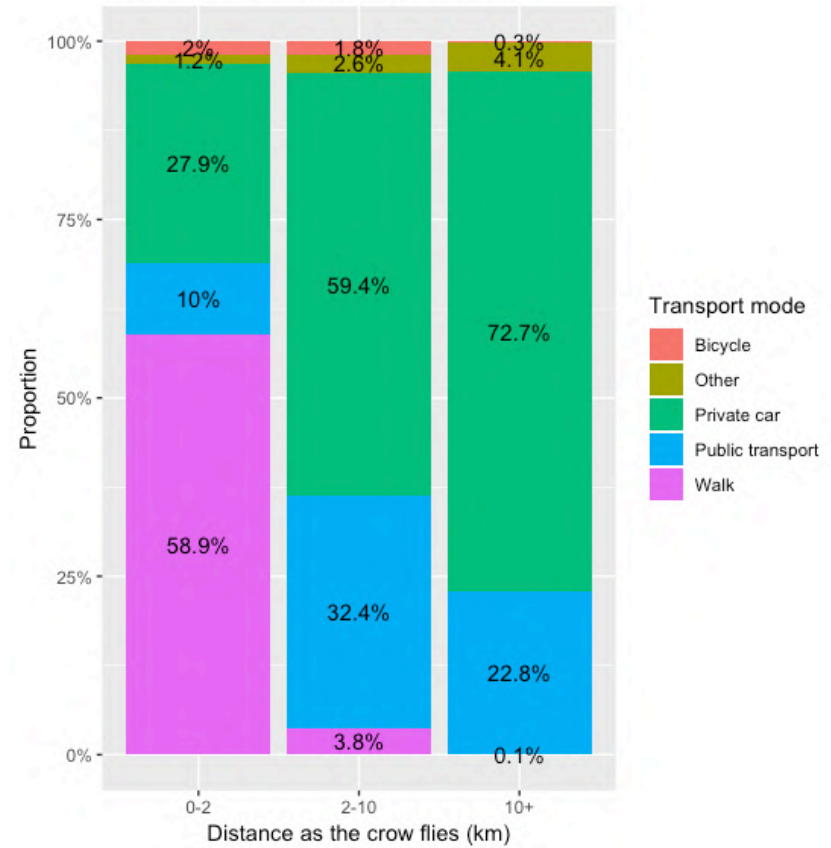


11.8 Distance

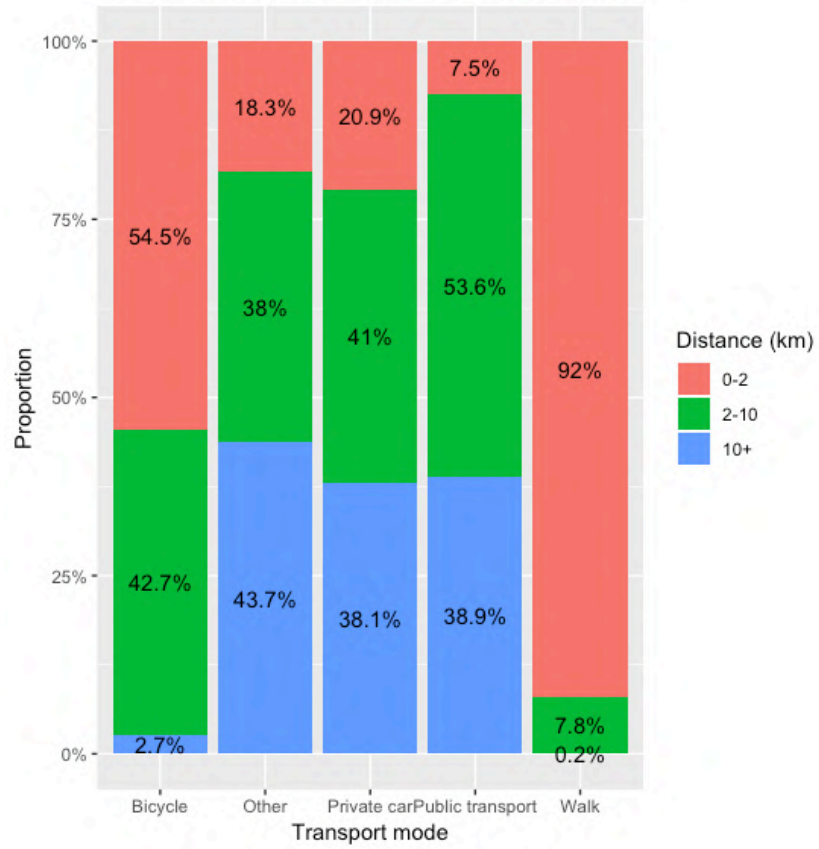
Distance and transport mode in Copenhagen



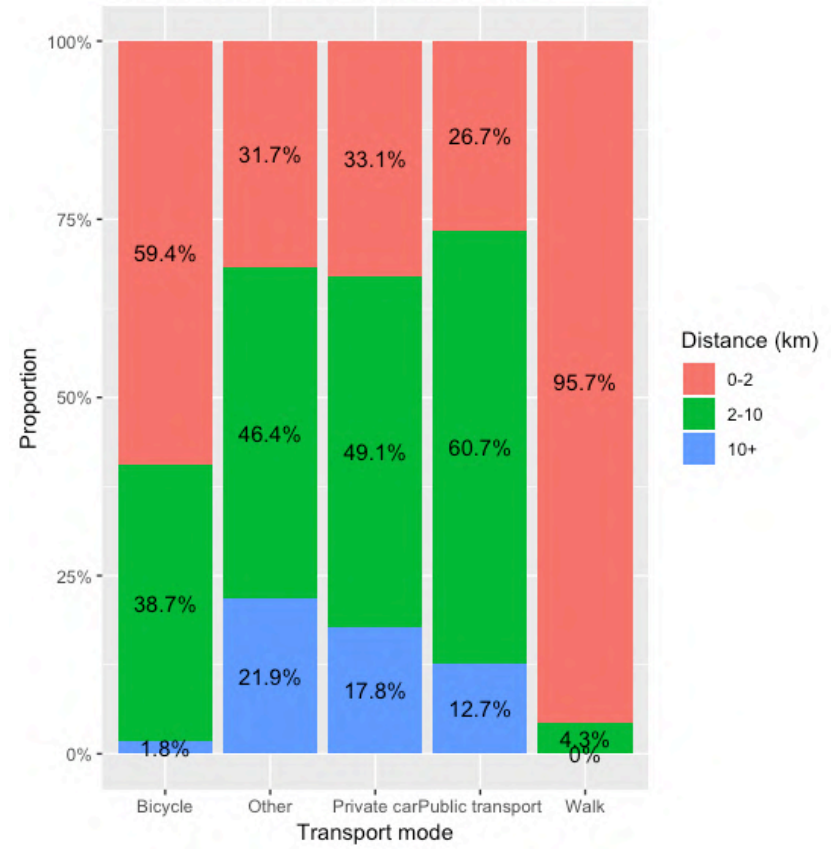
Distance and transport mode in Lyon



Transport mode and distance in Copenhagen

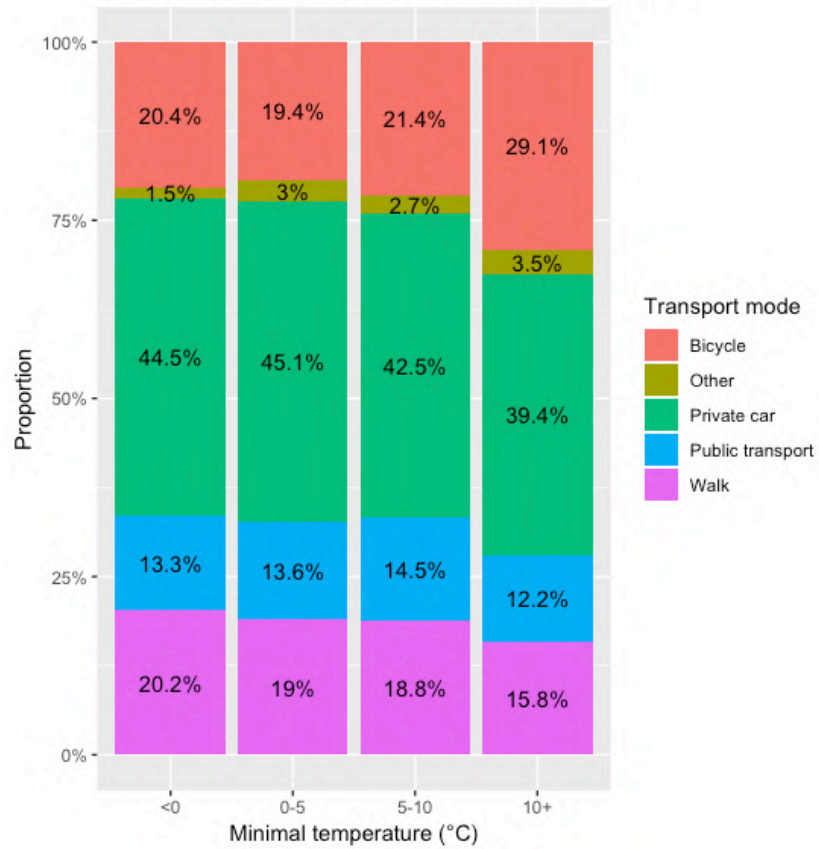


Transport mode and distance in Lyon

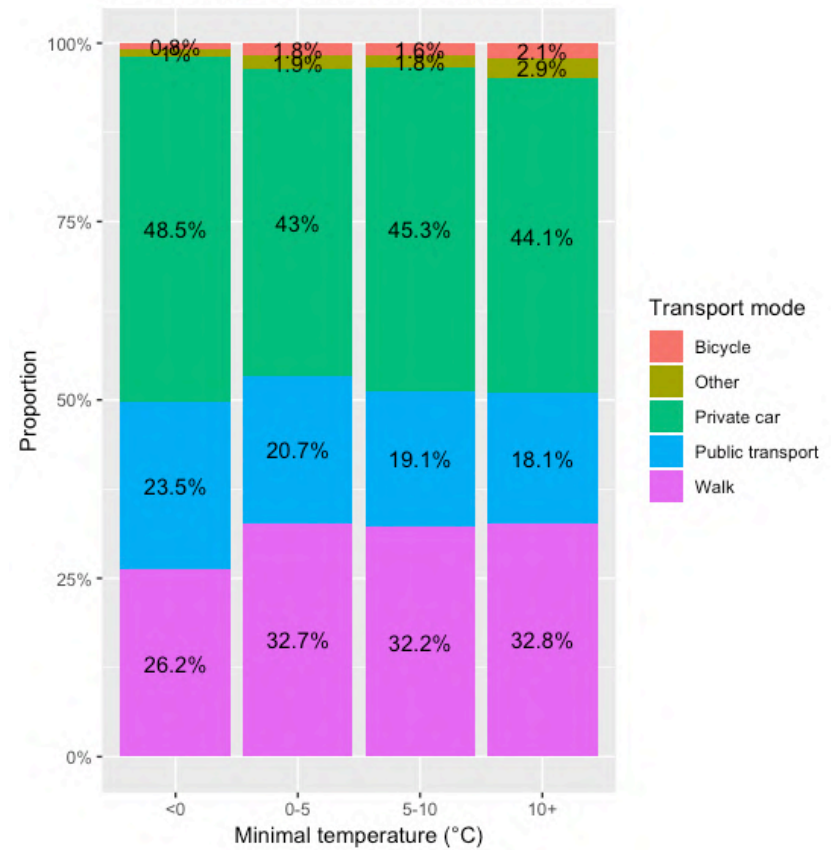


11.9 Weather

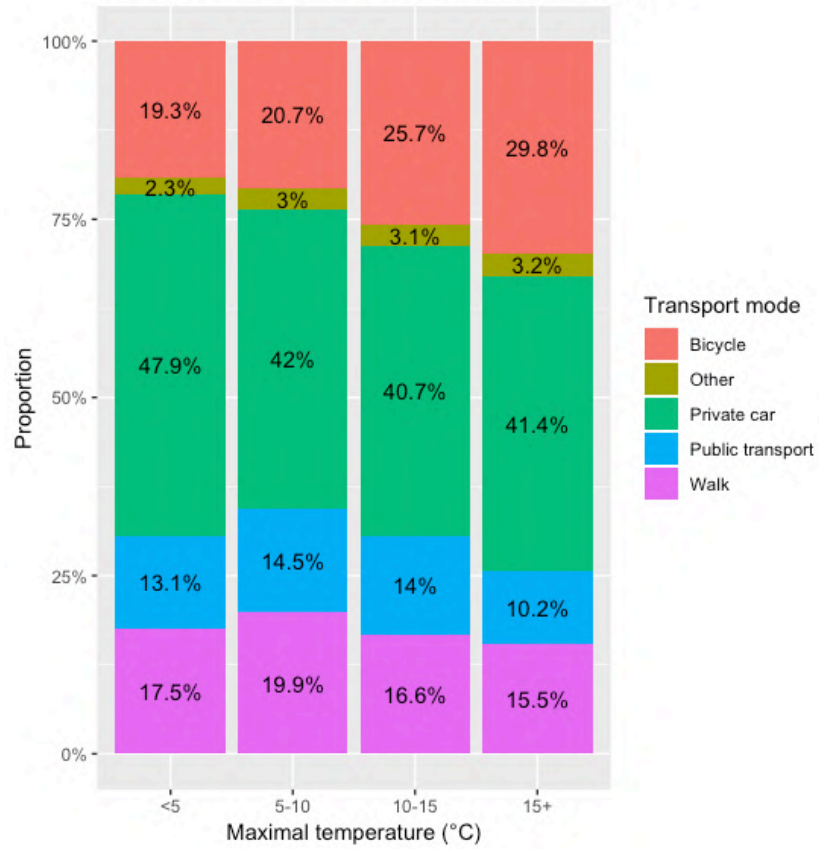
Temperature and transport mode in Copenhagen



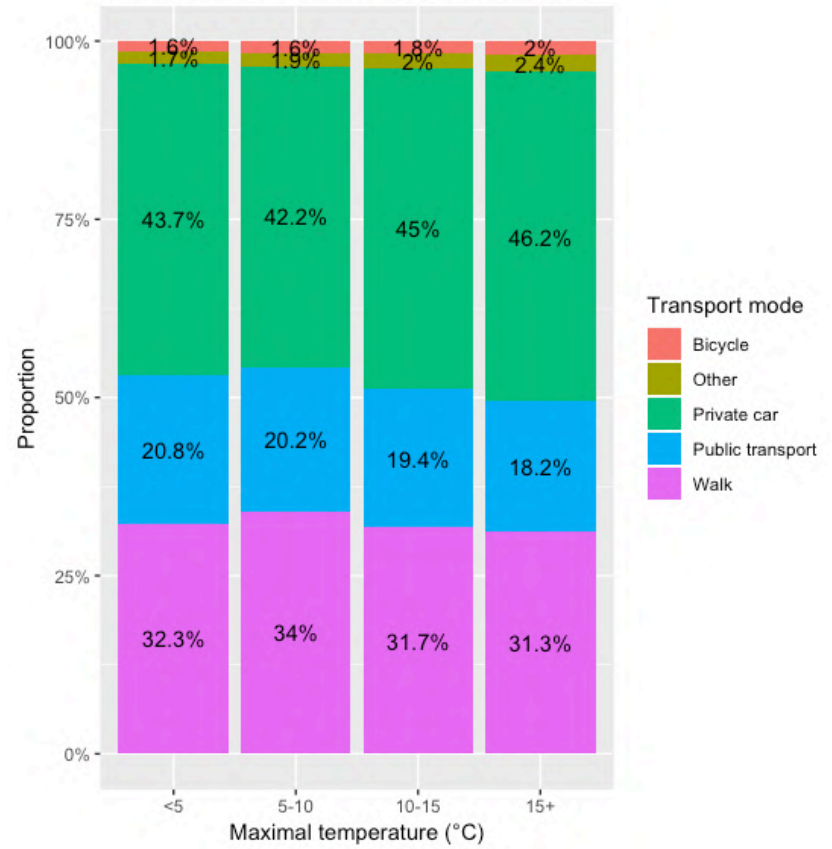
Temperature and transport mode in Lyon



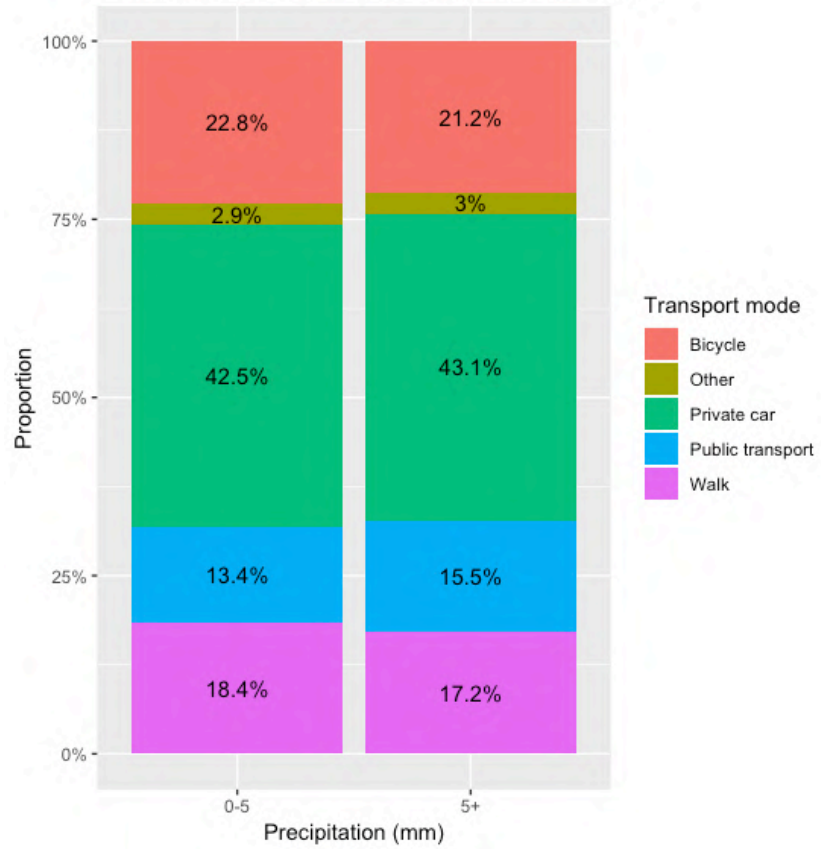
Temperature and transport mode in Copenhagen



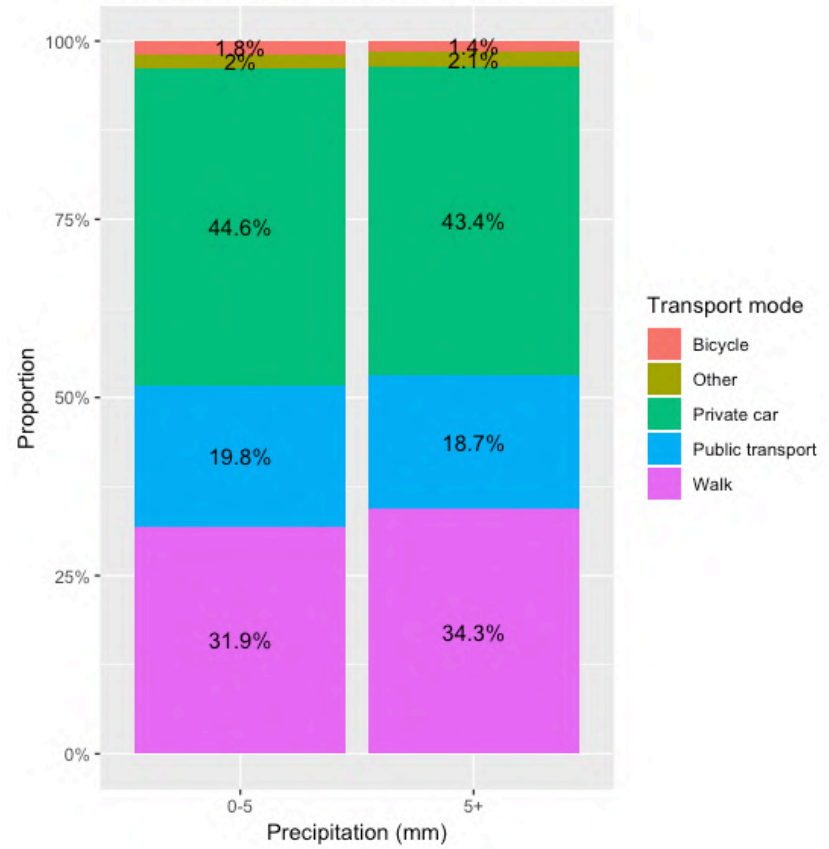
Temperature and transport mode in Lyon



Precipitation and transport mode in Copenhagen



Precipitation and transport mode in Lyon



12. Appendix 4 – Questionnaire designed for conducting the interviews

Interview of international students: the case of university campus in Copenhagen

I would like to thank you for having agreed to participate in this interview. It is a part of my master thesis and I aim at understanding how people consider their mobility in Copenhagen.

Please remember that your answers will be used for research only in anonymised form. It is important that you keep in mind there are no right or wrong answers, and the more transparent you are, the more useful information would be got from this interview.

The interview is expected to take from 30 to 45 minutes. If you have any question, do not hesitate to ask me.

Socio-demographics

- *Name?*
- *Gender?*
- How old are you?
- Do you have a driving license?
- Where do you live currently? (*Neighbourhood*)
- How long have you been here?
- How long will you stay here?
- Is it your first experience in Denmark?
- What are the reasons for your move to Copenhagen? (*Erasmus, PhD, Post-doc, Master/Bachelor thesis, internship...*) What is the topic of your studies/research?
- Why did you choose Copenhagen over another city?
- Do you plan to stay in Copenhagen/Denmark after your studies/research?
- Where did you live before coming in Denmark?

Experiences in the former city

- What were your usual trips on weekdays there?
 - What were the different transport options available for these trips?
- What were your usual trips on weekend there?
 - What were the different transport options available for these trips?
- What means of transport did you use in your former city?
- While you lived in your former city, did you switch from one means of transport to another? What were the reasons?
- How would you evaluate the transport system in your former city? Were you satisfied?

Mobility context in Copenhagen

- How did you choose your place of residence here? Did you choose the location according to proximity to work/study place?
 - Did you consider searching for another place? If yes, why and what are you looking for that your current place does not have?
- What are your usual trips on weekdays here?
 - What are the different transport options available for these trips?
- What are your usual trips on weekend here?
 - What are the different transport options available for these trips?

- Do you have a driving license?
- Do you have access to a car here? (*Ownership or car sharing?*)
- Do you have another motorized or non-motorized vehicle here? (*Motorcycle, scooter, roller, skateboard...*)
- Do you have a rejsekort? If yes, what type of rejsekort do you have?
- Do you know how much you spend monthly on transport considering all travels and all modes that you use? (*Public transport, fuel, insurance, car/bicycle/... maintenance, etc.*)
- How would you evaluate transport accessibility from your home to workplace? To leisure places?
- Did you use another means of transport in your first months here for your main trips (*work/study place, regular activities*)?
 - Yes:
 - What was this transport mode?
 - Why did you switch?
 - No:
 - Why did you choose this transport mode?
- In case of unforeseen circumstances, what other means of transport do you use? (*rain, car engine failure, flat bike tire, strike...*) Do you often have to use these alternative modes? How would you evaluate your flexibility in terms of mobility?
- Are you satisfied with your current mobility?
 - Yes:
 - Which aspect(s) do you appreciate more/less?
 - What change of the transport system, infrastructure, behaviour, etc... could improve your mobility?
 - No:
 - Which aspect(s) are a problem for you?
 - What change could improve your satisfaction?
- Do you usually use technology for getting information related to your travels? (*smartphone to find route, to know when the next bus/metro/s-train is, etc.*)
 - Yes: Is it easy to access information? Are you satisfied of the information you can get?
 - No: Why do you not use it? (*no internet access, no smartphone ownership, or other reason*)

Perception and feeling

- What was your first impression about bicycles when you arrived in Copenhagen?
- Have you heard about Danish cycling culture before coming to Copenhagen?
- Did you have any particular experiences with cycling before coming to Copenhagen? Have you ever been to another city where bicycle use is high?
- Did you get used to the bicycle culture in Copenhagen?
 - Yes: How it was for you? (*Easy/Difficult, pleasant/unpleasant, scary/funny*)
 - No: Why not? Have you tried?
- Do you have a bicycle or are member of bike sharing system?
 - Have a bicycle: Did you buy it or rent it?
 - Buy: How much did it cost?
 - Rent: For how long? What is the price? It was easy to rent?
 - Member of a bike sharing system: What is the system of bicycle sharing you use? How much does it cost?
 - Both above: Why did you choose to buy/rent/use shared bicycles?
 - No: Do you plan to buy/rent one soon or to subscribe to a bicycle sharing system?
- Do you cycle regularly?
 - Yes:
 - In your opinion, what are the benefits of this means of transport... (*for you, for society*)
 - ...in general?

- ...in Copenhagen?
 - What are the disadvantages of this means of transport...
 - ...in general?
 - ...in Copenhagen?
 - Do you feel safe as cyclist about...?
 - ...your own control of the bike
 - ...infrastructure
 - ...other cyclists
 - ...other vehicles (*cars, e-scooters, etc.*)
- No:
 - Is it specific to Copenhagen or general? What are the reasons?
 - In your opinion, what are the benefits of this means of transport... (*for you, for society*)
 - ...in general?
 - ...in Copenhagen?
 - What are the disadvantages of this means of transport...
 - ...in general?
 - ...in Copenhagen?
 - How would you evaluate ...?
 - ...your own control of the bike
 - ...infrastructure
 - ...other cyclists
 - ...other vehicles (*cars, e-scooters, etc.*)
- What change could improve your cycling condition/make you cycle? (*more facilities, less cyclists, parking facilities, showers at workplace...*)

Comparison with former city

- How cycling is seen in your former city/country? (*sport, leisure, daily means of transport...*) How would you compare this status to the one in Copenhagen? (*everyone cycles – only some categories of people cycle – it is considered good by others to use bicycle – leisure/sport vs. daily transport mode...*)
- What transport aspects are different in Copenhagen compared to your former city? (*ticket/fuel price, timetable, infrastructure...*)
- What aspects of the transport system of Copenhagen would you like to see established in your former city?
- Imagine that all of Copenhagen's cycling infrastructure are in place in your city, would you use a bicycle?
 - Yes: Do you think that members of your family, friends, etc. would use a bicycle too?
 - No: And if the prices of public transport were the same than in Copenhagen? *With or without same infrastructure (both scenario).*
 - Yes: Do you think that members of your family, friends, etc. would use a bicycle too?
 - Still no: What would be the main barriers to cycling?
- What aspects of the transport system are you missing in Copenhagen compared to your former city?

Conclusion

- Do you have any question or comment about this interview?

