Jomar Sæterøy Maridal

# Projecting sustainable mobility scenarios for Oslo towards 2040:

## The potential of car-sharing, ridesharing and cycling

Master's thesis in Entrepreneurship, Innovation and Society

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Supervisors: Asbjørn Karlsen and Samson Afewerki

External supervisor: Tanu Priya Uteng, Institute of Transport Economics

Norwegian University of Science and Technology

Faculty of Social and Educational Sciences

Department of Geography

NTNU
Norwegian University of Science and Technology

# Abstract

Pushing towards achieving a sustainable mobility future, policy-makers have introduced a zero-growth objective for car traffic in a number of urban areas in Norway, including Oslo. It stipulates that all future traffic growth is to be absorbed by public transport, walking and cycling. Taking into account Oslo's projected population growth and expected shifting age distribution through combining it with empirical evidence on different demographic groups' travel habits, this thesis sets out to investigate how the zero-growth objective possibly can be achieved for all by projecting future mobility scenarios. It finds that if current travel habits remain unchanged, almost 100,000 daily car trips will need to be substituted onto public transport, walking or cycling by 2040 in Oslo alone. Assessing what it will take for such a transition to happen, this thesis finds that the various demographic groups in Oslo will require vastly different growth rates in public transport, walking and cycling ridership at the expense of car travel in order to meet and maintain the zero-growth objective. This is found due to strong deviations between the groups' travel habits, expected willingness to substitute one mode of transport with another, and an uneven population growth rate.

In an effort to abridge the demographic variations in zero-growth obtainment for car travel, the application of car-sharing, ridesharing and cycling is also assessed in terms of their potential as agents for furthering sustainable mobility. These modes have in common that they offer innovative aspects to the mobility picture and thus might serve as covetable alternatives for demographic groups projected to resist shifts onto the modes of transport proposed through the zero-growth objective. A back-cast discussion on their future role based on empirical data and theoretical underpinnings finds that car-sharing and ridesharing have some, albeit limited potential in furthering sustainable mobility in Oslo. Their potential lies in that the demographic groups that currently show the strongest propensity towards them correspond to those projected to resist shifts onto other sustainable modes of transport. Their limitations lie in that they are car-based modes, and as such need to be applied in moderation, preferably when shifts onto other sustainable modes have been exhausted in order to uphold the zero-growth objective. Cycling on the other hand has no such restrictions, yet despite policy makers favouring it the mode has proven only moderately successful in absorbing car traffic to date. Cycling's potential application as an agent of furthering sustainable mobility is therefore found to largely be in recent improvements to it, like EL-cycling and city bike schemes; both constituting innovations that may help expand upon its current market share.

# Acknowledgements

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Second, a warm thanks to my friends and family for all their support throughout the process of working on this thesis. For boosting and maintaining my motivation by, every now and then, pulling me away from my work, I owe them a debt of gratitude.

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Jomar Sæterøy Maridal

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# Abbreviations and acronyms

| | |
|---|---|
| **BAU** | Business as usual |
| **B2C** | Business-to-consumer |
| **DEMOTRIPS** | Macro-based prognosis model used to generate scenarios |
| **DF** | Diversion factor |
| **EV** | Electric vehicle |
| **DOI** | Diffusion of innovations |
| **HOV** | High-occupancy vehicle |
| **MaaS** | Mobility as a service |
| **MLP** | Multi-level perspective |
| **NTP** | The National Transport Plan |
| **P2P** | Peer-to-peer |
| **RVU** | The National Travel Survey |
| **WP** | Work package |

# 1 Introduction

## 1.1 Research questions

1. What will Oslo's mobility distribution look like by 2040 if current travel habits remain unchanged?

2. How can the zero-growth objective for car traffic conceivably be met by 2040, for all demographic groups in Oslo, through shifts onto public transport, walking and cycling?

3. Could the introduction of new and innovative modes of transport like car-sharing, ridesharing and cycling have a role in furthering sustainable mobility and the zero-growth objective?

## 1.2 Research topic

Cities throughout the world are coming to grips with the realisation that radical changes are needed in order to combat rising emission levels from personal transport. Fossil-fuel driven cars in particular are singled out as one of the chief culprits contributing to this trend. Let alone the larger issue of climate change, increasing localised emission levels causing air pollution as well as negative social- and economic effects have led policy-makers in different cities to call for a shift towards more sustainable modes of transport. Oslo is one of these cities and has long since implemented a number of policy measures aiming to reduce emissions with even more in pipeline; many of which target cars directly (Oslo kommune, 2016). Notwithstanding these efforts, fossil-fuel driven cars continue to serve as a backbone mode of transport for a large number of people in Oslo. In 2014, 30% of daily trips in the city were by car (Hjorthol, Engebretsen, & Uteng, 2014) and although the car share has been falling relative to other modes, the number of cars on Norwegian roads both in absolute terms and by population continues to climb (Statistics Norway, 2017). Oslo is also one of the fastest growing major cities in Europe. This population influx poses a challenge for policy-makers as it means the need for transport will grow correspondingly, meaning traffic volumes are expected to increase in the years to come.

Despite these challenges policy-makers both in Norway in general and Oslo in particular have committed to a sustainable transition in the transport sector, albeit to a varying degree. These policies come in different shapes and sizes and can generally be classified as aiming for either *modal improvements* or *modal shifts*. The former refers to either developing- or incentivising the use of new and more sustainable versions of existing modes, while the latter refers to efforts in shifting patronage from one mode of transport onto others. Electric cars in particular is a type of modal improvement that Norwegian policy-makers have promoted by offering generous subsidies, tax breaks and other benefits for those who opt for them over fossil-fuel driven cars. These policies have, at least in part, led to Norway currently having the world's highest market penetration of electric vehicles per capita (Campbell, 2017). At the same time, a rising number of cars on the roads – electric or otherwise – constitutes an increasing problem for Norwegian cities as congestion happens regardless of fuel source. This has led to policy-makers increasingly promoting modal shifts as a solution to battle gridlocked urban areas. In Oslo, recent city-planning developments such as pedestrianising streets, building bicycle lanes and removing parking spaces downtown are all examples of policy-initiated efforts to stimulate modal shifts, notwithstanding increased investment in public transport part-financed by imposing road pricing and rush-hour fees on cars (Oslo kommune, 2016).

The case for modal shifts is also being recognised at the national level, as demonstrated by the National Transport Plan (NTP). It outlines the Norwegian government's transport policy over a twelve-year period and the most recent version puts forward a *zero-growth objective* for car travel. This entails that all future car traffic growth in a number of Norwegian urban areas, including Oslo, is to be absorbed in its entirety by the *sustainable modes* public transport, walking and cycling (NTP, 2017). In light of the current population growth in Oslo and corresponding increase in future mobility needs the zero-growth objective is undoubtedly a lofty goal. A high number of future would-be car trips will likely need to be substituted onto other modes of transport if car travel is to be kept at today's level, making it obvious that if successful, the goal will have major implications for the transport sector in the years to come. It requires policy-makers and operators of transport networks to find new and innovative ways to secure the mobility needs of the Oslo population, and to prove successful, many travellers will need to change the way they travel in the future.

For these reasons, further examining trajectories towards achieving this goal and what it will mean for future mobility in Oslo makes for an interesting case; particularly in combination with population projections. The overall challenge is how future mobility needs can be met while also securing a more environmentally friendly trajectory for personal transport. This thesis seeks to contribute to parts of that challenge by assessing the potential role of new and innovative modes of transport in furthering sustainable mobility in Oslo towards the year 2040.

Car-sharing, ridesharing and cycling are examples of modes whose increased use, in addition to that of public transport, are identified as potential absorbents and deterrents of future car traffic growth; particularly in an urban environment (Prettenthaler & Steininger, 1999). Though wile broad-stroke transition trajectories onto public transport as a means of reducing emission levels and congestion are widely studied and acclaimed, less attention has been given to the role of more modest-capacity modes. When considered, the literature overwhelmingly looks at these modes' potential in isolation without positioning them into the broader mobility picture. This thesis aims at filling this research gap by assuming car-sharing, ridesharing and cycling in context with the other modes available in Oslo mobility. Moreover, current mobility trends demonstrate that there are clear variations in which modes different age groups and genders make use of on daily trips. This has implications for future mobility because the level of change needed to achieve sustainable mobility differs between the various demographics' current travel habits. This is important to consider because different age groups are projected to see varying population growth in the years to come, resulting in a shift in the Oslo population's age distribution. Pairing this information on Oslo demographics and their projected developments with an analysis on car-sharing, ridesharing and cycling's potential as part of the larger Oslo mobility picture will hopefully provide a wider and deeper understanding of the challenges and possibilities in achieving a sustainable mobility future because, as presented in NTP, the zero-growth objective makes no reference to these demographic variations in travel habits. Acknowledging that there indeed are variations and analysing them in the context of this policy goal can therefore provide new and useful insights useful for policy-makers pushing for sustainable mobility.

The above provides the foundation for what this thesis seeks to address. It aims at analysing future mobility scenarios for Oslo and to discuss car-sharing, ridesharing and cycling's potential as means to help achieve sustainable mobility in Oslo; maintaining the zero-growth objective in the years to come. In order to do so, a two-step approach is employed. First, quantitative-based scenario projections for Oslo mobility towards the year 2040 are put forward and analysed. This involves the modelling of scenarios that take into account current mobility distributions and expected population growth for various demographic groups. These scenarios are split into two sets: One that projects how mobility will develop if current travel patterns remain constant, and one that projects an alternative trajectory towards reaching the zero-growth objective; opening for shifting mobility away from cars and onto the sustainable modes of transport identified in NTP. The scenario sets are also subdivided by trip length to account for varying travel habits at different trip intervals. To be applied in a forthcoming article co-authored by myself (Uteng, George, Throndsen, Uteng, & Maridal, 2018) the first scenario set illustrates how car traffic in Oslo can be expected to develop if nothing is done to current mobility trends, while the second explores the level of change needed in order to shift the various age cohorts onto sustainable modes. This is done by introducing a set of mode substitution factors for the various age cohorts and by determining ridership targets and growth rates for the different modes reflecting policy-maker goals. The main projection is that the rates of substitution onto sustainable modes will vary between the demographics assumed due to differing baseline modal shares, rates of substitution and projected population growth. This means that the degree of travel habit change needed to achieve zero-growth in car traffic is expected to vary significantly between demographic groups.

Analysing these differences feeds into the second step of the analysis. While both NTP and this thesis recognise public transport as the mode with the highest potential for absorbing future car traffic growth, the deviations in modal shifts onto sustainable modes projected by the scenarios allow for interesting talking points on whether new and innovative modes like car-sharing, ridesharing and cycling might play a role in securing sustainable mobility; particularly for demographics projected to be harder to shift in this direction. Therefore, a back-cast discussion follows atop the scenario results and analyses on how the deviations in modal shifts between demographics may be abridged through the potential application of car-sharing, ridesharing and cycling. This discussion will draw on relevant theoretical underpinnings, assessments of the modes' innovative aspects, their applicability to various trip lengths, and aggregate map-data on to what extent the various modes provide workplace accessibility in Oslo. This in sum allows for discussing and identifying the potential that, if applied, car-sharing, ridesharing and cycling have in furthering a sustainable mobility future.

The goal and contribution of this thesis is thus twofold: First, the scenarios combining mobility data with population growth projections provide useful insights in the varying level of challenges facing different demographic groups in upholding zero-growth in car traffic vis-à-vis current travel habits. This has implications for the overall achievability of this policy goal because so far, it has not been thoroughly linked to how different demographics' travel habits *and* their projected population development can potentially affect overall mobility. This information can be of interest to policy-makers who could target demographics showing both strong propensities towards car travel and are projected to see strong population growth in the years to come. Second, it assumes the applications of car-sharing, ridesharing and cycling atop the scenarios based on empirical and theoretical foundations, tying these into the overall Oslo mobility picture. This allows for a back-cast discussion on the potential of these modes in contributing to sustainable mobility, emphasising whether they may serve as covetable alternatives for demographic groups that are projected to be less readily transferred onto the NTP proposed sustainable modes of transport.

## 1.3 Context and thesis relevance

When searching for a topic to write this thesis on, I approached the Institute of Transport Economics to ask whether they had topics or projects where they could foresee my participation. This led to this thesis being connected to a broader research project called SHIFT; a Nordic collaborative flagship project in which the Institute of Transport Economics participates alongside the Technical University of Denmark, RISE Viktoria and IVL Swedish Environmental Research Institute (TØI, n.d.). Financed by Nordic Energy Research (NER) through the Nordic Council of Ministers, its goal is to assess how the transport sector in the Nordic countries can be made sustainable by producing scenarios and projections that explore, among other things, which policy measures are needed to achieve sustainable mobility shifts. SHIFT has four primary *work packages* (WPs) and this thesis is tied to SHIFT's WP3, *"Promoting uptake of modal shifts and efficient mobility solutions"*. What serves as this thesis' foundation is my contributions to the already mentioned forthcoming article on sustainable mobility in Oslo. This involved working with models projecting future mobility scenarios and analysing trajectories towards reaching the zero-growth objective. In this thesis, these scenario results are expanded on and also serve as background for further discussing the potential of car-sharing, ridesharing and cycling in light of their results. The methods by which the scenarios were devised are also laid out in more detailed in this thesis than what will be the case in the article, and the focus is widened to assume the innovative aspects of car-sharing, ridesharing and cycling as well as their applicability in Oslo's future mobility plans based on theoretical foundations. For these reasons, this thesis should be considered as an expansion of the article.

One important implication of this thesis being party to a larger research project is that aspects of it is to be re-published in external publications. Specifically, this relates to the scenarios presented in chapter 0. At the time of submitting this thesis, the planned scope of these external publications includes the aforementioned article of which I am a co-author, and a forthcoming

Institute of Transport Economics report (*TØI rapport*). In the latter case, the Institute of Transport Economics wishes to re-use some of the graphs and tables I have made in the scenario projections and certain points from my analyses. I have been assured that their report will accredit this thesis and myself as the author of this material and not directly reiterate the corresponding analyses carried out in this thesis. Still, I find it important to mention the fact to remedy any conceivable doubts relating to the originality of the material presented here.

In addition to the connection to an external research project, this thesis retains several points of relevance to the master's programme in Entrepreneurship, Innovation and Society. Firstly, it considers the innovative aspects of modes of transport like car-sharing, ridesharing and cycling in light of relevant theoretical frameworks and discusses how these can affect their future role in the Oslo mobility picture. Second, the overall topic of transport projections sits well within the framework of economic geography as population distributions and the geographical features of Oslo both feed into the analyses and discussions on sustainable mobility. Third, the scenario projections allow for identifying potential challenges in future mobility and provide indications on which demographic groups can be more or less prone to shift towards new modes of transport based on current mobility trends. This can contribute to further understanding of market possibilities for new and innovative breeds of urban transport.

## 1.4 Thesis outline

This thesis is divided into seven chapters: Introduction, Background, Literature review, Methodology, Scenarios and analyses, Discussion, and Conclusion.

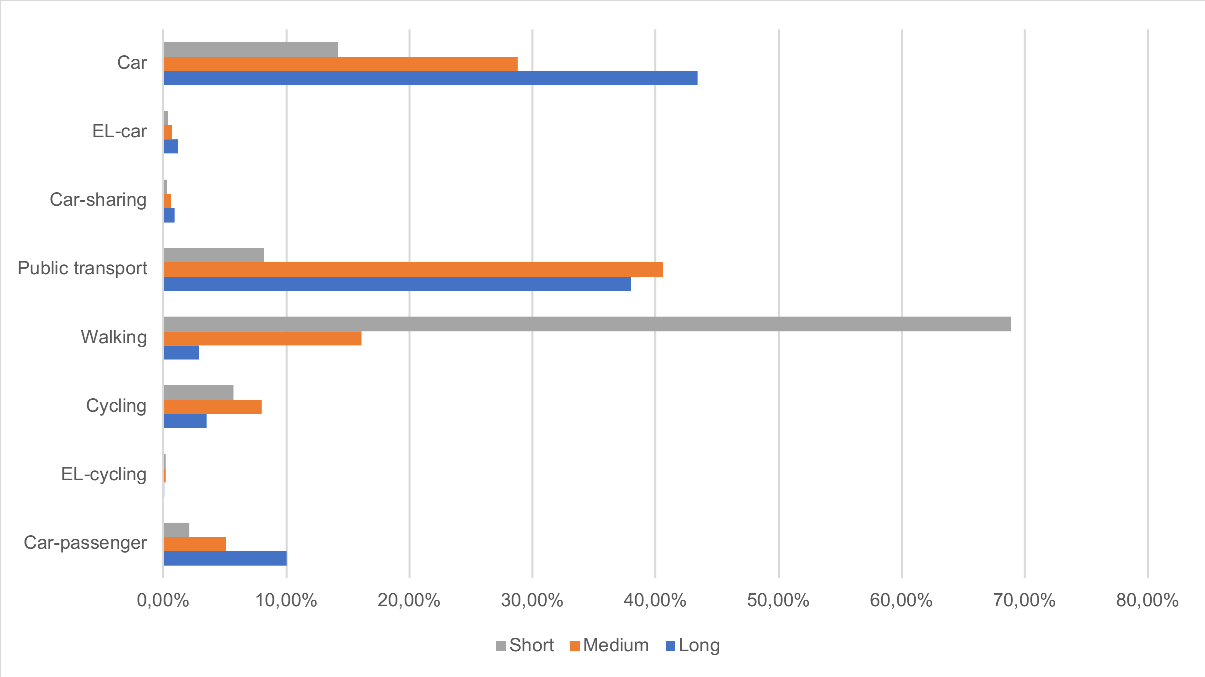
The background chapter starts by setting the tone for this thesis; presenting the current standing of various modes of transport in Oslo and pinpointing why a change is warranted. It then goes on to present the zero-growth objective and how this thesis seeks to expand on it. In the literature review, empirical and theoretical data relating to sustainable mobility obtainment is presented. Two theoretical frameworks – the multi-level perspective and diffusion of innovations – serve as foundations for understanding and contextualising the empirical data gathered. In addition, empirical data on the innovative aspects and developments of car-sharing, ridesharing and cycling is also presented to provide points of discussion later on in the thesis. Next, the Methodology chapter presents the means by which the research questions posed are to be answered. It starts by defining and defending the research design employed and goes on to present the data material that is utilised. This includes a rundown of travel habit data gathered from the national travel survey as well as how supplementary estimations have been made. Next, the model framework employed in generating scenario projections is accounted for, as are the inputs to it. This includes mobility figures, population projections, growth rates for the various modes and substitution factors between them. In the Scenarios and analyses chapter, the results outputted by the model is presented and analysed. First, projections are made and discussed on how Oslo mobility can be expected to develop if current travel trends remain. Then in contrast, an alternative trajectory is projected and analysed wherein mobility is set to shift towards sustainable modes of transport. The points of analysis relate to how these shifts can be projected to differ between demographic groups and how a shifting population makeup contributes to this effect. A Discussion chapter then follows, back-casting whether and how car-sharing, ridesharing and cycling can be applied to further sustainable mobility and potentially fill the obtainability gaps identified by the scenario projections. The thesis ends with a Conclusion that sums up the answers found to the three research questions posed and provides suggestions for further research.

# 2 Background

It is important to provide some context as to why a discussion on sustainable mobility and innovative modes of transport is relevant and topical. To that end, this chapter starts by providing some insights into current mobility in Oslo; briefly presenting modal splits at different trip lengths and overall mobility trends. Additionally, the goals and implications of the zero-growth objective from NTP are accounted for and put in context with this thesis' aims.

## 2.1 Current mobility in Oslo

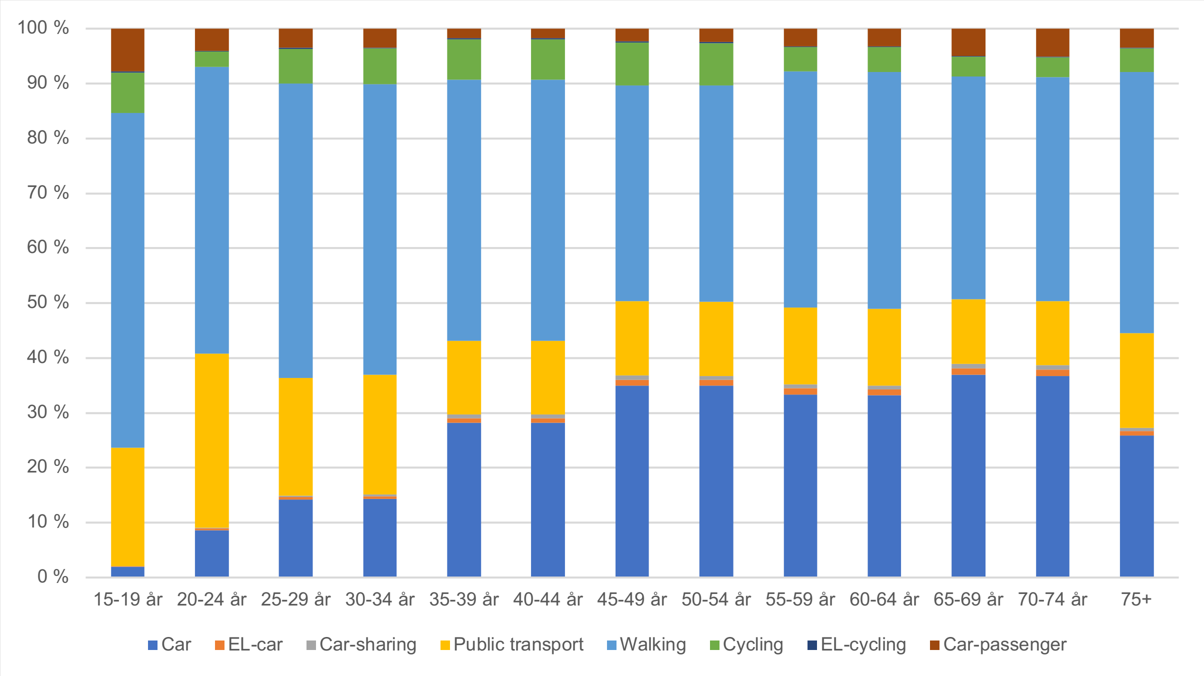
Oslo has by far the highest share of public transport ridership out of any urban area in Norway. According to the 2013/2014 National travel survey (Hjorthol, Engebretsen, & Uteng, 2014) 25% of all daily trips were by public transport. Much of this can be attributed to a very well developed public transport network, at least when comparing Oslo to cities of similar size. At the same time, cars accounted for 29.6% of all daily trips. While significantly lower than in any other urban area in Norway, car travel still remains a backbone mode in daily travel. The largest mode, however, was walking at 34.1%. The remaining 11.3% of daily trips were divided between cycling (5.6%) and car-passengers (5.8%). The other modes this thesis seeks to assess more closely; car-sharing and ridesharing, accounted for a very limited amount of overall daily trips. Car-sharing was not even assessed as a mode by the National travel survey and neither was electric cycling's share of total cycling trips. The same goes for the position of electric cars vis-à-vis fossil-fuelled cars and ridesharing beyond accounting for overall car-passengers. To allow for a more detailed overview, the Institute of Transport Economics has gracefully provided this thesis with more in-depth background data of modal splits at different trip lengths for various age cohorts and estimates of the standing of car-sharing, EL-cars and EL-cycling (accounted for in chapter 4.2.2). Pooling this data allows for presenting a relatively detailed account of current modal splits at different trip lengths in Oslo suitable for the purposes of this thesis:



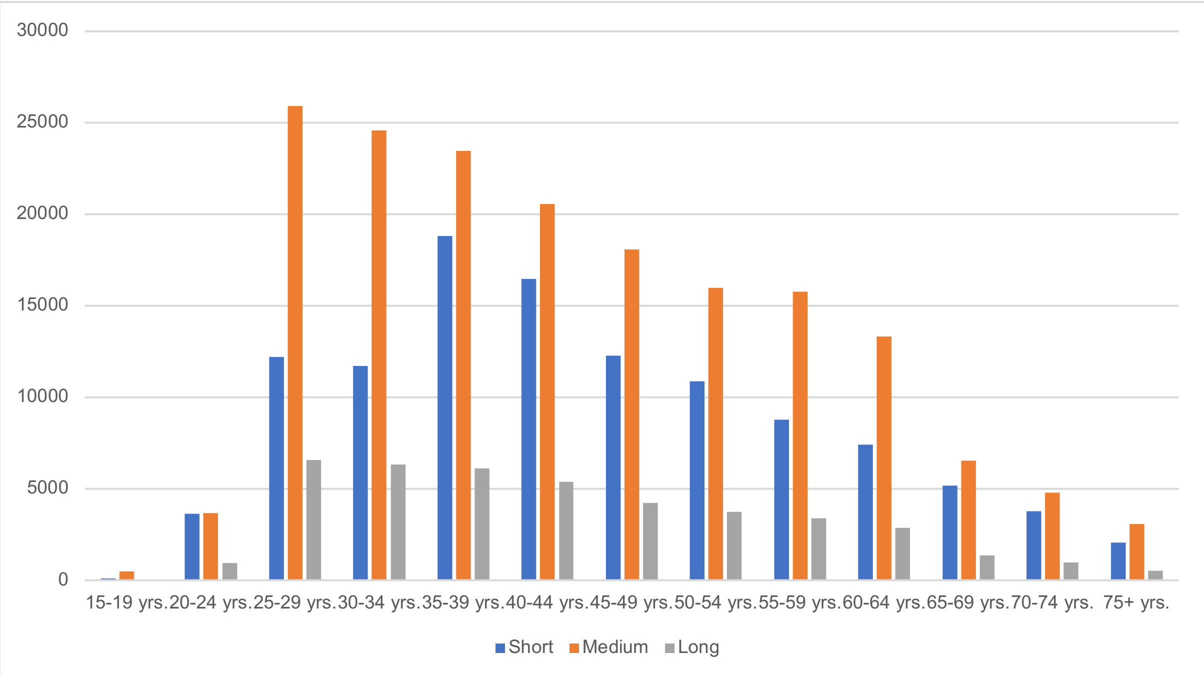

*Graph 2-1: 2016 distribution of modal shares for short, medium and long trips*

On short trips (≤ 2.5 km) walking was by far the dominant mode at 68.9%. This was followed by car (14.2%), public transport (8.2%), cycling (5.7%) and car-passenger (2.1%) while the remaining modes all accounted for less than one percent of overall daily trips. Medium trips (2.5–7.5 km) were characterised by much less walking; accounting for only 16% of daily trips. Here, car and public transport dominated by accounting for 28.8% and 40.6% of daily trips respectively. Cycling also had a higher modal share on medium trips than on short ones at 8%. The remaining trips were made up by EL-car (0.7%), car-sharing (0.6%), EL-cycling (0.1%) and car-passenger (5.1%). On long trips (> 7.5 km) car dominates at 43.4%, followed by public transport at 38%. Car-passenger was at 10%, while the remaining modes accounted for minuscule shares of daily trips (EL-car 1.2%, car-sharing 0.9%, walking 2.9%, cycling 3.5% and EL-cycling 0.1%).

These overall trends contain few surprises. A general assessment would be that car ridership and public transport modal shares were reported to increase in longer distances, while active modes' shares, walking in particular, decreased by trip length. There are however strong deviations between various age cohorts in to what extent modes were being used for various trip lengths, resulting in some demographics accounting for larger portions of total number of trips on certain modes. This is particularly true for car trips, as shown in graphs 2-2 and 2-3.




*Graph 2-2: 2016 modal shares per age cohort. Aggregate for all trip lengths*




*Graph 2-3: 2016 daily car trips per age cohort for short, medium and long trips*

The modal share of cars on daily trips is clearly higher in the middle-aged and elder age cohorts than in the younger ones, as is apparent from graph 2-2. Again, this is hardly surprising, but it is potentially problematic. Norway, including Oslo, is facing a demographic shift where its population is ageing. By 2040, it is expected that the middle-aged age cohorts and elders will account for a much larger percentage of the total population than today. According to Statistics Norway (n.d.), Oslo is expected to be affected by this age wave to a lesser extent than more rural areas, but the forthcoming demographic shift will none the less be felt. The implications of this is that if the travel habits of the middle-aged and elder age cohorts in Oslo remain at current levels, the projected population increases in these demographic groups will undoubtedly lead to car travel increasing in the years to come, contributing to further congestion and emission levels associated with car traffic. Chapter 5.2 provides more detail as to how Oslo mobility is expected to develop if no changes to this are made, but what has been presented above alone speaks clearly towards a change in travel habits being necessary if Oslo seeks to avoid car ridership continuing to climb.

## 2.2 NTP and the zero-growth objective

> *"*The growth in passenger traffic in urban areas shall be covered by public transport, walking and cycling*"* (NTP, 2017).

The National Transport Plan (NTP) is a white paper that encompasses the Norwegian government's transport policy over a twelve-year period, serving as an important indicator of which transport projects the government seeks to prioritise. The current NTP covers the years 2018–2029, replacing the 2014–2023 plan; both of which were proposed by Prime Minister Erna Solberg's cabinets (NTP, 2017). First included in the 2014–2023 plan and maintained in the current version, NTP puts forward a zero-growth objective for cars in several urban areas in Norway. *Nullvekstmålet*, as it is referred to in Norwegian, states that personal traffic growth in large urban areas [1] in its entirety is to be absorbed by public transport, walking and cycling in the future. However, the goal originally stems from a 2012 parliamentary agreement on environmentally friendly development reached by all but one of the political parties in Parliament (*Klimaforliket*). In terms of reaching the objective, the former NTP (2014–2023) set out to promote measures securing that the urban areas affected are able to facilitate more environmentally friendly urban transport. This included the introduction and funding of overall integrated urban environment agreements, allowing policy-makers at various levels of government to better coordinate and steer their transport systems towards reaching the goal of zero-growth in car ridership. These also involved an aspect of commitment for policy-makers at the municipal, county and national level to adhere to the urban environment agreements by

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[1] Oslo and Akershus; Greater Bergen; Trondheim Region; Stavanger Region; Buskerudbyen (Drammen, Kongsberg, Lier, Nedre Aker, Øvre Aker); Fredrikstad/Sarpsborg; Porsgrunn/Skien; Kristiansand Region; Tromsø

rewarding those successful in promoting public transport, cycling and walking at the expense of car travel. In addition, funds were to be made available for improving walkability, cycling infrastructure and for investments in public transport systems (NTP, 2017).

The current NTP 2018–2029 is even more clear in its commitment to the zero-growth objective than the former version. NTP 2018–2029 also defines the goal as applicable to personal transport on low or zero-emission cars such as hybrids or EVs, arguing that these types of vehicles take the same toll on road infrastructure and take up the same area for parking as fossil-fuel driven cars. In addition to the integrated environment agreements proposed in NTP 2014–2023, NTP 2018–2029 proposes urban growth agreements for the nine urban areas affected. Their intention is to coordinate the development in transport infrastructure with land-use policy; ensuring that land development is done while keeping the zero-growth objective in mind. This can for example mean policy measures to prevent urban development resulting in sprawling or to allocate land area surrounding transport hubs like railway stations for future transit-oriented projects. Densification is also considered important, with a goal of making walking and cycling become reasonable modes of transport for most shorter trips while public transport can serve as a backbone mode for longer trips. These urban growth agreements require increased coordination between state, county and municipal levels, as is the case with the urban environment agreements from NTP 2014–2023 (NTP, 2017).

It is obvious from both versions of the NTP that the zero-growth objective is a central framing factor in the government's policies on future urban transport planning. Just the sheer number of times the term is mentioned throughout the white papers demonstrates that it is considered an important goal. That being said, none of the NTPs lend much insight into how exactly it is to be achieved beyond in general terms promoting agreements at various policy-maker levels, improved coordination, and increased funding for public transport, walking and cycling. This might be due to the fact that the different urban regions for which the goal is set are expected to meet significantly varying levels of challenges in reaching the goal. Oslo proper, which is the urban area assumed by this thesis has already a relatively low dependency on cars to meet its personal transport needs thanks to a well-built-out public transport network. In 2016, 29% of daily trips in Oslo proper were conducted by car compared to 42% in Oslo and Akershus combined (NTP, 2017). This assessment is reflected in a memo issued during the preparatory work leading up to NTP 2018–2029. It states that Oslo today is by far the most suited urban area to successfully reach the zero-growth objective (NTP, 2015). Much of this can be attributed to having dense urban areas, an already low level of car dependency, and widespread policy-restrictions on the use of cars. Oslo has the densest population footprint of all major cities and urban areas in Norway, the highest public transport ridership figures per capita, the highest road tolls for entering the city core, and the highest share of the population not having access to a car (NTP, 2015).

This is in part the reason why Oslo is chosen as the case for this thesis rather than a broader defined urban area. If any urban area in Norway is to prove successful in reaching the zero-growth objective, Oslo will in all likelihood be it. Notwithstanding the factors mentioned above, policy-makers in Oslo have a pedigree for adopting and implementing progressive environmental policies (Grundt, 2016). A bird's-eye view of Oslo would also reveal it as a densely built city with very little urban sprawl as it is surrounded by the Oslo Fjord to the south and the wooded hills of Marka to the north and east. This also makes Oslo an interesting proving ground for assessing alternative modes' potential role in contributing to the zero-growth objective and sets it apart from more sprawling urban areas such as Akershus. The latter encompasses a much larger geographical area with urban centres spread throughout that all require a level of interconnectedness which today to a large extent is provided through the use of cars. In these areas, the public transport share is at present considerably lower than in Oslo to the point where large infrastructural investments and developments will be needed in the future to make zero-growth in car travel become reality (NTP, 2015).

On that note it is worth noting that the expectation of this thesis is not that car-sharing, ridesharing and cycling are to become backbone modes of mass-transit – public transport will fill that role, in-line with the goals put forward by NTP. What this thesis seeks to explore is to what extent car-sharing, ridesharing and cycling may contribute to a sustainable transition within trip lengths and demographics where a shift towards public transport is projected to be relatively weak; essentially filling in the gaps to achieve sustainable modal shifts. Sprawling urban areas like Akershus and other Norwegian metropolitan areas do not at present have public transport modal shares or infrastructure that realistically allow for such projections, as substantial development is needed towards reaching the zero-growth objective. These are yet to be thoroughly planned or built out which makes it difficult to say something meaningful about which direction development will and should take place; making it necessary to project future mobility from an even more hypothetical standpoint. For these reasons, this thesis opts for looking at Oslo as a proving ground for ascertaining sustainable transport developments.

Keeping in mind the argument put forward that Oslo today has the best conditions of any urban area for successfully reaching the zero-growth objective, assuming its applicability here can provide useful insight and lessons for other Norwegian urban areas as well.

### 2.2.1 Sustainable mobility beyond the zero-growth objective

While the introduction of the zero-growth objective in NTP is the triggering factor behind this thesis' overall choice of topic and area of study, it is not the sole forming framework within which future mobility is to be assessed. This should be evident by the choice of modes to be examined further, and the fact that this thesis does not only consider goal as applicable to the aggregate level but also to all demographic groups in Oslo. Bar cycling, neither car-sharing nor ridesharing are identified by NTP as modes whose future growth will contribute to the zero-growth objective. The reason why these modes are to be assumed in addition to the ones identified by NTP is twofold. First, this thesis' points of analysis build on scenarios and projections to be presented in a forthcoming co-authored article on pathways towards sustainable mobility in Oslo (Uteng, George, Throndsen, Uteng, & Maridal, 2018). Here, trajectories towards achieving the zero-growth objective are identified; emphasising the possibilities of achieving shifts towards public transport, and to a lesser extent, walking and cycling. Opting only for a similar broad-stroke aggregate analysis in this thesis would produce a very limited amount of new insights. This is why this thesis also aims to expand on the article's findings by identifying ways car-sharing, ridesharing and cycling might fill in the gaps in cases where the scenarios project public transport to absorb relatively few car trips in the future. This means exploring how to further secure sustainable mobility atop what is projected by the scenarios; identifying possible futures wherein none of the trip lengths or demographics remain excessively dependent on car travel. In other words, while the article's main focus is at the macro-level in the sense that it makes overall projections on how Oslo conceivably can reach the zero-growth objective, this thesis has an additional micro-level approach; identifying inefficiencies in sustainable transitions and arguing how these may be mitigated through the increased use of car-sharing, ridesharing and cycling. This analysis and discussion should therefore be seen as an expansion of the article; analysing trajectories for furthering sustainable mobility beyond the requirements of the zero-growth objective.

Moreover, car-sharing, ridesharing and cycling are, in a Norwegian context, rather innovative modes of transport in various ways and opting for an analysis of these kinds of modes fits well with the orientation of the master's programme in Entrepreneurship, Innovation and Society. Arguably most so car-sharing, which is a relatively new addition to Oslo mobility with a rising number of providers offering various business platforms. Ridesharing too has seen a recent innovative development with the advent of mobile technology and new forms of communication, making short-notice *real-time ridesharing* a more viable option for a larger number of travellers (Shaeen, 2001). As for cycling, city bikes are increasing in popularity and electric bikes are more affordable than ever (Sande, 2018). This combined with an overall trend where cycling is becoming a more popular mode of transport within new demographics (NTB, 2017) means it does have potential for further growth. The innovative aspects of these modes will be discussed more thoroughly in chapters 3.3.1 through 3.3.3, but developments do indicate that car-sharing, ridesharing and cycling may very well play a larger role in future mobility than what is the case today.

# 3 Literature review

Due to the exploratory nature of this thesis some empirical data and context is needed to aid the forthcoming back-cast discussion on the future applications of car-sharing, ridesharing and cycling. To meet this requirement, this chapter seeks to explore the modes' development and innovative aspects in context of relevant theoretical frameworks applicable to urban mobility and modal shifts in an Oslo context. In sum, the goal is to provide an empirical and theoretical foundation on which a sound discussion on the modes' potential future role may be built. The literature review starts by defining what transitioning towards *sustainable mobility* may entail for Oslo before assuming this in light of *transition pathways* within a *multi-level perspective*. This is then put in context with policies on *modal improvements* and *modal shifts*. Next, empirical evidence on car-sharing, ridesharing and cycling's developments and innovations are presented – essentially providing some background as to why they are being assessed as well as a rundown of literature assessing their assets and limitations. The empirical evidence is also tied to the concepts of sustainable mobility, modal improvements and modal shifts; positioning the modes relative to these concepts. Lastly, this is linked to theoretical frameworks surrounding the *diffusion of innovations* and an overall discussion of the framework's contributions to challenges and possibilities in achieving a sustainable mobility future. Drawing on these theoretical underpinnings as well as empirical evidence on the modes' development in and by themselves is meant to provide a deeper level of understanding and a foundation for discussing the potential of car-sharing, ridesharing and cycling in contributing to sustainable mobility in Oslo.

## 3.1 Sustainable mobility

The term *sustainable mobility* or *sustainable transport* is inherently vague, yet it is identified as a goal for a number of urban areas, including Oslo. There is no universally agreed upon definition of it beyond being linked to the even more broad term *sustainability* that, despite its vague nature, retains a certain general understanding (Beatley, 1995). A useful and often cited definition of sustainable transport was coined in a 1992 green paper by the European Union Council of Ministers of Transport, providing a rather detailed definition of a sustainable transport system as one that:

1. Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations
2. Is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development
3. Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise

(Comission of the European Communities, 1992)

This definition is useful in that it does not only frame a sustainable transport system in the light of phasing out non-renewable resources in favour of renewables and keeping emission levels down, but also stipulates that such a system must meet the mobility needs of the population. This is an important caveat that may easily lose its prominence amidst lofty policy goals of percentage decreases in emission levels and congestion over some arbitrary timeline. In Oslo's case, where a key goal is zero-growth in car ridership, this involves securing future mobility for the equivalent 100,000 daily car trips by 2040 according to current estimates of population growth and future mobility needs[2]. Yet while this goal and many like it remain clear it has so far proved challenging to achieve them. According to Tennøy & Øksenholt (2018), the main tools policy makers have at their disposal to push towards sustainable mobility include either controlling land-use by for example promoting urban densification over sprawls to reduce overall travel demand, or to promote shifts onto more desirable modes of transport; the means by which will be discussed more thoroughly in chapter 3.2. There are however some key challenges associated with these tools. Steering land-use has been difficult in a number of cities and urban areas, including Oslo, in part due to lack of coordination between the multitude of actors involved. This does not only refer to potential conflicting interests between private and public actors, but also coordination at the various levels of government. Responsibilities for- and initiations of land-use planning in Norway is split across municipal, county and state levels which may contribute to a fragmented power structure in which unified planning and execution towards a common goal becomes an issue (NTP, 2017). NTP acknowledges this problem, seeking to better coordination efforts which illustrates that coherent structural conditions are important in order to successfully move towards sustainable mobility. Land-use planning

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[2] See chapter 5 for context.

translates to *transport planning* in that the physical landscape to a large extent determines a population's mobility needs (NTP, 2017). In cases where the physical landscape is not supportive of certain modes of transport, be it that their use become too time-consuming for travellers or that their levels of utility remain low relative to other modes, achieving modal shifts becomes more unlikely which essentially halts the transition towards sustainable mobility in a case like Oslo's, where the goal is to reduce car ridership.

There is a broad consensus among scholars that cities in having a dense geographical footprint promote the use of sustainable modes more so than sprawling urban areas where car dependency tends to be greater (Næss & Vogel, 2012). "Compact cities" have less car traffic and higher shares of walking and cycling because densification reduces the physical distance between dwellings, workplaces and services. Increasing proximity also reduces the need for mobility, which according to Newman & Kenworthy (1999) partially explains why people living in dense population centres use cars less as their main mode of transport than people living in more sprawling urban areas. Though while the overall potential for Oslo as a dense city is worth noting, the city's boroughs differ considerably in population density. The borough of Sagene is for example the densest populated at 13,400 people per $km^2$ while Søndre Nordrstrand is only populated by 2,100 people per $km^2$ (Oslo kommune, 2018). This means that the boroughs' potential and trajectories towards sustainable mobility are likely to differ from one another due to current and future variations in landscape attributes causing differing access to the various modes of transport, suggesting that rather than identifying a "one-size-fits-all" mobility solution for Oslo a more targeted approach should be pursued.

### 3.1.1 A multi-level perspective

The above speaks to the complexity of the issue at hand, the large number of actors involved, and the structural conditions as determinants of Oslo's pathways in transitioning towards sustainable mobility. It can therefore be argued that achieving sustainable mobility requires a *transition* from the current *socio-technical system* of transport. According to Geels (2004), a socio-technical system can be defined as "A cluster of elements, including technology, user practices and markets, cultural meanings, infrastructure, maintenance networks and supply networks". A transport network is one type of socio-technical system and is defined by the actors involved; such as policy-makers who frame and decide on land-use development, operators of the various modes of transport, and the general public who utilises the transport network and have demand needs for the system to meet. The current system is maintained by the sum of technology, policy, consumer wants, infrastructure and norms applied and reproduced by the actors involved in the system at different levels (Geels, 2004). Transitions from this can occur as a result of *system innovations*; causing disruptions to the current system makeup that alter its structure. Examples of such system innovations include new technologies substituting current ones, change in usage patterns or infrastructural developments (Geels, 2004). Due to the complexity of a socio-technical system arising from the large number of actors involved in it at various levels, these transitions often take time to complete (Lawhon & Murphy, 2011). To help untangle and conceptualise possible pathways of such transitions, the multi-level perspective (MLP) theory might prove useful. MLP provides a framework allowing for better understanding of the interlinkages of actors in a socio-technical system and how this affects pathways for achieving transitions. In a nutshell, MLP considers transitions as non-linear and as a result of changes taking place at three different levels:

1. *Niches*: Spaces (such as incubators, entrepreneurial efforts or R&D-facilities) located outside the incumbent socio-technical regime where new and radical-, albeit immature innovations are being developed

2. *Regime*: The conventions, rules and actors that make up the incumbent socio-technical regime

3. *Landscape*: The context within which the incumbent regime operates; subjecting it to exogenous pressures (such as climate change or increased fuel prices) that potentially disrupt the regime's trajectory

(Geels, 2002)

Developments in each of these levels have in sum the potential to alter the trajectory the incumbent socio-technical system; i.e. the transport system. To illustrate: A niche development might mature and begin to gain traction amongst consumers. Simultaneous landscape changes favouring the niche development then put additional pressure on the regime, allowing the nice development to find a *window of opportunity* through which more consumers chose to adopt it. If the adoption of the niche development becomes mainstream, it then triggers a change in the overall socio-technical system; re-aligning it in-line with the new development (Geels, 2004). To a certain extent, the development of Electric vehicle use in Norway aligns with this MLP-framework. Just a few years ago, EVs were a niche product used only by a few individuals. As the technology matured and range improved, more people chose to adopt it. This trend was accelerated by pressures to the regime, notably the Norwegian government's decision of exempting EVs from sales tax and tolls, as well as a rising public consciousness on the effects of climate change, allowing EVs to become a mainstream mode of transport. This altered the incumbent socio-technical system in that infrastructure was developed and adapted to support the use of EVs (such as by constructing a network of charging stations) and further adoption of EVs at the expense of fossil-fuelled vehicles became widely encouraged.

While the above illustrates how MLP might help explain transitions in the transport sector it denotes a past development. As this thesis seek to explore future transport development, it is more important to ascertain how MLP can help explain future pathways for sustainable transport. According to Frans, Smith & Stirling (2003) there is a risk associated with blindly adopting a descriptive approach by leaning on examples such as the one above in the projection of future developments because this implies that there is some level of inevitability in that the incumbent socio-technical system will change for the better. This is not the case. While EVs development and successful implementation as a fully-fledged mode of transport in the Norwegian context is an example of a niche-development altering the incumbent socio-technical transport system, it should be noted that most niche-developments remain precisely that (Frans, Smith, & Stirling, 2003). Moreover, because MLP is a non-linear framework (Geels, 2004) past developments do not translate to projecting future sustainable pathways because MLP does not consider simple causality in transitions – rather, processes at multiple levels reinforce each other; the sum of which decides the faith of the incumbent socio-technical system (Geels, 2012). This also means that no transition pathway can be identical to that of a past development. That being said, MLP does offer overall *typologies* within which various transition pathways can be categorised. As presented by Geels & Schot (2007), these are:

*Table 3-1: MLP transition pathways (from Geels & Schot (2007) p. 414)*

| | **Main actors** | **Type of interactions** |
|---|---|---|
| ***Transformation*** | Regime actors and outside groups (social movements) | Outsiders voice criticism. Incumbent actors adjust regime rules (goals, guiding principles, search heuristics) |
| ***Technological substitution*** | Incumbent firms versus new firms | Newcomers develop novelties, which compete with regime technologies |
| ***Reconfiguration*** | Regime actors and suppliers | Regime actors adopt component-innovations, developed by new suppliers. Competition between old and new suppliers |
| ***De-alignment and re-alignment*** | New niche actors | Changes in deep structures create strong pressure on regime. Incumbents lose faith and legitimacy. Followed by emergence of multiple novelties. New entrants compete for resources, attention and legitimacy. Eventually one novelty wins, leading to restabilisation of regime |

These typologies of transition pathways provide interesting frameworks within which the potential future role of the modes assessed by this thesis can be explored. The incumbent socio-technical system this thesis addresses is a transport system wherein the share of car ridership is too high to remain sustainable. Though as previously noted, car-sharing, ridesharing and cycling are not expected to develop into *backbone modes* onto which mass-transfers from car ridership are likely to happen in a future sustainable transport scenario. Rather, this thesis seeks to explore their potential as secondary absorbents in cases where public transport, identified as a main absorbent in NTP, is projected to "fail" as a substitute for car trips relative to other trip lengths and demographics. For this reason, car-sharing, ridesharing and cycling are unlikely to arise as winning novelties in a *de-alignment and re-alignment* transition pathway, although such a transition might provide these modes with a more prominent position in a future socio-technical system compared with today. Within the three remaining transition pathways there are however potential for car-sharing, ridesharing and cycling to carve out future markets in various ways. Why this may be the case will be discussed more thoroughly in chapter 3.3, but an example of a *transformation* pathway could be pressure amassing from environmental agencies and other actors pointing out the lack of resource maximisation involved in private car ownership, resulting in the system being geared towards promoting car-sharing and ridesharing to better utilise vehicle capacity. *Reconfiguration* could for example involve EL-cycling increasing the range and applicability of the cycling mode, while *technological substitution* could conceivably involve new business models and sharing platforms that make a dent in the market held by established actors.

The pathways envisioned above and in general do however require pressures to amass to the point where *cracks* in the incumbent regime occur. The already mentioned challenges in achieving a sustainable modal shift brought on by the large number of actors with vested interests involved are further complicated if the incumbent socio-technical system is particularly stable. This minimises the presence of windows of opportunities through which novelties or pressures can bring about change. In a 2012 study, Geels aims at applying MLP to identify pathways towards sustainable mobility and away from what he refers to as the *auto-mobility system* in the Netherlands and the United Kingdom. He notes that this system, in which cars serve as a key mode, retains substantial stability although some important cracks are identified: 1) policy-makers demonstrate a weakening commitment to maintain the incumbent regime, 2) car restrictions are becoming commonplace in urban areas, and 3) system actors are becoming aware of landscape pressures brought on by climate change and other external factors

(Geels, 2012). These cracks are also transferrable to an Oslo context, cf. the goals put forward by NTP and Oslo's policy onset of restricting car ridership. He concludes that the auto-mobility systems in these countries seem to remain *path dependent*, i.e. stable and dominant, albeit less so than fifteen years ago due to emerging cracks. That being said, it is worth to take note of some of his reflections presented in a related article:

> […] we do not take for granted that a transition to sustainable transport will happen. Transport and automobility may well be the 'hardest case' because there are many stabilizing mechanisms and secular trends that point in the direction of more, not less, mobility. So, it is an open question if and how fast a transition to sustainable mobility can happen on the ground. If a transition will take place, a further question is what kind of path will it follow? Will a future sustainable transport system be based on 'green' cars? Or will this system look very different from current transport systems, with intermodal linkages between various sub-systems and less prominence for cars?
>
> (Kemp, Geels, & Dudley, 2012)

Whatever the case may be, if a transition is to take place the pathways presented by MLP point to one of two things happening to the modes of transport: Either modes need to be improved to become more sustainable in their own right, or mobility needs to shift over onto other and more sustainable modes than the incumbent ones.

## 3.2 Policies for modal improvements and modal shifts

As mentioned earlier, the push towards sustainable mobility has by and large been led by policy makers that can be said to add pressure to the existing socio-technical system. In-line with the proposed transition pathways in MLP, these efforts inevitably encompass *modal improvements* or *modal shifts* relative to that of the incumbent mobility system. Examples of policy measures sought in Norway in general and Oslo in particular aiming for modal improvements include incentives favouring EVs over fossil-fuel driven cars, claiming traffic lanes for public transport (*samkjøringsfelt*), and taxing or restricting the use of studded tyres in downtown areas (TØI, 2018). These policies all have in common that they seek ways to improve upon an incumbent mode of transport in various ways. In other words, it is not the mode in and by itself that is identified as a problem and barrier to achieving sustainable mobility but rather *aspects* or *by-products* of it whose negative impacts policies seek to address. A successful transition occurring from these sorts of developments would loosely correspond to the transition pathways of transformation and reconfiguration in the MLP framework; essentially building on- and improving what is already at play in the socio-technical system. Opposite of this is modal shifts. Policies at this end of the spectrum do identify an incumbent mode as the problem or barrier to sustainable mobility and seek to shift patronage from these onto alternative and more sustainable modes. Examples of policy-implementations in this category include pedestrianising streets, removing parking spaces or transforming important traffic arteries into bus-only zones (TØI, 2018). This can be tied to the de-alignment and re-alignment transition pathway outlined in MLP.

While there are some basic differentiations to be drawn between the policy mechanisms of modal improvements and modal shifts, things are not this black and white when applied. Some policies would be categorised in the intersect between the two. For example, the undergoing project of expanding and improving the InterCity train system that covers south-eastern Norway is by definition a modal improvement, yet one of the primary reasons why the project is undertaken is to attract modal shifts from cars onto it (Jernbaneverket, 2012). This exemplifies why it is important to consider both modal improvements and modal shifts even though this thesis is predominantly concerned with modal shifts. After all, NTP stipulates shifts occurring, and transferring patronage onto car-sharing, ridesharing and cycling also implies shifts. But because modal improvements can conceivably trigger these shifts it plays an important role in the overall framework of discussion. At the same time, acknowledging the differences between the two is important as well because deciding whether a mode of transport can be "fixed" or is "beyond repair" for contributing to a sustainable transition represents an overarching fork in the road for policy makers if one considers the big picture: A future socio-technical system of mobility based on green cars would look vastly different than one based on public transport; each having massive implications for land-use as well as the potential role of secondary modes such as car-sharing, ridesharing and cycling. NTP's framework aims for the latter option – as does this thesis – but this contrast underlines that policy-makers need to consider sustainable mobility as a *systemic* because how they chose to attempt influence mobility through policy has implications for the overall trajectory taken by the mobility system.

Beyond the differentiation above there is a second dimension wherein policies on sustainable transport can be grouped, namely whether they are *restrictive* or *incentive-based*. Restrictive policies are just that; targeting certain modes by restricting how or whether they can be used in certain situations. Incentive-based policies on the other hand are less intrusive and rather than forcing change they encourage it to happen in various ways. However, these extremities can also be placed on a spectrum and certain policies can be categorised between the two. For example, building cycling lanes that take up space along an already existing road is an incentive-based effort in the sense that improving navigability for bicycles might encourage more people to opt for cycling. Yet it is also restrictive in the sense that areas previously allocated for car traffic has been repurposed; effectively improving navigability for one mode of transport at the expense of another. Therefore, policies are in reality more fluid than the sharp differentiations imply, but the overall contrasts presented between these two extremes do allow for a neat, albeit somewhat unprecise cross-tabulation useful for broadly categorising policy measures employed in seeking to achieve sustainable mobility:

*Table 3-2: Cross-tabulation of proposed and implemented policies for modal improvements and shifts in Oslo. Compiled from (TØI, 2018)*

| | **Restrictive** | **Incentive-based** |
|---|---|---|
| **Modal improvements** | Ban on diesel-fuelled vehicles<br>Studded tyres ban<br>Claiming HOV lanes | Tax-breaks on EVs<br>EV access to bus lanes<br>Studded tyres fee |
| **Modal shifts** | Pedestrianising streets<br>Removing parking spaces<br>Car-free downtown cores | Cycling lanes<br>Free public transport<br>Tolls |

There are a number of studies covering specific geographical areas that aim to assess the goal obtainment of certain policies. The problem with generalising a broad sample of these lies in the fact that their relative effectiveness must be seen in the context of the socio-technical system they have been applied to. Built environments, access to alternative modes, cultural norms and outset modal share structure all influence to what extent a policy will prove successful or not; factors that all vary greatly between geographical areas (Banister, 2004). Moreover, one would be justified in assuming that policies seeking sustainable transitions are geared towards the unique challenges of the socio-technical system it is applied to. This means that what has proven to work in, say London, might not produce the same results if introduced in Oslo, indicating that policy effectiveness for achieving sustainable mobility is highly *context specific*. This issue also relates to MLP, which has received criticism for lacking a geographical dimension by not allowing for assuming the varying spatial characteristics of different socio-technical systems (Truffer, Murphy, & Raven, 2015). It is therefore important to keep Oslo's current mobility particularities in mind of one is to analyse its potential future.

In the case of Oslo, a combination of restrictive and incentive-based policies both seeking modal improvements and modal shifts have been introduced and proposed, cf. table 3-2. The one that has undoubtedly gained the most international attention is the package of incentive-based subsidies favouring electric cars. The explosive increase in number of registered EVs in

Norway, particularly in Oslo, has largely been credited to extensive tax breaks and other benefits rather than being brought on by altruistic motives within the general public (Figenbaum & Kolbenstvedt, 2013). None of these policies do, however, explicitly restrict other cars – EVs are merely exempt from taxes and fees that already were in place and given benefits never allotted fossil-fuelled cars. This arguably makes it an example of a successful non-intrusive incentive-based policy. However, the relative success of this specific set of policies does not mean that incentive-based policies tend to be the most effective in all cases. Opting for an electric car over a conventional car does not involve much habitual change – it is still a car and can therefore be considered a modal improvement. For modal shifts, however, evidence suggests that incentive-based policies are more challenging to successfully implement. A 2012 study (Fearnley) shows that even radical measures such as offering free city buses, piloted in Stavanger and Bergen, only have a negligible effect on reducing car ridership. This is interesting because the cost aspect in terms of savings is identified as a key reason why the Norwegian EV policy has proved successful (Figenbaum & Kolbenstvedt, 2013), implying that there might be different mechanisms at play between inducing modal improvements and modal shifts. Indeed, Fearnley (2016) argues that the "carrot" measure of incentivising modal shifts is likely to produce less of an effect than the "stick", i.e. policies directly aimed at the mode from which shifts are desirable. According to Fearnley, et al. (2016), this is particularly true for achieving modal shifts onto modes considered sustainable. By compiling demand interactions between various modes of transport from multiple studies, they note that:

> The general tendency of the collected evidence is for public transport to have less impact on demand for car and walk/cycling than car policies have on the demand for walk, cycle and public transport. […] Policy makers should therefore understand that 'carrot' measures of improving public transport or improve walkability with the goal of reducing car use, are likely to be exceedingly optimistic.
>
> (Fearnley, et al., 2016)

Nevertheless, these "carrot" measures in bringing about modal shifts have proven popular with policy-makers in Norway. A 2008 report by Fearnley & Nåssum analyses the preferences given by Norwegian policy-makers to various policies for achieving sustainable mobility. It demonstrates that many policy-makers, also in Oslo in particular, favour incentive-based policies over restrictive ones in bringing about modal shifts. This particularly applies to politicians, who self-report being optimistic of the positive effects of these policies and often seek to avoid more restrictive and intrusive measures. This is hardly surprising but is yet another example of vested interests influencing the mobility system. In comparison, bureaucrats working on transport related issues, who unlike local politicians need not seek re-election to stay in position, were reported to more readily accept restrictive policies in bringing about sustainable mobility (Fearnley & Nåssum, 2008). This further underline the presence of vested interest in transport policy planning and points towards policy-maker squeamishness of employing unpopular policies affecting it.

Getting people on-board with achieving sustainable mobility through policy ties into what Banister (2008) refers to as *the sustainable mobility paradigm* which attempts to understand the reasons why certain policies on modal improvements and modal shifts succeed. He argues that it would be more effective to include all stakeholders in the transport system, including travellers, in a push towards sustainable mobility rather than attempting to simply persuade them through policy; demonstrating a structural multi-actor perspective in-line with the frameworks presented by MLP. Underscoring the necessity for public willingness to change and a collective consciousness, broad involvement can hopefully result in an equally broad consensus, but the question of which direction this development should take still remains. As argued by Kemp, Geels & Dudley (2012), much is still unclear as to how a sustainable mobility future will look and knowing that past developments do not translate into future development, some attention should be given to new and innovative solutions or modes of transport that do not constitute dominant factors in the current mobility system – but might in the future. Considering the rapid societal changes that have occurred in the past decades it becomes less likely that people's needs, and utility gained, from incumbent modes of transport will remain the same in the future. Policy makers should therefore take into account that beyond sanctioning or improving upon a mode identified as problematic and promoting solutions in-line with the current socio-technical mobility regime, innovative solutions giving certain modes of transport new dimensions might allow for them to be applied in market segments that they currently do not serve. In other words, electric vehicles and public transport are not the only conceivable successors of transport by fossil-fuelled cars.

### 3.3 Introducing car-sharing, ridesharing and cycling

Understanding the mechanisms by which modal improvements and modal shifts are sought is useful when circling in on the modes of transport this thesis seeks to analyse, namely car-sharing, ridesharing and cycling. Below, an account of relevant literature, innovative aspects and mode-specific attributes are given for all three of these modes, in an effort to put the theoretical underpinnings accounted for thus far in context with the modes to be analysed.

### 3.3.1 Car-sharing

Defining car-sharing is more challenging than what immediately meets the eye because there is no standardised and universally agreed upon terminology for it. One broad-stroke way of defining it is that "car-sharing is a membership-based, self-service, short-term car-access system with a network of vehicles for which members pay by time and/or distance" (Millard-Ball, Murray, Schure, Fox, & Burkhardt, 2005). This definition sets car-sharing apart from ridesharing in that vehicles in the former case are made available to a person as a *driver* while in the latter case, vehicles are made available to a person as a *passenger*. To further complicate the matter, what is here referred to as car-sharing is called "car clubs" in the United Kingdom whereas "car-sharing" refers to what is termed ridesharing here. The definition of car-sharing provided above however is useful because it excludes certain types of peripheral car-access systems that could conceivably be regarded as car-sharing but should not, in this thesis opinion. Defining it as "membership based" and "self-service" excludes traditional car-rental services, "short term" excludes car leasing arrangements, and "network of vehicles" excludes informal sharing of one's vehicle between friends and family. In other words, this thesis treats car-sharing as something organised, membership-based and formal – baring traditional car-rental providers and leasing arrangements.

Within the definition outlined there are essentially three ways car-sharing services can be geared: *Business-to-consumer* (B2C), *peer-to-peer* (P2P) and *cooperative*. B2C car-sharing services are often characterised as being operated by for-profit corporations that operate a fleet of vehicles made available to members for a fee. Notable examples of such companies globally include Zipcar and Car2Go, while Hertz BilPool is the most prominent example of this type of provider currently operating in Oslo. P2P car-sharing services on the other hand do not have the same corporate structure but operate a platform through which private individuals lend out their cars to other members for short periods of time. Nabobil is a considerable actor in this category. Lastly, cooperatives are made up of a number of people joining together to collectively own one or more vehicles (Le Vine, Zolfaghari, & Polak, 2014). Bilkollektivet is an example of such a cooperative. In addition to the three business models outlined, car-sharing services vary in being free-floating or station-based; the former meaning cars can be picked up and dropped off in a wider general area and the latter referring to designated pick-up and drop-off locations. Payment plans also vary and range from members being charged a flat fee, a per kilometre fee, or both (Millard-Ball, Murray, Schure, Fox, & Burkhardt, 2005).

Much of the potential in car-sharing arguably lies in new internet-based solutions making access and usage easier for consumers. Cars from Hertz BilPool can, for example, can be unlocked by the members' smartphones and located by GPS, greatly reducing staffing needs to run the operation (Hertz BilPool, 2018). The advents of smartphones and apps have also made it easier to connect providers with consumers, paving the way for P2P sharing services in particular to develop in a similar fashion to that of Airbnb. Nabobil has achieved a dominant position in this market in Norway, facilitating short-term rentals of some 5,500 vehicles between 125,000 users according to their own website, all the while employing only eleven people in 2016 (Nabobil, 2018; Proff, 2018). This exemplifies how car-sharing operators are developing organisational innovations through the increased use of technology. The potential of car-sharing was singled out by a 2017 Official Norwegian Report on the *sharing economy*, stating that it is among the sharing services that up until now has gained the strongest foothold in Norway, largely due to its adoption of technological innovations (NOU 2017:4, 2017). The further development of car-sharing is, however, consequently reported to be dependent on the direction of these technological developments as well as mobility needs, economic factors and public opinion.

Proponents of car-sharing argue that its role in bringing about sustainable mobility lie in its potential as an alternative to car ownership. It also allows for better utilisation of resources in that a more people may gain utility from a single vehicle (Loose, 2010). This, however, has one important caveat: Car-sharing in and by itself can only be a means of achieving sustainable mobility if a shift towards it from private car ownership causes people to drive less than before. The pay-as-you-go pricing mechanisms employed by many car-sharing services could arguably aid this becoming a reality because at some point in increased usage, owning a vehicle would make more economic sense than making use of a car-sharing service. This also has a second implication: Car-sharing cannot be treated as a daily mode at par with conventional car ownership. Rather, it is an *occasional* mode of transport that might allow for a level of utility in certain situations where alternative modes fall short; for example, in transporting larger goods, the occasional commute, or weekend getaways for those without access to a car. This helps explain why car-sharing as of yet only accounts for a negligible modal share at the aggregate level in all the markets it is applied to. Currently, Switzerland has the largest market penetration of car-sharing usage in the world where just over one percent of the population report making use of such a service (Loose, 2010). This relative success is attributed to a number of factors, including strategic partnerships between car-sharing providers and key societal actors like the Swiss Federal Railways and Swiss Post. Moreover, car-sharing in

Switzerland enjoys public approval and recognition through a widespread image of being innovative, exiting and covetable while at the same time receiving political support as a means of achieving environmentally friendly transport (Loose, 2010). Policy-makers in Norway on the other hand have yet to actively promote car-sharing as a tool applicable to achieve sustainable mobility. In fact, a 2012 report by the Norwegian Ministry of the Environment rejects the notion of politically promoting car-sharing as a means for reaching this goal (Report no. 21 (2011–2012)). However, the latest version of NTP (2017) does briefly entertain the idea of supplementing and integrating public transport systems with car-sharing, moving it in the direction of *integrated mobility* where car-sharing for example can function as a feeder mode into larger public transport hubs. Access and integration could potentially be improved and deepened in such a scenario by, for example, integrating car-sharing booking systems with that of public transport operators.

As for market segmentation, car-sharing's role in promoting sustainable mobility can conceivably be applied to two main consumer groups: Those who opt for car-sharing over purchasing a car, and those willing to shift from car ownership to car-sharing. The key in both cases is, as mentioned, to maintain that car-sharing usage does not equal or surpass the car ownership alternative. Studies assessing the characteristics of people currently using car-sharing services produce somewhat unclear results as to which of the two consumer groups are dominant, arguably because car-sharing in most markets still remains a novelty. Bulks of the literature therefore focuses on the future potential of it and refers to current users as *early adopters*. According to Millard-Ball, Murray, Schure, Fox & Brukhardt (2005), these early adopters are likely to be well-educated, between 25–40 years old, live in urban environments and list environmental and social concerns among their main incentives for using car-sharing. According to Le Vine, Zolfaghari & Polak (2014), they also demonstrate a propensity for using non-car-based modes of transport like public transport in addition to car-sharing. A 2011 study that surveyed members of the Oslo-based Bilkollektivet (Hald, Christiansen, & Nenseth) found that the most frequent stated reasons for joining included avoiding the hassle of owning a car, economic factors, and not needing to own a car. Members were reported to likely be male, on average 40 years old, well-educated and having relatively high incomes. The income parameter does however vary in other sources. Surveys of car-sharing members in U.S. cities like Portland and San Francisco characterise average members as high-income "young professionals" while similar surveys in Switzerland and Germany find the average member to have a more moderate-income level (Le Vine, Zolfaghari, & Polak, 2014). Still, the sum of these characteristics does apply to a relatively large group of Oslo's population that, importantly, demonstrate relatively high mobility needs and account for a sizable portion of current daily car trips according to the travel survey data outlined in chapter 2.1. This might be a positive indication for car-sharing's future potential in Oslo. But again, this potential can and should only be utilised in combination with other modes if the goal is sustainable mobility. The inherent dilemma of car-sharing, as put by Nenseth & Julsrud (2012), is that the easier the access, the easier it may replace private car ownership – but also more sustainable modes of transport like public transport, walking and cycling – potentially exasperating a problem rather than being an agent for solving it. Striking the right balance is therefore key if car-sharing is to succeed as a means of achieving sustainable mobility.

### 3.3.2 Ridesharing

Ridesharing in a broad sense refers to the sharing of a vehicle on a journey so that more people than the driver gain utility from it. This can happen both formally and informally, spontaneously or planned. One way of characterising various types of ridesharing is:

1. *Informal*: Friends, family members, co-workers etc. agree to car-pool
2. *Slugging*: An organised network of pick-up locations where drivers may stop to pick up potential passengers. The drivers decide the destination and the potential passengers may catch a ride with any driver going where they plan to go
3. *Real-time ridesharing*: A system (internet or app-based) facilitating short-notice one-time trip-matching allowing flexibility for both drivers and passengers

(Amundsen, 2016)

Ridesharing, as treated here, refers to adding passengers to a pre-determined trip either free of charge or for a nominal fee. This sets it apart from ride-sourcing, which refers to private individuals making a car available for public *hire* through services like Uber, Lyft and Haxi. The latter is not included and assessed as a means of achieving sustainable mobility in Oslo by this thesis because its function mimics that of a taxi service that ultimately has the potential of generating more car trips as a consequence of drivers' motivation to earn money through these platforms (Amundsen, 2016). Ride-sourcing services are also currently at odds with Norwegian law which requires drivers to be licenced in order to operate taxi-like services (Yrkestransportlova, 2002).

The potential of ridesharing in any capacity as an agent for achieving sustainable mobility lies in improving resource utilisation by having more people use the same car rather than having them drive separately. The average car-occupancy in Norway was only 1.55 people in 2014 (Hjorthol, Engebretsen, & Uteng, 2014). Occupancy for work trips were even lower at 1.1 people per car within Oslo in 2005 (Ramsfjell, 2015). This is indicative of a large untapped potential for ridesharing. There are, however, organisational challenges in establishing large-scale implementations that can produce measurable results. In particular with regards to informal ridesharing because the organisational aspect necessarily lies at the hands of those agreeing to car-pool – policy efforts can therefore only do so much to persuade people in these situations. Some large corporations in Norway have previously piloted organised car-pooling amongst its employees with varying success. One of the key challenges of such arrangements is finding enough people who share the same route to work so that they are willing to consider ridesharing an option (Amundsen, 2016). As for slugging, it requires a large number of participants in order to be effective and is therefore faced with much of the same challenges corporations face in organising car-pooling to and from work for their employees (Amundsen, 2016). In a Norwegian context it is argued that both informal ridesharing and slugging has a limited potential as agents for achieving sustainable mobility because their impacts on overall traffic development has proven to be relatively small (Ramsfjell, 2015). The focus should therefore arguably be on the potential in future development of real-time ridesharing, which also constitutes the most innovative aspects of this mode of transport.

As with car-sharing, real-time ridesharing has identifiable potential through internet- and app-based solutions that can contribute to an added level of flexibility; setting it apart from informal ridesharing and slugging. Drivers can, for example, list planned trips through this system and potential passengers can sign up to trips corresponding to their travel needs. This can be particularly useful for increasing car occupancy for work trips as drivers for the most part will drive the same route multiple times a week at set times, providing a level of consistency that makes it an option in areas where, for example, public transport does not serve all travel needs. A different approach to internet/app-based ridesharing is a spontaneous "matching" service between drivers and passengers that utilises GPS location data. Carma is an example of the latter operating in Norway which is geared towards short-notice trips, while Samkjøring.no is an example of the former and is mostly used for longer-distance trips that are planned in advance (Amundsen, 2016). The key benefit of either version of real-time ridesharing as opposed to car-sharing is that it has very little potential for generating additional car trips because the driver would in all likelihood carry out the journey regardless if he or she is carrying passengers. This means that it is also essentially unproblematic if ridesharing were to shift patronage from sustainable modes onto it from a sustainable mobility perspective because it would not add to the overall car traffic, with the notable exception of potential detouring to pick up passengers.

However, unlike car-sharing, real-time ridesharing has not really gained foothold as a transport niche in Oslo. While car-sharing has measurable effect on the micro level and is currently being operated by well-functioning providers, the simple theoretical frameworks allowing for ridesharing have proven difficult to employ in practice (Ramsfjell, 2015). An important aspect to consider if ridesharing is to become successful is the drivers' motivation to participate. As mentioned earlier, drivers will not be able to earn money from ridesharing beyond at-cost level. One potential measure to encourage drivers could be to designate traffic lanes for high-occupancy vehicles (HOV). Unlike in North America, these are a rarity in Norway as well as elsewhere in Europe where designated lanes usually are reserved for buses and taxis. These could either be expanded to include HOVs or separate lanes could be designated, although the latter has already unsuccessfully been attempted in some Norwegian cities (Ramsfjell, 2015). Other policy measures include parking restrictions, which as previously mentioned are already being employed in Oslo or designating combined pick up- and parking spaces at central locations for ridesharing vehicles. Toll discounts is another example of an incentivising policy that would benefit drivers and possible persuade them to take on passengers (Ramsfjell, 2015). Both designated parking spaces and toll discounts have been employed at limited scale in the Netherlands and the United Kingdom with positive results (Amundsen, 2016).

Still, even if incentives are introduced through policies favouring ridesharing it will in all likelihood remain a complimentary mode of transport suitable for a limited segment of the transport needs in Oslo. For most people, public transport would arguably be a better option to suit most needs because it does not require people to make arrangements in advance or "match" journeys. There is also an element of uncertainty, perceived or otherwise, in travelling with strangers in this way. Therefore, one would be justified in assuming that the potential of ridesharing lies in segments that are not reliably served by public transport and between people where travel needs coincide – at least as a starting point, seeing that no considerable niche has been carved out for real-time ridesharing in Oslo as of yet. That being said, the current trajectory of policy pressures targeting car traffic in general could potentially trigger an increase in informal ridesharing as a result of economic factors. For example, Oslo recently upped the toll for entering the downtown core by car as part of an effort to improve overall air quality and plans for adding more toll booths around the city are in pipeline (Mikaelsen, 2017). While the stated goal of these toll policies is to reduce emission levels and incentivise more people to opt for public transport, those who still opt to drive could conceivably instead be incentivised to take on passengers that foot a portion of the toll bill as a means of reducing the overall cost of driving. However, seeing that the goal of the toll policy is to reduce congestion it is unlikely that policy-makers would take on an active role in promoting ridesharing. If it catches on, it will therefore likely be a result of developments happening independently of policy-based steering efforts.

### 3.3.3 Cycling

Cycling is by no means new mode of transport in Oslo mobility but much of its future potential arguably lies in recent and future improvements to the mode and the landscape it operates in, combined with well-established backing from policy-makers. Of the modes assessed more closely by this thesis, cycling is the only one that is both identified as a mode onto which NTP would like to see ridership shift and one that has seen considerable promotional efforts by policy-makers. At the local level, Oslo has implemented a cycling strategy spanning 2015–2025 that aims to increase rates of cycling (Oslo kommune, 2014). It puts cycling's current modal share in Oslo at 8% of daily trips and sets forth a goal of reaching 16% by 2025 which, if successful, would mean a threefold increase in ridership. Being a relatively dense city as mentioned earlier, Oslo does have landscape qualities that should allow for a high cycling share but lags considerably behind cities like Amsterdam and Copenhagen in this effort. According to Oslo kommune (2014), a very large portion of Oslo's population reports being positive to the municipality's efforts in promoting cycling (94% overall, 88% for non-cyclists). The main reservations non-cyclists report are the lack of cycling routes and facilitation perceived as safe, which arguably manifest themselves in which demographics currently cycle on a daily basis: Two out of three are men and the typical Oslo cyclist is identified as an upper-income working professional travelling to and from work; somewhat substantiating the "tour de finance" stereotype (Oslo kommune, 2014). In an effort to change this and broaden the cycling demographic, the cycling strategy focuses of expanding the network of cycling lanes across the city and improving cyclist navigability and safety. The effectiveness of developing comprehensive networks of long-distance cycling lanes, particularly when separated from car traffic, in bringing about an uptake in urban cycling is well founded (Pucher, Dill, & Handy, 2010). Similarly, an assessment by Jensen (2006) on the effects caused by improving cycling infrastructure in Copenhagen found that cycling lanes separated from car traffic generated an 18–20% increase in cycling and scooter trips and reduced car traffic by 9–10%, while cycling lanes not separated from traffic generated a cycling and scooter increase of 5–7% but car traffic remained unchanged. Because perceived safety is reported to be one of the main concerns of would-be Oslo cyclists, the cycling plan aims for providing Oslo's future cycling network with a higher standard than what is outlined in the national Cycling Manual (*Sykkelhåndboka*) (Oslo kommune, 2014); prioritising separated cycling lanes wherever possible. At present, the development of this cycling network remains in the planning phase (Ericson & Kjørven, 2016).

However, Oslo's last cycling strategy, spanning 2005–2015, did not see its goal of ridership growth fully come to fruition. A possible explanation might be the lack of an overall coordinated approach as well as having an incentive-based focus rather than a restrictive one (Oslo kommune, 2014). While both plans allot much attention to the realisation of a safe, dense and interconnected cycling lane network they thread lightly on underscoring whether this is to be developed at the expense of car-supporting infrastructure. This ties into what was mentioned earlier, namely that some groups of Oslo policy-makers are reported to favour carrot-based policy measures and overestimate the effects they yield. According to Sørensen & Amundsen (2016), infrastructural developments supporting cycling are necessary, but in isolation not enough to bring about modal shifts towards cycling. Let alone other cycling-supporting infrastructure, policies restricting cars in particular are identified as important and can range from downtown parking restrictions to claiming entire roadways previously allotted cars for cycling. In other words, an uptake in cycling is seen to be dependent on both incentive-based and restrictive policies targeting both cycling and competing modes.

Parallel to this matrix of policy efforts, the innovative aspects of cycling also come into play. EL-cycles is one such innovation which have the potential of making cycling a viable option for a larger portion of Oslo's demographic. One key reason is that unlike the aforementioned cycling hotspots Copenhagen and Amsterdam, Oslo is not a flat city. Ellis et al. (2012) find that people residing at a height difference of more than 50 metres from the downtown level on average cycle 40–50% less than those residing at a height difference of 15 metres or less. EL-cycles minimise much of the physical strain associated with uphill cycling as well as increasing the mode's range applicability because they allow for cycling longer distances with less physical effort. According to the Norwegian Ministry of Transport and Communications (Prep. St. 389 S, 2015), EL-cycles constitute 3–4% of the overall cycling fleet, meaning it remains a relatively small niche mode of transport. One reason why EL-cycles have not reached a higher market penetration in Norway might be legislative, as a ban on them was in place up until 2002 (Fyhri & Hesjevoll, 2016). Per capita sales still remain much lower in Norway than in EL-cycling front-runner countries like Germany and Switzerland, which according to Fyhri & Sundfør (2014) in part is due to it having an image problem; particularly amongst people that already cycle. Seen in isolation this is not necessarily a drawback for EL-cycles because its application as a means of reaching sustainable mobility must be seen in its potential for reducing car ridership. For example, if people that already cycle were to switch to EL-cycles the environmental effect would be slightly negative if one takes into account inputs associated with producing EL-cycle batteries. Therefore, the fact that the non-cycling population holds EL-cycles in higher regard than the cycling population could indicate a potential market for it replacing unsustainable modes of transport. Fyhri & Sundfør (2014) also look at who the potential EL-cyclist in Oslo and Akershus might be. They found that the youngest portion of the population demonstrated the strongest desire for buying an EL-cycle, while the elder population had the highest willingness to pay for it. That being said, people's willingness to cycle, electric or otherwise, were reported to still be dependent on external factors like the quality of cycling lanes, perceived safety and the weather. This again speaks towards a systemic approach being necessary in order for EL-cycling to successfully absorb daily car trips.

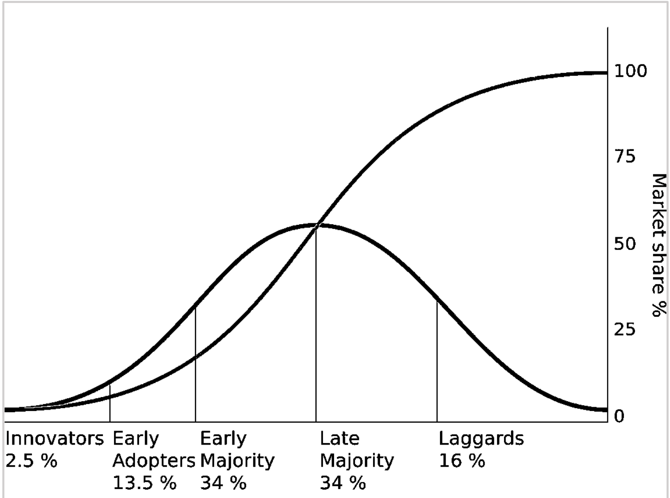
A key barrier associated with EL-cycle use is their price which is much higher than that of conventional cycles and typically lies in the range of NOK 10,000–35,000. This makes it less accessible to the more price sensitive portion of the population and means that it for many is not a mode one can simply "test out" due to the relatively high barrier to entry. That being said, when Fyhri & Sundfør (2014) surveyed what a representative sample of Oslo and Akershus' population was willing to pay for an EL-cycle, people's willingness to pay increased substantially after they were given the opportunity to test one out. Oslo municipality has also piloted application-based subsidies covering part of the EL-cycle cost that proved successful in both incentivising people to buy them and in reducing beneficiaries' reliance on other modes of transport (Fyhri, Sundfør, & Weber, 2016). These subsidies were, however, implemented on a limited basis unlike the current nationwide tax exemptions granted for electric cars. Similar policies could potentially be allotted EL-cycles in order to reduce the entry cost but are not currently in pipeline.

Bar the physical strains, the same drawbacks people identify for conventional cycles also apply to EL-cycles. In addition to issues of navigability and perceived safety, this can be both maintenance and the need for finding suitable spots for parking. A relatively new and innovative concept that removes the latter drawbacks are city bike schemes. This refers to rental bikes that are picked up and dropped off at designated stations placed across the city, which means that users do not have to worry about the cycle beyond picking it up and dropping it off when needed. Oslo is served by Oslo Bysykkel that maintains an extensive network stations at strategic locations (Oslo Bysykkel, 2018). According to Amundsen (2016) city bikes are currently often used on last-mile short-distance trips at the end of a longer journey, in essence serving as an extension of the public transport network. Such combined usage patterns could potentially make public transport a more viable option for people who currently drive due to public transport hubs being located far away from where they live or work. Additionally, in dense urban areas city bikes could potentially replace cars on short trips. City bikes can also be made electric to add the range benefits and lack of physical strain associated with EL-cycles, as is done in Copenhagen's city bike scheme (Bycyklen, 2018). Recent technological innovations have also made city bikes easier to use and increased their reliability. The Oslo Bysykkel network is, for example, app-integrated which means users can check availability at the different stations and rent a cycle using their smartphones.

As mentioned in the introduction to this chapter, cycles are identified by NTP as a key factor in reaching the zero-growth objective. What this thesis is concerned with in this regard is how cycling innovations might contribute to this development. While EL-cycles represent a direct modal improvement, city bike schemes and improved cycling lane networks represent system improvements that affect the usability of cycles. Both of these are important to consider and have, through their respective assets, the potential to open up cycling for a wider number of travellers. The key for cycling's role in bringing about sustainable mobility is that it in any form develops as a covetable alternative to driving rather than absorbing trips from other sustainable modes of transport. Of the three modes this thesis examines more closely, cycling is also the one with the highest mass potential if current usage patterns are anything to go by. It is also the cleanest because while car-sharing and ridesharing both improve resource utilisation their use still stipulate that there necessarily will be cars on the road. Cycling does not.

## 3.4 Diffusion of innovative modes of transport

Considering the outlined aspects of innovations and assets tied to the three modes assessed above, the question still remains whether or how these can contribute to an uptake in the modes' ridership at the expense of car ridership. Earlier on, transition pathways, modal shifts and improvements were tied to the framework of MLP but considering a different and supplemental theoretical approach could also prove useful because the innovations made to car-sharing, ridesharing and cycling will not affect Oslo mobility if they are not adopted by the travelling public. Rogers' (2003) theory on diffusion of innovations (DOI) is a well-established framework that seeks to explain how an innovation over a period of time is diffused, i.e. spreads and adopts in a population. By adoption, DOI refers to the population doing something differently like, for example, change its travel behaviour by utilising an innovation over past modes of transport. The theory subdivides the population into five distinct categories of adoption illustrated in graph 3-1. These are *innovators*; *early adopters*, *early majority*, *late majority* and *laggards*. Rather self-explanatory, these categories of adopters are placed along the Gaussian curve. The sigmoid curve represents the growth in the innovation's market share as more and more people adopt it; reaching its saturation point when the last of the laggards have made a decision on whether to do so. Keeping these categories in mind, DOI sets out to explain how innovations spread in social systems and identifies five factors of influence:




*Graph 3-1: Rogers' (2003) diffusion of innovations. Source: Public domain*

1. *Relative advantage*: To what extent the innovation is perceived superior to what it sets out to replace

2. *Compatibility*: The innovation's consistency with the needs, values and goals held by potential adopters

3. *Complexity*: Whether the innovation is perceived hard to understand or use

4. *Testability*: To what extent potential adopters can test the innovation before having to commit to it

5. *Observability*: To what extent tangible results are provided by the innovation

(Rogers & Shoemaker, 1971)

These five factors can be thought of as a "checklist" for an innovation's potential of being successfully absorbed, but in addition to qualities associated with the innovation in and by itself DOI also assumes the social system in which it is applied. This sets the framework apart from MLP. The rate of adoption, according to DOI, is more dependent on the characteristics of social systems as well people's decision-making process. Well-developed communication channels, social norms allowing for change, and a relatively high socio-economic status are examples of societal traits identified that allow for innovations to take root and be adopted (Rogers E. M., 2003). That being said, which societal traits are the most beneficial is subject to continued interpretation and should not be treated as absolute. The DOI framework is, however, very clear on that *opinion leaders* and *agents of change* play a central role in driving forward the process of innovation adoption in a society. This can refer to policy-makers who push certain mobility developments as well as private individuals that through their networks are able to influence others. These are the ones with the ability to affect and change a society's established behavioural patterns that potentially amplifies the rate of adoption and influences the rate by which an innovation becomes accepted – or rejected, for that matter (Rogers E. M., 2003).

When assessing the potential for new and innovative modes of transport, DOI and MLP (cf. chapter 3.1.1) can be seen as complementary to one another. While MLP has a more systemic approach wherein a more constrained model-based framework is applied, DOI lends more focus on the more loosely defined and intangible workings of a social system and its actors. Both approaches have their strengths and weaknesses. MLP has, amongst other things, been criticised for subdividing the levels of model operation in a way that does not line up with empirical data and to be overtly focused on the role of niche innovations in bringing about shifts to the socio-technical system at play; ignoring the diverse origins of innovations (van Ewijk, 2013). The aforementioned lack of a geographical dimension is also a weakness when applying it to discuss mobility developments. DOI on its part has received criticism for being difficult to quantify and apply in measuring diffusion of innovations due to the complex and diverse nature of social systems and interactions (Katz, Levin, & Hamilton, 1963). Because of this, MLP and DOI's respective qualities and sum applicability to this thesis lie in combining the systemic frameworks of MLP with the actor-oriented focus of DOI. This allows for substantiating talking points on both the Oslo mobility system at large in terms of a socio-technical system, and its actors and their dynamics in terms of adopting or rejecting innovative modes of transport as successors to current mobility.

#### 3.4.1 The role of demographic differences for adoptability

When it comes to actor dynamics in mobility, one should consider whether various demographic groups can be shown to have stronger propensities towards some modes over others. After all, this thesis seeks to project demographic variances in reaching sustainable mobility. The question becomes whether there is empirical backing for saying that some age groups in general terms will more readily adopt new modes of transport than others. The reason for rising this question is that it might be tempting to assume from the get-go that the elder population is more reluctant to adopt new modes of transport; particularly modes whose innovative aspects lie in technological advances like car-sharing, real-time ridesharing or EL-cycling. Such blanket statements are, however, unhelpful and largely refuted (Olson, O'Brien, Rogers, & Charness, 2011). They also cut both ways. If one does assume that the younger demographic is more tech-savvy than the older, the younger demographic is still bound to have lower purchasing power and, oftentimes, willingness to pay then the older one which consequently limits the younger demographic's choices.

A better approach for indicating adoptability of innovations and adaptability in mobility might therefore be looking at to what extent different demographic groups previously have changed travel habits, particularly with respect to cars. A 2016 report (Nordbakke, Sagberg, & Gregersen) finds that young people in Norway (18–24-year-olds) obtain a driving licence at a lesser rate than before. In 1991, 80% of this demographic had a driving licence compared to 64% in 2014. As a partial consequence, the younger demographic is reported to have changed its travel habits significantly; moving away from car travel and towards public transport and walking in particular (TØI, 2012). The same cannot be said for portions of the “working” population. Males aged 35–45 residing in and around Oslo in particular are singled out as the population’s most eager drivers by the National travel survey. Still, this age group’s average number of daily car trips has been falling in recent years; by 2014 it was almost down at par with 1992 levels while public transport saw a roughly corresponding increase (TØI, 2012; Nordbakke, Sagberg, & Gregersen, 2016). This is in contrast with the development seen for the middle-aged demographic (45–65-year-olds) which has increased its average number of daily car trips over the same time period. This trend has been even stronger in the older demographic (65+ years) which saw an accelerating increase in the number of daily car trips by age. (Nordbakke, Sagberg, & Gregersen, 2016).

The latter find must be said to be worrisome for sustainable mobility in light of Oslo’s impending age wave, but it does not necessarily translate into increasing age equalling a stronger propensity towards car travel and unwillingness to adopt new modes of travel. One factor explaining it is found in that while the rate of driving licence obtainment is falling in the younger demographics, it is rising in the elder ones. Not because elders are taking more driving tests but because a generation for which car ownership became mainstream and vital for mobility is ageing (TØI, 2012). Old age does therefore not equal car-dependency, but current trends are likely a result of a car-dependent generation getting old. The fact that the current younger generation has shown stark changes in their travel pattern in recent years, obtain driving licences at a much lower rate than before, and that those who do drive do it less than past generations could indicate that when these people get old, current trends will reverse or stagnate. These sorts of long-line perspectives thus become rather important caveats for the goal of considering mobility developments as far into the future as the year 2040.

A related and important aspect to consider is groups across age divides whose mobility needs at present show strong propensities towards car travel which is indicative of low levels of adoptability for alternative modes of transport. Julsrud (2012) identifies three categories of car travellers who he argues will need differing paths in shifting their mobility patterns in a sustainable direction: Habitual car commuters for whom alternative modes of transport may or may not be available, frequent drivers who need a car to carry out their line of work or other duties, and locally-mobile elders who make use of a car for shopping or social calls in their local community. It is clear that these categories both cut across various age groups and that efforts in reducing their car dependency will need varying approaches. For example, building good commuting infrastructure does little to meet the travel needs of locally-mobile elders. This, again, also speaks against suggesting that it is a particular age group that will resist adopting new and innovative modes of transport and, in the context of DOI, make up the lion share of laggards. The complexity of the population's transport needs (or rather, its social systems) is therefore important to keep in mind when analysing and discussing pathways towards realising sustainable mobility.

### 3.4.2 Policy-steered modal shifts and rates of substitution

So far in this literature review, policy-makers have been identified as the main driving force behind changes in Oslo mobility which corresponds to the role of opinion leaders as per the DOI framework. In a mobility sense, the adoption of an innovation translates to a change in travel habits. From an MLP perspective, these changes are brought on by shifts to the socio-technical system amassing from pressures on it. Regardless, policy-makers do try to steer mobility patterns but the precision and success by which this is done is not always clear. For example, while an uptake in cycling is perceived beneficial for achieving sustainable mobility, this is only the case if it leads to a reduction in the number of car trips. Understanding rates of *diversion* or *mode substitution* is therefore important for any policy-maker. According to Fearnley, et al. (2016), the directionality of travel following an attribute (i.e. restriction) placed on a mode is relatively poorly understood and under-researched which also bleeds over in policy. Chapter 3.2 demonstrated that policy-makers often favour carrot-based measures to incentivise modal shifts but that these do not always have the desired effect. This was exemplified by pilot efforts offering free public transport having a near-zero effect on car traffic. Fearnley (2016) argues that directly targeting the mode policy-makers want to divert trips *from* is a better approach but finds that the rates of substitution will vary according to which mode is targeted and its relative *market share*. He finds that car demand is much less sensitive to attributes placed on public transport than the reverse. Moreover, a restrictive policy on car travel can be projected to cause a high percentage increase in public transport ridership if the initial modal share of public transport is low. In a way, these findings can be perceived as disheartening for Oslo mobility and the zero-growth objective because the public transport modal share is at present relatively high; almost at par with car travel. It might indicate, somewhat tendentiously, that those that are going to be substituted away from cars and onto public transport already have done so and that the car drivers reaming represent laggards and "the hardest case" in terms of sustainable mobility obtainment. On the other hand, car-sharing, ridesharing and cycling all have relatively low modal shares relative to cars. Continued restrictive policies on cars could therefore, following Fearnley's arguments, potentially transform these three modes of transport from niche innovations into more developed absorbents of future traffic growth – if mobility opinion leaders subscribe to the idea.

## 3.5 Summary

This literature review admittedly casts a wide net. It seems necessary however, as citywide mobility is dependent on a wide range of factors. To that end, two overarching and somewhat contrasting theoretical frameworks have been outlined to establish a world view for the discussion to take place in: Multi-level perspectives (MLP) that constitute a *systemic view* of Oslo mobility as a whole, and diffusion of innovations (DOI) that has a more user-oriented or *individual view* on how people might adopt changing travel behaviour. Through their respective assets, combining the two might prove beneficial in gaining a deeper theoretical understanding of mobility developments. In addition to theoretical frameworks, the empirical data presented throughout the literature review feeds into the discussion alongside the scenario results that will be presented in chapter 0. This includes the traits of various policies aiming for sustainable mobility, past policy experiences, the innovative and user-applicable characteristics of car-sharing, ridesharing and cycling, and empirical data on various demographics' rates of travel habits change.

Again, the analytical aspect of this thesis will happen through a two-step process. The first step is a quantitative analysis wherein current travel trends serve as a foundation for projecting future travel scenarios. This is an *exploratory* effort wherein the present is extrapolated into the future. The second step is where what has been gathered through this literature review comes into play. This step is *normative* in the sense that the present is disconnected from the past. A goal, sustainable mobility, is identified and the discussion seeks to back-cast analyse how this goal can become reality by drawing support from the empirical data and theories presented in this chapter. The latter step also leans on the findings in the first step. Exactly how, will be detailed in the following chapter.

# 4 Methodology

This chapter presents the overall methodology applied to answer this thesis' research questions. Beyond providing a rundown of methods employed in this effort, it also provides an account of the assessments made in choosing the final methodical framework and presents arguments for why certain approaches were chosen over others. It also aims at acknowledging potential weaknesses in the framework chosen while at the same time arguing why, in this thesis opinion, they provide the best possible framework of answering the research questions posed. The chapter starts by positioning this thesis within methodological frameworks and outlining its research design. It then continues to present and argue the data material used, before laying out how the scenarios are to be generated. Finally, it summarises the challenges and limitations associated with the chosen framework and argues how these have been overcome.

## 4.1 Research positioning and design

Because this thesis serves as a part of an ongoing research project and as an extension of a forthcoming article, much of its methodological framework is pre-determined. The thesis points of analysis are based on quantitative data generated by the National travel survey, which aims at generalising and describing people's travel habits by surveying a representative cross-section of the population. Due to the quantitative nature of the background data, a corresponding approach is necessarily warranted in this thesis. The largely pre-determined research topic and associated methodological frameworks mean that the process of positioning the two relative to one another proved rather straight-forward: The goal is to make use of a *quantitative approach* and to carry out *scenario analyses* upon which a *back-cast discussion* is conducted. What required much more work was deciding on how the scenarios were to be made, how the data should be processed and refined, and how to fill considerable data gaps to allow for making scenario projections. For these reasons, this chapter on thesis positioning and research design is kept relatively brief, while chapters 4.2 and 4.3 describing the process of working with the data material and how the scenarios are to be projected are given more attention.

As is evident by the research questions and research topic presented in chapter 1, this thesis aims at utilising current data on travel habits in Oslo as a starting point to project sustainable mobility trajectories by creating various scenarios that extrapolate how mobility will develop if nothing changes, and how a push towards zero-growth in car ridership could unfold. The scenario results then feed into a theory-based back-cast discussion on the applicability of car-sharing, ridesharing and cycling to further aid sustainable mobility obtainment in the years to come. Below, the methodological frameworks applied in reaching these goals are outlined and discussed before presenting and arguing the thesis' research data and means of analysis.

#### 4.1.1 Quantitative approach

Quantitative methods are characterised by being concerned with measurable numbers or statistics that serve as foundation for analysis. They differ from qualitative methods in that the former is concerned with measuring a greater number of data points and seeks to generalise the results they produce for a larger population, while the latter assumes more in-depth measurements of fewer data points and is more interpretive in nature (Befring, 2015). Seeing that this thesis' goal is to project mobility developments at a city-wide level spread across various demographic groups it became clear early on that a quantitative approach was warranted in this effort because the analysis rests on assuming a wide cross-section of the population.

What serves as the quantitative data material for this thesis is generated through surveys and has been pre-made by the Institute of Transport Economics (detailed in chapter 4.2.1). Surveying is one of the most commonplace quantitative research designs and is carried out by sampling a portion of a population who is then prompted to answer a series of questions (Tufte, 2011); in this case related to travel habits. The goal of a survey analysis is not to ascertain results related to the sample population but to generalise the results for a larger population (Tufte, 2011). It is therefore important that the sample is representative of said larger population. One pitfall in leaning on samples is that those surveyed might have biases that prove unrepresentative. This is particularly true if the sample surveyed is small compared to the population onto which results are to be generalised. A rule of thumb is therefore that the larger the sample, the lower is the potential for biases affecting generalisability (Skog, 2004). Ideally, of course, one would prefer that the sample includes the entire population that is to be assessed but this is rarely practically possible to achieve. The next best thing is therefore to aim for a representative sample which, in this case, is sought by choosing a random sample of the Norwegian population. The combination of having a large and randomised sample should provide a good foundation for securing its representativeness (Skog, 2004).

#### 4.1.2 Scenario analysis

The quantitative data material used in this thesis serves only as the starting point for analysis because it measures current travel habits, whereas the goal is to project future developments in travel and to identify potential pathways towards reaching sustainable mobility. Because this thesis assumes future scenarios of travel distribution it makes sense to use a framework of scenario analysis. The literature is however vague on exactly what the term "scenarios" means in a methodological sense as it has different applications across various fields and practices (Ramirez, Mukherjee, Vezzoli, & Kramer, 2015). While some scholars argue that scenario analysis is characterised by envisioning futures independent of past or current trends (also known as *alternative worlds*), others treat scenario analysis as a way of projecting developments in, for example, an economy wherein various growth factors are assumed that provide different scenario outcomes. Within research on transport planning and development, scenario-based approaches have become commonplace in recent years for projecting trajectories towards sustainable mobility in defined geographical areas (Shiftan, Kaplan, & Hakkert, 2003). This application of scenario analysis is useful because it provides a framework for dealing with the high levels of uncertainty associated with projecting travel developments into the future. Rather than letting this become a liability, scenario frameworks treat this insecurity as a means for exploring *scopes of opportunity*; illuminating potential trajectories and pitfalls in reaching the desired outcome (Wright, Bradfield, & Cairns, 2013). Such a framework sits well with this thesis' trajectory which is characterised by high levels of uncertainty with respect to making future projections.

According to Geurs & van Wee (2004), two types of scenario methodologies are often used in transport planning efforts: *projective* and *prospective*. The former refers to extrapolating current trends in the future, while the latter refers to identifying a future goal and assuming it will be met at some point leading up to the future. While there is no standard recipe for either, Geurs & van Wee (2004) argue that projective scenarios are characterised by "forecasting" while prospective ones are characterised by "back-casting". As is evident by this thesis' research questions, it aims for using a combination and variation of both by: 1) projecting how Oslo mobility will develop if nothing happens to current trends, 2) projecting obtainability of the zero-growth objective in light of mode substitution factors and simulated growth rates for sustainable modes, and 3) back-cast how demographics that prove difficult to shift onto sustainable modes might still achieve sustainable mobility. Put simply, the analytical structure can be summarised as:

1. Extrapolations of current trends into the future (*where are we going?*)

2. Providing alternative trajectories towards goal obtainment through scenarios (*where will we go if certain constraints are introduced to the current trajectory?*)

3. Back-casting how solutions can theoretically become reality by connecting the desired outcome to the present (*Where do we actually want to go and how can we get there?*)

#### *4.1.2.1 Extrapolations of current trends: BAU scenarios*

Extrapolation refers to estimating or determining a function's value beyond its known range. In this context, it refers to the projections made in the business as usual (BAU) scenarios. They seek to estimate how Oslo mobility will develop if current mobility trends remain constant by assuming projected population growth. In essence, they serve as reference points and identify the mobility issues Oslo is likely to face if "nothing" is done to achieve sustainable mobility. BAU scenarios are often included in scenario-based studies to draw attention to forecasted problems and to underscore the necessity for change (Kosov & Gaßner, 2008).

#### *4.1.2.2 Providing an alternative scenario: Zero-growth*

The zero-growth objective scenarios provide a more sustainable alternative to the BAU scenarios. A goal, as per Geurs & van Wee's (2004) prospective approach has been identified, namely zero-growth in car traffic and substitution onto public transport, walking and cycling. However, unlike the framework for prospective scenarios outlined above, the zero-growth scenarios are still dependent on projections because they seek to illuminate disparities in goal obtainment between different demographic groups. This is done by introducing mode substitution factors between the various modes of transport and setting growth rates for the different modes wherein sustainable modes of transport (public transport, walking and cycling) are set to grow at the expense of unsustainable modes (cars) (see chapters 4.3.1 through 4.3.3). The points of analysis in these scenarios are that while the zero-growth objective and the growth rates plotted to get there remain constant across demographic divides, their differing travel habits, projected population growth and rates of modal substitution mean that the obtainment of zero-growth in car traffic will be significantly more difficult to achieve for some demographics than for others. Identifying these disparities is one of this thesis' core contributions, and as such needs to be illuminated by leaning on projective estimations in addition to putting forward a prospective goal to obtain.

#### *4.1.2.3 Back-casting analyses: Discussion*

Back-casting is a term coined by Robinson (1982) which describes the process of first identifying a desirable future (i.e. sustainable mobility) and then analysing "backwords" in time to pinpoint interventions (policies, socio-technical shifts, innovations etc.) that can make this future become reality. The projection-based zero-growth scenario outputs identify disparities in ease of goal obtainment between demographic groups which warrant a discussion on the potential of goal obtainment for all. In other words, the discussion chapter seeks to assess if it is possible to fill the disparities projected by the scenarios by back-casting the theoretical applications of car-sharing, ridesharing and cycling atop the substitutions made in the zero-growth scenarios. This is done by leaning on the theoretical and empirical findings presented in chapter 3.

In transport planning, back-casting is increasingly being used as a prospective tool to navigate complex futures and to analyse them more broadly than the more formalised structures scenario modelling allows for (Dreborg, 1996). For this thesis, it translates into leaning on the theoretical insights gained through the literature review which will complement the scenario analyses since the latter is based for the most part on travel survey data. The present mobility situation is therefore a deciding factor in the scenarios as it represents their starting points. In the back-cast discussion on the other hand, the future is more disconnected from the present and the starting point is sustainable mobility. As a methodology, back-casting is used in a variety of ways and is not as prescriptive in format as for example scenario projections. It is more normative, and the idea of the desired future is the main thing that matters (Dreborg, 1996). Moving backwards in time from this desired future and towards the present, back-casting involves analysing the consequences and feasibility of certain choices in making the desired future come true. This approach allows for discussing what actions needs to be taken at various stages towards the goal; both now so as to steer development towards the desired outcome and later down the timeline (Dreborg, 1996).

It is worth noting that a back-casting discussion was not originally planned as part of this thesis' research design – instead, the scenario projections were to be the sole analytical framework. However, due to lack of mobility data on modes like car-sharing and EL-cycling, their scenario data inputs had to be largely estimated (discussed at length in chapter 4.2.2). This means that the scenario outputs for these modes are characterised by a higher level of uncertainty than what is the case for other modes. This, in combination with the desire to also consider their innovative aspects led to the inclusion of a back-casting discussion as an expansion atop the scenario results. This means that the future applications of car-sharing, ridesharing and innovative subsets of cycling first come into play in the discussion chapter because the scenario projections for these modes hold lower levels of validity than the other modes. The back-cast discussion thus serves as an effort in increasing the validity of projecting these modes' applicability in future mobility. An added benefit of including this discussion is also that it distinguishes this thesis from the forthcoming article wherein the scenarios also will be presented, as well as allowing for positioning the thesis closer to core concepts and theories treated in the master's programme in Entrepreneurship, Innovation and Society.

The different approaches associated with the three methods presented above are in summation illustrated in figure 4-1 which is compiled from Robinson (2003). *Forecasting* corresponds to the BAU scenarios. They project a likely future development if current mobility trends remain constant towards 2040. *Scenarios* corresponds to the zero-growth scenarios. Here, alterations to the current mobility trends are introduced to project which alternative futures they might lead to. *Back-casting* refers to just that; the discussion wherein the goal of sustainable mobility is being considered the starting point and assessments are made for how mobility can get there. Making use of all three approaches for analysing the same goal will both broaden and deepen the analytical structure and hopefully provide a thorough framework for assessing Oslo's sustainable mobility future.

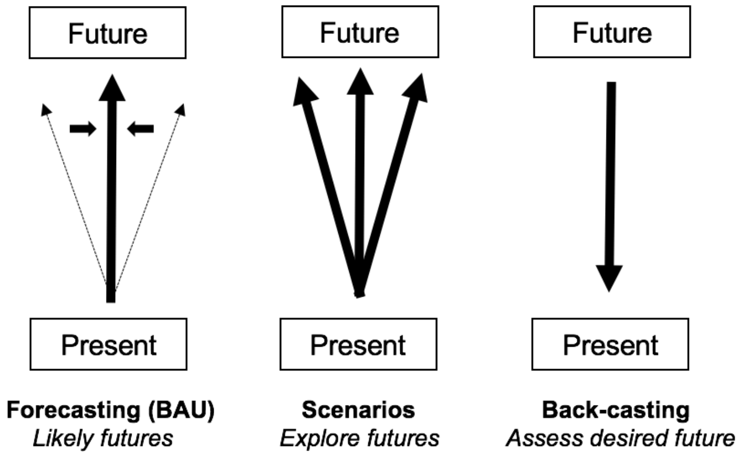



*Figure 4-1: Forecasting, scenarios and Back-casting from Robinson (2003)*

## 4.2 Research data

A key requirement for this thesis is reliable quantitative data material of current mobility in Oslo. This chapter lays out the data used in this pursuit, explains how it has been tweaked and expanded on to suit this thesis' research needs, how it has been prepared in order to serve as the foundation on which scenarios of future mobility in Oslo are generated, and which assets and weaknesses this data material encompasses.

### 4.2.1 Base-data source: RVU 2013/14

The national travel survey (RVU) has been published every four years since the 1985 by the Institute of Transport Economics. The report is based on interviews and surveys of a representative portion of the Norwegian population above the age of 13 on access to various modes of transport, the number of trips conducted on each of them, trip lengths on a given day, the number of long trips conducted over the last month, as well as general characteristics of respondents' households, incomes and work positions. Respondents were randomly selected from the National Population Register and interviewed over the phone by TNS Gallup[3]. For the 2013/14 report, 61,314 respondents were interviewed. According to the report, 10,000 of these constitute a representative cross-section of the general Norwegian population while the remaining respondents constitute regional supplementary samples. In Greater Oslo alone, 13,800 interviews were conducted. (Hjorthol, Engebretsen, & Uteng, 2014). RVU enjoys solid recognition as the chief document in assessing the overall state of transport habits in Norway. The report is commissioned and financed by Avinor, Jernbaneverket, Kystverket, Statens vegvesen and the Norwegian Ministry of Transport and Communications (Hjorthol, Engebretsen, & Uteng, 2014). Its findings are also referred to by NTP (2017) and serve as foundational in NTP's assessments of future travel needs and planning. The inclusion of RVU's findings in this key governmental document as well as recognition from the main transport actors in Norway more than satisfies this thesis in trusting RVU's reliability and validity for measuring current transport habits in Norway in general and Oslo in particular.

To help provide a more in-depth analysis, the Institute of Transport Economics has provided this thesis with more detailed data than what is presented in the publicly available RVU report. This includes reporting on the mean number of daily trips for people in Oslo on various modes across age cohorts and genders. The modes covered by this data set are cycling, walking, scooter, car, car-passenger and public transport.

[3] The RVU interview guide is publicly available as an appendix to (Hjorthol, Engebretsen, & Uteng, 2014)

*Table 4-1: RVU background data on daily trips (aggregate level, all trips lengths)*

| OSLO, MALE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Agegroup | | Mean trips | Cycle trips | Walking trips | Scooter trips | Car trips | Car-passanger trips | Public transport trips |
| 13-17 | Mean | 2,67 | ,24 | 1,17 | ,03 | ,08 | ,41 | ,71 |
| 18-24 | Mean | 3,11 | ,08 | 1,18 | 0,00 | ,38 | ,17 | 1,28 |
| 25-34 | Mean | 3,46 | ,24 | 1,26 | ,01 | ,84 | ,14 | ,91 |
| 35-44 | Mean | 3,37 | ,23 | 1,07 | ,01 | 1,36 | ,04 | ,62 |
| 45-54 | Mean | 3,20 | ,25 | ,81 | ,02 | 1,47 | ,04 | ,54 |
| 55-66 | Mean | 3,21 | ,13 | ,90 | ,00 | 1,54 | ,07 | ,53 |
| 67-74 | Mean | 2,97 | ,10 | ,83 | ,01 | 1,49 | ,08 | ,44 |
| 75 + | Mean | 2,49 | ,13 | ,66 | 0,00 | 1,08 | ,11 | ,45 |
| Total | Mean | 3,21 | ,19 | 1,03 | ,01 | 1,12 | ,10 | ,72 |

Table 4-1 shows an excerpt of the data set provided by the Institute of Transport Economics when plotted in a spreadsheet. The far-left column designates the different age cohorts and "mean trips" refers to the mean number of daily trips each person within a particular age cohort is expected to conduct on any given day. In this case, it denotes the aggregate for all trip lengths. The numbers plotted for the various modes refer to each mode's share of the total number of mean trips within a particular age cohort. To gain practical application, these numbers need to be combined with population figures for Oslo. To that end, Statistics Norway provides up to date population data and future projections subdivided by gender and age[4]. This in sum allows for estimating the number of daily trips in Oslo on various modes for the different age cohorts. For example, table 4-1 shows that the mean number of daily cycling trips for men aged 25–34 was 0.24. The male population in Oslo within that age cohort was 69,503 in 2016. Thus, it is possible to project $69{,}503 \cdot 0.24 = 16{,}680.72$ total daily cycling trips conducted by men within the 25–34-year-old age cohort in Oslo.

There is one potential pitfall in leaning on Oslo population data because it does not take into account the trips of non-residents; notably commuters. This can potentially lead to an underrepresentation of actual trips conducted within Oslo at a given day. At the same time an overrepresentation is also possible because the entirety of Oslo's registered population is not likely to be present or travel normally on any given day. Still, seeing that the RVU data applied is based on Oslo-specific responses to the survey it makes sense to consider this population rather than including others as well. Doing so would certainly lead to a gross overrepresentation

[4] Statistics Norway table 11168: Population projections 1 January, by sex and age, main alternative (MMMM) (UD) 2016– 2040

of total trips conducted and because the goal is an overall assessment of Oslo mobility, assuming its population's mobility needs makes the most sense. This, however, means that the scenario results must be treated at projections of the Oslo population's mobility.

### 4.2.2 Estimating mobility in modes not assessed by RVU

RVU provides important baseline-data information but it does not cover all the modes that are of relevance for this thesis. Firstly, it does not allow for differentiating conventional cars from electric ones. This is admittedly less important when projecting mobility far into the future because one could assume the rate of substituting fossil-fuel driven cars with electric cars or cars running on other clean fuel sources will be dependent on a very high number of external factors; all of which this thesis' framework does not allow accounting for. Moreover, because the zero-growth objective applies to all cars, fossil-fuelled or otherwise, distinguishing the two becomes less important in the projections of scenarios towards the NTP goal meaning cars can be treated as a whole (this will be discussed further in chapter 5.3). Still, electric cars play an important role in Oslo mobility today and it therefore makes sense to illuminate their role in isolation, at least in the short term. Much of the same applies to electric cycles, which constitute an important innovation to the cycling mode and opens it up to be used in a broader range of trips, as discussed in chapter 3.3.3. Initial differentiation between the two could therefore be an asset aiding the back-casting discussion on the mode's potential. Lastly, car-sharing also needs to be included in the data set as it is one of the main modes this thesis seeks to discuss later on.

The Institute of Transport Economics was able to provide estimations for all three modes' rates of mobility by pooling data from various internal sources. This has made it possible to expand on the data set shown in table 4-1. How, is reported in full in appendix B. However, the reason EL-car, EL-cycling and car-sharing is not included in the RVU data to begin with is that comparatively little is known about their usage, and particularly how it is distributed across demographic groups because they all account for very limited shares of overall mobility. Therefore, the underlying data material supporting rates of mobility in EL-car, EL-cycling and car-sharing is weaker than the data material for the other modes, as it is based on fewer observations. This brings with it a level of uncertainty and it could be argued that by including these estimations, the RVU data material becomes diluted and loses some of its reliability. This is a valid concern. However, it is not the case that including these estimations add more trips to overall mobility. EL-car and car-sharing trips represent a *subset share* of overall car trips, while

EL-cycling represent a share of overall cycling trips. In other words, the estimations are included as subdivisions of a "parent mode". This is useful because it secures the option of re-merging the modes and to both consider overall car and cycling as well as the subset estimates – in both cases the same number of trips are produced. Including the estimations in this way also means that the remaining modes remain unaffected in terms of mobility output and that their RVU reliability remains intact.

Still, it is important to note that the scenario outputs for EL-car, EL-cycling and car-sharing are characterised by a higher level of uncertainty than the outputs for the modes supported by RVU data. Seeing that the latter two are amongst the modes this thesis sets out to consider more closely, their data gaps are not ideal. However, because the means of discussion related to car-sharing, ridesharing and cycling in this thesis are theoretical and applied *atop* the scenarios, these data gaps can hopefully be abridged. As will become apparent by the scenario results, neither of them project that these modes will constitute a large part of overall mobility because of their initial low modal share. The potential of these modes really first comes into play in the discussion chapter, where their applications for demographics that are projected to be hard to shift away from car travel are discussed based on theoretical underpinnings rather than travel survey data. Including them in the scenarios still makes sense though, as their current and projected market shares also serve as points of discussion.

#### 4.2.3 Considering different trip lengths

The initial aim of this thesis was to consider all trips in Oslo at the aggregate level. This, however, proved to generate a shallow foundation for analysis. The main problem was that the applications of the various modes vary greatly in distance. Car trips, for example, can be expected to constitute a greater percentage of long-distance trips than short-distance ones while the reverse can be expected in walking. These and other nuances disappear when treating mobility at an aggregate city-wide level and since it is precisely these nuances this thesis sets out to explore in filling sustainable mobility voids through car-sharing, ridesharing and cycling, a more detailed approach is needed. The solution became to differentiate mobility and subsequent scenario projections by trip length. This was made possible by the Institute of Transport Economics having in-depth data from the travel survey whose questions also differentiate by trip length. Although intended as internal data material for research use, they were kind enough to share this data for the purposes of this thesis.

The RVU data provided is identical in form to that shown in table 4-1, but rather than assuming all trips in Oslo at the aggregate level it is subdivided for three different trip length intervals: short (≤ 2.5 km), medium (2.5–7.5 km) and long (> 7.5 km). As expected, this subdivision produced vastly different number of mean trips across modes between the different trip lengths. It also allows for gaining insight in demographic differences in car dependency at various trip lengths and also which demographics are more prone to active modes and public transport.

This change of background data material had few implications for the trajectory of this thesis' analysis and points of discussion beyond expanding it to three different scenarios rather than just one. As for the estimations of EL-car, EL-cycling and car-sharing's share of RVU mobility, the Institute of Transport Economics has provided estimates in the same fashion outlined in chapter 4.2.1 subdivided for the various trip lengths.

#### 4.2.4 Factoring in varying accessibility

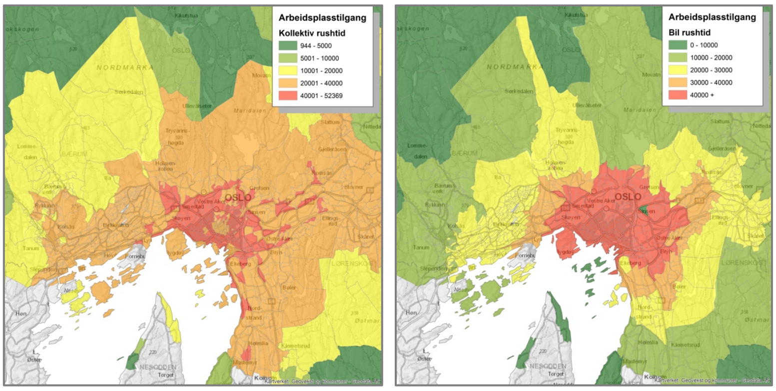



*Figure 4-2: Maps illustrating workplace access during rush hour in Oslo for public transport (left) and car (right). Source: Rambøll*

Considering different trip lengths also allows for the inclusion of an additional tool as foundation for discussion. While the main analytical backdrop will be the theoretical and empirical underpinnings presented in chapter 0, it also makes sense to consider the practical applications of the modes to be assessed in terms of accessibility. This is because much of the potential of car-sharing, ridesharing and cycling is assumed to be found where public transport comes up short in providing a good level of transport utility. For use in the article upon which this thesis expands (Uteng, George, Throndsen, Uteng, & Maridal, 2018), consulting engineering firm Rambøll has provided a series of maps that show current workplace accessibility for all the basic statistical units (*grunnkrets*) in Oslo. Two of these are shown in figure 4-2 and are colour-coded corresponding to the number of workplaces people have access to within one hour of travel by using the various modes. Workplace access is a good measurement and predictor of transport needs because travelling to and from work is something a large portion of the population does every day. Many places of work also have a function for people not employed there and are visited frequently. Trips to, for example, hospitals, banks and stores all generate a considerable amount of traffic. The level by which a mode provides access to these workplaces for a specific geographical area is thus indicative of the level of utility it provides.

While these maps constitute a more central part of the analysis in the aforementioned article, they will be treated as a supplement to the discussion in this thesis. They allow for talking points on where in Oslo, geographically, car-sharing, ridesharing and cycling might provide a good level of utility as an alternative to public transport, albeit based on current workplace accessibility distribution. This is because for all practical purposes, accessibility gained by car-sharing and ridesharing would mirror that of conventional car accessibility while a separate map has been generated for cycling. Because the data material is subdivided into short, medium and long trips, arguments could be made on, for example, which of the three new modes would provide the best level of utility between certain points in the city based on the information provided by the maps. Still though, the main foundation for discussion will be theoretical.

#### 4.2.5 Background data summary

The above encompasses the building blocks made available for analysing future mobility. The foundational background data set is that provided by the Institute of Transport Economics: RVU reporting on the number of daily trips carried out on various modes by different age cohorts and genders. This data set has been further subdivided to allow for considering three different trip lengths: short (≤ 2.5 km), medium (2.5–7.5 km) and long (> 7.5 km). To account for a broader range of modes in the analysis, the current mobility of EL-car, EL-cycling and car-sharing has been estimated and included into the data set. Lastly, maps depicting current workplace accessibility in Oslo have been introduced for use as tools for further discussion. The theoretical framework and empirical data presented in the literature review also feed into the discussion that follows the presentation of the scenario results.

## 4.3 Constructing the scenarios

Current mobility is foundational, but only the starting point as the goal is to project future mobility scenarios. What has been accounted for thus far will be utilised in a model to project scenarios of transport development in Oslo towards the year 2040. This chapter explains the workings of this model, what the different scenarios encompass and seek to achieve, and the means by which they are created.

### 4.3.1 The DEMOTRIPS model

DEMOTRIPS is a macro-based prognosis model integrated with Microsoft Excel. It can be used to forecast developments in travel trends based on current mobility figures, projected demographic developments in Oslo and the potential for changes in travel behaviour. It has been developed by André Uteng at consulting engineering firm Rambøll to be applied in scenario-making for articles within the SHIFT research project. The model makes projections using four main points of data:

1. Current mobility data, i.e. the RVU data set combined with the mobility estimations for EL-car, EL-cycling and car-sharing

2. Population figures for Oslo subdivided by gender and age cohorts, as well as Statistics Norway's projected population development towards the year 2040

3. *Mode substitution factors* between the various modes of transport for all age cohorts and genders (detailed in chapter 4.3.2)

4. A *logistical growth model* that considers *capacities* and *growth rates* for the various modes (detailed in chapter 4.3.3)

*Table 4-2: Current mobility data as plotted in DEMOTRIPS*

| MEN | Cycle | Walking | Car | Car-passenger | El-Car | Car-sharing | Public Transport | El-cycle |
|---|---|---|---|---|---|---|---|---|
| 15-19 | 0,234688 | 0,7838 | 0,1505216 | 0,7568 | 0,0111918 | 0,0004866 | 1,2162 | 0,008512 |
| 20-24 | 0,0715065 | 1,2135 | 0,4410784 | 0,2284 | 0,0327957 | 0,0014259 | 1,6754 | 0,0025935 |
| 25-29 | 0,2270645 | 1,0945 | 1,0336992 | 0,1716 | 0,0768591 | 0,0033417 | 1,085 | 0,0082355 |
| 30-34 | 0,2270645 | 1,0945 | 1,0336992 | 0,1716 | 0,0768591 | 0,0033417 | 1,085 | 0,0082355 |
| 35-39 | 0,265182 | 0,9084 | 1,5797344 | 0,0458 | 0,1174587 | 0,0051069 | 0,7672 | 0,009618 |
| 40-44 | 0,265182 | 0,9084 | 1,5797344 | 0,0458 | 0,1174587 | 0,0051069 | 0,7672 | 0,009618 |
| 45-49 | 0,311309 | 0,682 | 1,7063136 | 0,0415 | 0,1268703 | 0,0055161 | 0,6313 | 0,011291 |
| 50-54 | 0,311309 | 0,682 | 1,7063136 | 0,0415 | 0,1268703 | 0,0055161 | 0,6313 | 0,011291 |
| 55-59 | 0,1338455 | 0,7857 | 1,836512 | 0,0882 | 0,136551 | 0,005937 | 0,6639 | 0,0048545 |
| 60-64 | 0,1338455 | 0,7857 | 1,836512 | 0,0882 | 0,136551 | 0,005937 | 0,6639 | 0,0048545 |
| 65-69 | 0,105571 | 0,6094 | 1,8270464 | 0,1094 | 0,1358472 | 0,0059064 | 0,6172 | 0,003829 |
| 70-74 | 0,105571 | 0,6094 | 1,8270464 | 0,1094 | 0,1358472 | 0,0059064 | 0,6172 | 0,003829 |
| 75+ | 0,1670415 | 0,5577 | 1,4098176 | 0,1731 | 0,1048248 | 0,0045576 | 0,6923 | 0,0060585 |

The main mechanism by which DEMOTRIPS projects daily trips is similar to that exemplified in chapter 4.2.1: The RVU reporting in addition to the estimations on mean number of trips on each mode is multiplied by population data. Table 4-2 illustrates how mobility is plotted in

DEMOTRIPS. Note that the values in this table differ from those shown in table 4-1. This is because the scenarios are subdivided by trip length, meaning the aggregate mean number of daily trips for each age cohort (shown in table 4-1) is spread across long, medium and short trips in accordance with the distribution provided by the Institute of Transport Economics. Table 4-2 also includes the estimated mobility for EL-car, car-sharing and EL-cycle which is plotted in the same format as the mobility data derived from RVU. The population data is plotted in a similar fashion, with the different age cohorts on the vertical axis and the projected population number for each cohort at any given year towards 2040 on the horizontal axis. The population data plotted corresponds to what Statistics Norway refers to as the *main alternative* for population development. This involves medium growth in population fertility, life expectancy, internal migration and immigration (Statistics Norway, 2016). In other words, it is a modest projection which is well suited for use in this context because it is less likely to produce inflated figures of mobility than more steep population projections. The projections used are included in full in appendix A.

While the population data changes from year to year and thus causes the number of trips projected to do the same, the mean number of trips per capita (table 4-2) remains constant. This is in and by itself fine for projecting how mobility will develop if travel habits do not change (cf. the BAU scenarios in chapter 5.2) but it is not adequate when the goal is to project changing travel behaviour scenarios that push towards sustainable mobility. Therefore, DEMOTRIPS includes three more factors that affect the number of daily trips it produces:

*Table 4-3: Mode substitution factors in DEMOTRIPS*

| **Oslo** | **Walking** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenger | El-Car | Car-sharing | ublic Transpo | El-cycle |
| 15-19 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 20-24 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 25-29 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 30-34 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 35-39 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 40-44 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 45-49 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 50-54 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 55-59 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 60-64 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 65-69 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 70-74 | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |
| 75+ | -0,3 | 1 | -0,05 | -0,3 | -0,05 | -0,05 | -0,2 | -0,05 |

Beyond multiplying population figures with modal share data, mode substitution factors can be added to DEMOTRIPS which influence the model's output. Mode substitution factors refer to the rate by which ridership on a mode is reduced following an increase in ridership on a different mode. Table 4-3 illustrates how this may be plotted in DEMOTRIPS and shows what happens if walking increases by one (1) trip. Here, it will be met by a corresponding decrease of 0.3 cycling trips, -0.05 car, -0.3 car-passenger, -0.05 EL-car, -0.05 car-sharing, -0.2 public transport and -0.05 EL-cycling. In this example the increase in walking trips (1) are exactly countered by the sum of the negative transfers from other modes (-1) which means that no additional trips are added in total, but when walking trips are increasing it is happening at the expense of other modes. Identical panels as the one shown in table 4-3 are also made for the other modes, in which they increase at the expense of one another. These mode substitution factors thus add a layer of interaction between the various modes; essentially providing a tug-of-war between them in the sense that while an increase in walking is set to reduce cycling, an increase in cycling is also set to reduce walking by a certain amount. In practice, this means that the actual growth generated by the mode substitution factors in, for example, walking from one year to the other equals the sum of negative transfers from competing modes *minus* the sum of negative transfers from it onto competing modes.

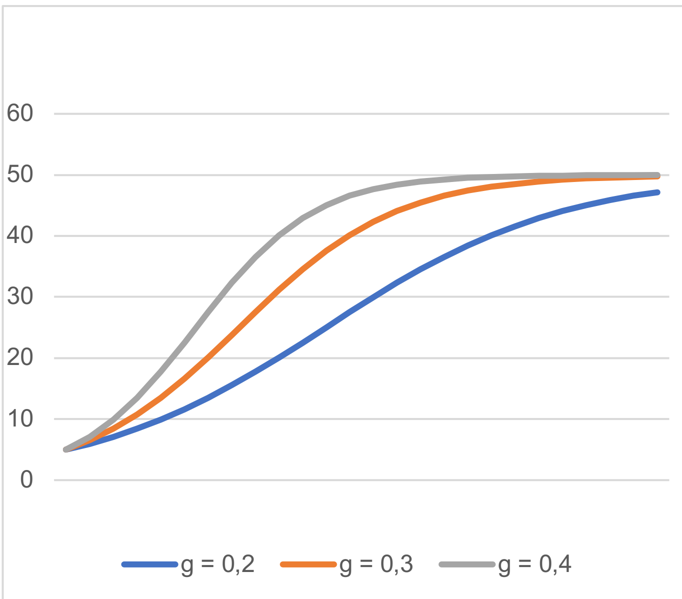
The inclusion of these mechanisms in DEMOTRIPS is based on the rationale that people indeed do switch between modes of transport. For example, if a person who normally commutes to work by car for whatever reason switches to using public transport it represents a public transport trip gained at the expense of a car trips. In other words, when people change their travel habits and adopt new modes of transport, the increased ridership observed in the new mode has to come from somewhere. This can conceivably be from either population increases, increased travel frequency within a population, or modal substitutions. Population increases are, as mentioned, already factored into the model framework. As for increasing travel frequency, the average number of daily trips across the population has proven remarkably stable over time. From 1992 to 2014, all RVU reports have put the population's average mobility within the range of 3.03 to 3.3 daily trips, with the most recent RVU reporting an average of 3.26 (Hjorthol, Engebretsen, & Uteng, 2014). That leaves mode substitutions as an important factor explaining changing ridership figures on various modes which warrants its inclusion in a model framework used to project future mobility.

Beyond the rationales for inclusion mentioned above, considering mode substitution factors is also important in order to allow for projecting scenarios of sustainable mobility because in such scenarios, what is being projected is precisely growth in certain modes at the expense of others. NTP's zero-growth objective, for example, states that public transport, walking and cycling should absorb all future car traffic growth. This means that it is necessary to account for the relationships between the modes and assess how changes in one mode's use will interact with the others. The reasoning behind the relationships that are plotted in DEMOTRIPS to generate the scenarios for this thesis are provided in in chapter 4.3.2 and reported in full in appendix C.

*Table 4-4: Yearly growth rates and capacities in DEMOTRIPS*

| Yearly Growth-rate (%) | Cycle | Walking | Car | Car-passenger | El-Car | Car-sharing | Public Transport | El-cycle |
|---|---|---|---|---|---|---|---|---|
| Youth (Age: 13-17) | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Students (Age: 18-24) | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Workers (Age: 25-66) | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Elders (Age: 66 +) | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| | | | | | | | | |
| | Cycle | Walking | Car | Car-passenger | El-Car | Car-sharing | Public Transport | El-cycle |
| **Capacity Oslo** | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % | 0,00 % |

There are also two more factors available in DEMOTRIPS that affect the overall development of the scenario projections. As shown in table 4-4, this includes *yearly growth rates* for each mode and their *capacity* in terms of overall mobility share. Paired with the current mobility data (RVU + estimates) they make up a logistical growth model for each mode. Setting a yearly growth rate for the different modes is important when projecting scenarios where certain modes (car) are not to have increased ridership while others (public transport, walking and cycling) are. Cars can, for example, be given a growth rate of zero while the modes the scenarios want to steer a shift towards can be given a higher growth rate. It can also be varied between the different demographics. This is useful for projecting shifts within age cohorts currently having high levels of car ridership and therefore need stronger growth rates in public transport, walking and cycling to meet the zero-growth objective. The capacities for




*Graph 4-1: Different growth rates towards same capacity*

the various modes represent their end-point in terms of overall modal share, and the growth rates determine how fast that end-point is reached. Graph 4-1 illustrates the relationship between the two. Here, three modes are given different growth rates but they all grow towards the same capacity. The higher the growth rate, the faster a mode reaches its capacity at which point the modal growth stagnates, as represented by the sigmoid curves. Simply put, the practical application of this logistical growth model in DEMOTRIPS is that the capacity of a mode refers to its target overall modal share in the future while its growth rate determines how fast a mode reaches that goal. Mathematically, the model is expressed as:

$$MS(t) = \frac{C}{1 + \left[\frac{C}{MS(0)} - 1\right] e^{-g*t}}$$

Where $MS$ refers to the current modal share, $C$ to the desired capacity, $g$ to the growth rate plotted and $t$ to time in years. The reasoning behind the growth rates and capacities plotted in DEMOTRIPS to generate scenarios for this thesis are laid out in chapters 5.3.1 through 5.3.3.

DEMOTRIPS uses the logistical growth model to estimate a future growth path for each mode which determines the projected growth in terms of number of daily trips on each of them towards the year 2040. Though when combined with mode substitution factors, the actual growth and modal distribution projected is also dependent on these as well because they transfer trips between the modes. Therefore, when combining with mode substitution factor data, the logistical growth model in essence 1) steers the direction of modal growth based on how the capacity plotted deviates from the mode's current modal share, 2) determines the relative growth of the modes towards the capacities set for them, which in turn 3) causes the mode substitution factors to kick in and transfer trips between all the modes based on their relative growth in number of trips.

To summarise the above accounted for workings of DEMOTRIPS: Current mobility data (RVU reporting + estimates) are multiplied with population data and projections to generate the number of daily trips for various demographics towards the year 2040. If a certain development is to be projected, in this case trajectories towards zero-growth in car traffic, the logistical growth model and mode substitution factors are applied as well. The former consists of a specific growth rate for each mode as well as a capacity (target) modal share for each of them to grow towards. The latter consists of a set of substitution factors between the various modes wherein growth in one mode's ridership happens at the expense of others; simulating people switching between various modes of transport. Taking all this into account, DEMOTRIPS outputs a mobility scenario that projects the mean number of daily trips each demographic is set to conduct on the various modes towards the year 2040.

*Table 4-5: Example of DEMOTRIPS scenario output for the development in car trips. 2016–2040*

| car trips men | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|
| 15-19 år | 184,78356 | 187,50381 | 191,8683 | 197,09118 | 200,05323 | 202,85811 | 207,65784 | 213,44895 | 217,16058 |
| 20-24 år | 1376,28506 | 1379,83955 | 1381,68026 | 1396,91378 | 1410,0527 | 1415,70179 | 1418,11377 | 1424,90538 | 1444,20117 |
| 25-29 år | 13955,6363 | 14398,3188 | 14825,2057 | 15018,8033 | 15074,6955 | 15069,4303 | 15064,5701 | 15045,1294 | 15067,8102 |
| 30-34 år | 14194,1907 | 14605,282 | 14898,1085 | 15273,5584 | 15708,5456 | 15999,7521 | 16270,3028 | 16535,9932 | 16622,2617 |
| 35-39 år | 11756,1218 | 11935,8826 | 12234,8241 | 12449,0325 | 12576,924 | 12705,6075 | 12859,2357 | 12960,5986 | 13175,5989 |
| 40-44 år | 10303,3849 | 10477,6024 | 10525,9082 | 10610,6413 | 10614,9967 | 10673,5972 | 10708,4407 | 10857,7135 | 10964,6197 |
| 45-49 år | 10069,7052 | 10281,5225 | 10555,5611 | 10723,6911 | 10883,8779 | 10953,6011 | 11018,4701 | 10977,4305 | 11004,349 |
| 50-54 år | 8779,38497 | 9054,74743 | 9218,90583 | 9439,10754 | 9582,52549 | 9798,75563 | 9957,1773 | 10172,9662 | 10285,9354 |
| 55-59 år | 9667,89995 | 9787,72425 | 9987,24303 | 10192,4139 | 10465,9751 | 10642,3203 | 10956,5765 | 11152,1388 | 11411,5697 |
| 60-64 år | 8014,66362 | 8200,05217 | 8390,52761 | 8599,65494 | 8754,5222 | 8979,47538 | 9091,95197 | 9268,86239 | 9457,6422 |
| 65-69 år | 4186,16348 | 4070,50413 | 4030,13549 | 4009,63079 | 4049,67904 | 4135,86287 | 4230,05636 | 4331,29833 | 4438,94803 |
| 70-74 år | 2988,24022 | 3387,76156 | 3631,57531 | 3765,17627 | 3786,32175 | 3790,16638 | 3689,24479 | 3656,24503 | 3642,46843 |
| 75+ | 1608,90093 | 1638,85995 | 1698,90494 | 1793,09813 | 1926,39038 | 2046,09951 | 2213,66691 | 2348,99028 | 2478,60113 |

| car trips men | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
|---|---|---|---|---|---|---|---|---|
| 15-19 år | 221,04147 | 224,20905 | 226,04673 | 226,17972 | 223,77381 | 221,67015 | 220,13472 | 219,08289 |
| 20-24 år | 1452,77002 | 1461,14846 | 1482,66581 | 1512,81548 | 1535,03103 | 1557,24658 | 1576,92321 | 1585,04776 |
| 25-29 år | 15127,3476 | 15142,7382 | 15075,1005 | 15025,2836 | 15086,036 | 15090,4911 | 15097,7814 | 15250,0674 |
| 30-34 år | 16654,6629 | 16677,3438 | 16702,0498 | 16695,5696 | 16687,4692 | 16723,5157 | 16721,0856 | 16608,0861 |
| 35-39 år | 13495,5257 | 13771,1062 | 14023,3257 | 14260,8951 | 14342,8566 | 14375,3244 | 14392,3502 | 14407,7922 |
| 40-44 år | 11051,3325 | 11161,4064 | 11311,0751 | 11415,2097 | 11615,5599 | 11896,2877 | 12143,7558 | 12365,0913 |
| 45-49 år | 10986,2563 | 11040,5344 | 11077,1612 | 11228,5223 | 11332,6658 | 11417,834 | 11529,038 | 11678,634 |
| 50-54 år | 10399,3459 | 10443,0332 | 10472,1581 | 10402,4349 | 10401,5523 | 10371,5449 | 10405,9652 | 10435,09 |
| 55-59 år | 11593,0018 | 11838,3025 | 12017,4738 | 12260,5136 | 12374,1206 | 12478,6843 | 12508,6404 | 12503,5535 |
| 60-64 år | 9707,46458 | 9884,37499 | 10173,762 | 10356,3245 | 10597,1035 | 10768,9271 | 10981,4457 | 11140,2694 |
| 65-69 år | 4523,52993 | 4637,26696 | 4696,85876 | 4785,2853 | 4879,79917 | 5008,59434 | 5101,82666 | 5248,24307 |
| 70-74 år | 3683,47784 | 3767,09859 | 3857,44744 | 3953,56324 | 4057,68869 | 4139,70751 | 4247,99797 | 4305,98784 |
| 75+ | 2597,67554 | 2699,48543 | 2803,70727 | 2903,61299 | 3001,36064 | 3106,85193 | 3212,59712 | 3322,53149 |

| car trips men | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 |
|---|---|---|---|---|---|---|---|---|
| 15-19 år | 218,79273 | 221,27118 | 223,71336 | 227,12274 | 231,1608 | 234,76362 | 237,79821 | 240,30084 |
| 20-24 år | 1590,44296 | 1576,92321 | 1562,07053 | 1551,40707 | 1543,79031 | 1541,75917 | 1557,31006 | 1572,86094 |
| 25-29 år | 15446,5002 | 15621,0621 | 15814,6598 | 15977,8812 | 16043,0888 | 16087,2355 | 15966,1357 | 15822,3551 |
| 30-34 år | 16503,592 | 16525,0578 | 16518,9826 | 16507,6421 | 16653,8529 | 16828,4148 | 17005,8118 | 17204,2696 |
| 35-39 år | 14396,3097 | 14376,9082 | 14392,7462 | 14380,8677 | 14277,129 | 14179,3296 | 14184,8729 | 14169,4309 |
| 40-44 år | 12572,9645 | 12643,8394 | 12669,1802 | 12678,287 | 12690,1655 | 12677,4951 | 12657,3017 | 12670,7639 |
| 45-49 år | 11784,5426 | 11991,5058 | 12277,0178 | 12533,8463 | 12766,404 | 12979,5451 | 13056,7702 | 13083,2473 |
| 50-54 år | 10569,241 | 10661,911 | 10734,7232 | 10831,8062 | 10973,9002 | 11080,6915 | 11278,8289 | 11551,5436 |
| 55-59 år | 12388,2509 | 12365,0773 | 12310,252 | 12337,9473 | 12365,6425 | 12521,075 | 12627,3343 | 12715,5069 |
| 60-64 år | 11350,5271 | 11439,265 | 11516,6986 | 11526,8723 | 11500,8727 | 11374,2659 | 11342,049 | 11288,9194 |
| 65-69 år | 5345,9608 | 5470,59095 | 5559,65826 | 5665,70602 | 5743,88021 | 5848,96682 | 5889,33545 | 5919,77212 |
| 70-74 år | 4389,2882 | 4477,39435 | 4599,14103 | 4693,33451 | 4833,02281 | 4926,89591 | 5049,60375 | 5135,14681 |
| 75+ | 3426,49944 | 3529,57878 | 3634,5623 | 3748,68585 | 3847,44906 | 3952,30563 | 4059,7011 | 4179,91802 |

In light of the above it is very important to note that DEMOTRIPS should be understood as a tool for scenario projection and not for *predicting* travel developments; at least when mode substitution factors and the logistical growth model are applied to it. When they are not DEMOTRIPS does a fine job of generating daily trip forecasts based current mobility data and population projections, ceteris paribus. Their inclusion, however, allows for exploring trajectories where certain modes are limited in growth while others are set to grow, and what this in combination with the mode substitution factors produce in terms of modal distribution. In other words, DEMOTRIPS is a tool for conceptualising and illustrating how certain policy goals, such as the zero-growth objective, can conceivably come to fruition and pinpointing where and for whom this can be expected to be difficult to achieve due to current travel habits. Moreover, for this thesis' purposes it is not the exact number of trips projected in the future that are of most interest, but the projected *disparities* between demographic groups in obtaining the zero-growth objective. Therefore, the actual development in mobility will almost certainly deviate from what is produced in the scenarios. What they in essence do, is to present a conceivable trajectory towards sustainable mobility by demonstrating just how much needs to change in current travel behaviour if sustainability is to be reached by the year 2040.

### 4.3.2 Determining mode substitution factors

Although DEMOTRIPS makes projections rather than predictions, it is still important that the inputs to the model are as logically sound as possible. One of the most important factors affecting the scenario outputs the model produces is, as already mentioned, the mode substitution factors. Much research has therefore gone into exploring inter-modal relationships; attempting to pool empirical data on these types of modal interactions and apply this to the model framework. Determining this has, however, proven very difficult due to a staggering lack of empirical evidence and research on the subject. Mode substitution factors are closely linked to *cross-elasticities of demand*, which refers to the change in demand for a good following an attribute change in a different good (Riis & Moen, 2017). In this context it could for example mean demand changes in public transport following restrictions on car travel. While there is ample evidence and research on transport modes' *own-elasticities*, i.e. demand effects following an attribute change in that particular mode, very little attention have been given to the direction of modal shifts and cross-demand interactions (Fearnley, et al., 2016). This means that there is limited information and empirical data on where travellers end up when substituting a mode of transport for another following an attribute placed on the original mode, and what triggers such shifts.

The literature is even more scarce on diversions between modes, i.e. mode substitution factors, according to Fearnley, et al. (2016). In their article they pool all data material they could find on cross-elasticities of demand between various modes of transport. Of the 42 sources identified, only five consider diversion/mode substitution factors and neither of them consider as wide a range of modes of transport as this thesis, which means they provide a very weak foundation to build an overall logic upon. This conclusion was also drawn by Fearnley et al. (2016) who note that diversion/mode substitution factors are generally poorly understood and under-researched. In a recent article, Flügel, Fearnley & Toner (2018) attempt to fill this research gap by estimating diversion factors (DF) between modes of transport in Greater Oslo. By making use of a nested logit model they predict changes in ridership following a policy intervention put on a mode and estimate the DFs this causes onto other modes of transport. They summarise their findings as follows:

1. DFs to walk are in general high but decrease rapidly with increasing distance
2. DFs to cycling tend to be higher for work-related trips
3. DFs to car and train increase with distance
4. The public transport internal DFs are rather high
5. DFs are in general lower, the higher the number of available transport modes
6. DFs are in general higher to transport modes with a relative high market share

(Flügel, Fearnley, & Toner, 2018)

The above articles constitute the only two comprehensive sources found on mode substitution factors that are applicable to Oslo mobility; both of which are connected to a research project called Crossmodal whose main purpose is to better understand mode-switching behaviour in travel – which indeed is needed (TØI, n.d.). Though while providing a basis to build on for estimating mode substitution factors in DEMOTRIPS they do not provide empirical backing for all aspects relevant for this thesis. For example, neither article lends insights on potential variations between genders and age cohorts' DFs/mode substitution factors and not all modes assessed here are considered in the articles. This poses a challenge for this thesis because making projections for future transport scenarios based on sensical mode substitution factor relationship constitutes a major part of its analytical framework. Discovering this research gap represented a fork in the road and is the main cause as to why the scenarios produced by this thesis must be understood as theoretical and potential trajectories towards sustainable mobility adherent to the zero-growth objective rather than predicative of future modal distributions.

After discussing this issue with the Institute of Transport Economics, it was decided that the best way to move forward was to instead base the mode substitution relationships on the likelihood of one mode replacing another depending on the prevalence of various trip *purposes* on the different modes. This was made possible by the RVU survey also covering trip purposes. Utilising this, André Uteng at Rambøll has provided a framework for emulating mode substitution factors between the modes. The rationale is that if, for example, cycling trips according to RVU constitute a high number of school trips and a low number of medical trips for a particular age cohort, one can assume that any new cycling trip substituted onto that age cohort is more likely to be a school trip than a medical trip. These likelihoods are calculated across modes, age cohorts and trip purposes in the following way:

$$LH(purpose = x|y) = \frac{purpose_x^y}{\Sigma_{i=1}^n purpose_i^y}$$

Denoting the likelihood ($LH$) of a trip on mode $y$ having trip purpose $x$ for each age cohort. Put more simply, it reflects the probability for a trip on mode $y$ having travel purpose $x$, based on the information from the RVU survey. Table 4-6 shows the outputs these calculations provide for short-distance cycling trips across age cohorts and trip purposes:

*Table 4-6: Trip purpose probability, short cycling trips*

| | Work | Shopping | Services | Medical | Private visits | Other visits | Pickup/ deliver | School | Other |
|---|---|---|---|---|---|---|---|---|---|
| **15–24 years** | 5.57% | 11.15% | 1.39% | 0.70 % | 10.45% | 17.42% | 1.74% | 45.64% | 5.92% |
| **25–39 years** | 30.46% | 21.29% | 3.5% | 1.35 % | 7.28% | 12.13% | 10.24% | 1.89% | 11.86% |
| **40–64 years** | 28.66% | 25.45% | 2.61% | 0.80 % | 6.21% | 14.03% | 8.02% | 0% | 14.23% |
| **65+ years** | 2.94% | 46.08% | 8.82% | 1.96 % | 8.82% | 19.61% | 0% | 0% | 11.76% |

Based on the information in table 4-6, the likelihood of a short-distance cycling trip for 15–24-year-olds being school-related is 45.64%. As such, any new cycling trip projected for this age cohort in the future is estimated to have the same likelihood of being school related. Next, it is necessary to find the modes most likely to be substituted onto cycling. This is done by assuming the information in table 4-6, which suggests a high probability of new cycling trips being school-related for 15–24-year-olds. The logic is then that if a trip also has a high probability for being school-related by car for this age cohort but a lower probability when travelling by public transport, then the likelihood of any new cycling trip being substituted from cars is necessarily *higher* than the likelihood of it being substituted from public transport. To account for this, the same approach as in the equation above is pursued:

$$LH(mode = y|x) = \frac{mode_y^x}{\Sigma_{i=1}^n mode_i^x}$$

Denoting that for a given trip purpose $x$, the likelihood that a given age cohort makes use of mode $y$ equals the share of mode $y$ on trips with purpose $x$, according to RVU. This produces the following probability distribution for 15–24-year-olds on trip purpose:

*Table 4-7: Probability distribution across modes, short trips 15–24-year-olds*

| | **Work** | **Shopping** | **Services** | **Medical** | **Private visits** | **Other visits** | **Pickup/ deliver** | **School** | **Other** |
|---|---|---|---|---|---|---|---|---|---|
| **Walk** | 59.32% | 76.2% | 66.07% | 40.91% | 63.78% | 68.68% | 52% | 68.21% | 78.59% |
| **Cycling** | 9.04% | 4.03% | 7.14% | 9.09% | 9.29% | 11.6% | 20% | 17.35% | 5.43% |
| **Car** | 7.34% | 10.33% | 8.93% | 0% | 10.84% | 2.09% | 20% | 1.32% | 5.75% |
| **Car-passenger** | 2.82% | 5.42% | 5.36% | 13.64% | 7.43% | 7.42% | 8% | 2.38% | 5.75% |
| **Public transport** | 21.47% | 4.03% | 12.5% | 36.36% | 8.67% | 10.21% | 0% | 10.73% | 4.47% |

To estimate mode substitution factors, in this case between cycling and car, the information in table 4-6 is combined with that of table 4-7. For example, the probability of a new cycling trip being work-related for 15–24-year-olds (table 4-6) is 5.57%. This is multiplied with the probability that the work trip is by car (table 4-7; 7.34%) and added to the probability of it being a shopping trip (11.15%) multiplied with the probability that the shopping trip is by car, and so forth for all the trip purposes. This produces estimations of likelihoods for all modes reflecting the probability of one being replaced by another for the age cohort in question:

*Table 4-8: Likelihood estimators for cycle*

| | **Likelihood (LH) estimates for cycle** | | | |
|---|---|---|---|---|
| **Men** | Walking | Car | Car-passenger | Public Transport |
| **15–24 years** | 68.34% | 4.48% | 4.57% | 9.92% |

What remains is to adjust the likelihood estimates so that they sum to one, as described in chapter 4.3.1. This is done by re-scaling the estimations in table 4-8 according to the ratios of their combined space. When also re-adjusting the age cohorts to fit DEMOTRIPS' framework, the above produces the following substitution estimates for short trips:

*Table 4-9: Adjusted likelihood estimators for cycle*

| | Likelihood (LH) estimates for cycle | | | |
|---|---|---|---|---|
| **Men** | Walking | Car | Car-passenger | Public transport |
| **15–19 years** | 78.27% | 5.12% | 5.23% | 11.36% |
| **20–24 years** | 78.27% | 5.12% | 5.23% | 11.36% |

Table 4-9 states that any new short-distance cycling trip added for 15–24-year olds has a 78.27% change of being absorbed from walking, 5.12% from car, 5.23% from car-passenger, and 11.36% from public transport. The calculations exemplified above are made for all age cohorts assumed, and between all modes covered by RVU which in sum provides their mode substitution relationships. That, however, leaves EL-car, EL-cycling and car-sharing. Because these modes' share of overall Oslo mobility is so small, it was decided to make reason-based estimations of their mode substitution. The Institute of Transport Economics provided assistance in this effort, and the exact plots for them, as well as for the RVU modes is reported in full in appendix C.

As a side-note, it is the opinion of this thesis that the information vacuum on mode substitutions factors in general constitutes a major challenge for policy-makers seeking to implement policies to bring about modal shifts such as the zero-growth objective. Much of the goal's premise rests on the rationale that travellers can be steered onto alternative modes (i.e. public transport, walking and cycling) through restrictions on the modes one seeks to shift ridership away from (cars) or by improving the alternative modes. Though, as touched on in chapter 3.4.2, while a plethora of literature supports the notion that restrictions and rising costs reduce ridership within a mode, the fact that there is a general knowledge gap of exactly how such attributes affect demand for other modes reveals that policy-efforts aspiring to steer mobility may in reality be much less targeted than intended.

### 4.3.3 Determining capacities and growth rates

As mentioned in chapter 4.3.3, the logistical growth model decides the modes' growth rates and is dependent on two factors: A capacity target which represents the end-point towards which a mode's share of overall mobility is to grow, and a yearly growth rate that determines how fast a mode reaches that end-point. As it is only applied in the zero-growth scenarios, its purpose in this context becomes to only plot for growth in the sustainable modes identified by the zero-growth objective (public transport, walking and cycling) and to *not* plot for growth in the remaining modes. Beyond this reasoning, as is the case with the mode substitution factors outlined in chapter 4.3.2, it is important to devise a logic for exactly which capacities and growth rates to plot. After consulting with the Institute of Transport Economics and Rambøll, the following general logic has been applied:

Regarding the modes not set to grow in the zero-growth scenarios (car, EL-car, car-sharing and car-passenger), their yearly growth rates are set to zero across all three scenarios. When this is done, DEMOTRIPS outputs remain unaffected regardless of which capacities are set for them because a growth rate of zero means that there is no identified growth path for the modes in reaching their desired capacity. Simply for clarity as well as to function as dummy variables, these modes' capacities are set equal to their current modal share in each zero-growth scenario. Keep in mind that setting a growth rate of zero does not mean that ridership on these modes will remain unchanged towards 2040, as the mode substitution factors still affect them. Thus, zero-growth modes can still be projected to both grow or decrease as this also depends on the rates of substitution between the modes. A zero-growth rate only means that the mode is not being *steered* towards growth, cf. chapter 4.3.3.

That leaves public transport, walking and cycling, i.e. the modes the zero-growth objective wants to see mobility shift towards; the implications of which these scenarios set out to project. Because the scenarios are divided by trip length, it became easier to rationalise that some modes are more applicable to certain trip lengths than others. Public transport, for example, can justifiably be said to have a higher potential for growth in long trips than walking, while the reverse is true for short trips. Therefore, it was decided to plot growth rates corresponding to each modes' presumed applicability for a particular trip length. Moreover, it was decided that a yearly growth rate of 7% represents the maximum awarded for any mode. 7% growth equals a doubling of current mobility levels over a ten-year period in DEMOTRIPS' framework, but because of the interactions caused by mode substitution factors and population projections, no such pure growth trajectories will happen in any mode as trips are transferred between them constantly when ridership in each of them change. Modes somewhat suited for a particular trip length are given a yearly growth rate in the range 4–5% while modes less suited are placed in the 1–2% range. As for capacities, it was decided to plot them as double that of current modal shares for the modes set to grow. This will provide ample room for projecting growth. For example, the current modal share for public transport on long trips is 38%. Double-capacity would mean a 76% modal share; far beyond the range of realistically projected growth. In the zero-growth scenarios (chapters 5.3.1 through 5.3.3), the yearly growth rates and capacities plotted for each mode is tabulated and the exact plots made are argued more closely.

It should be noted that in manipulating these growth rates and capacities, different mobility patterns will be outputted by DEMOTRIPS. What has been decided on by this thesis is by no means set in stone and anyone interested could decide on other inputs and get different results than those being presented here. The scenarios must therefore be understood as a product of their inputs. In this particular case, these inputs are a product of what this thesis aims to project, namely a trajectory towards the zero-growth objective and are, again, not predictive of actual developments in Oslo mobility.

### 4.3.4 Scenario sets

Now that the data material as well as the workings and inputs of DEMOTRIPS have been presented, what remains is explaining which scenarios this thesis are to assess and what they are to explore. As already mentioned, separate scenarios will be generated for short, medium and long trips. Beyond this, two *scenario sets* are to be created: One that projects how mobility in Oslo will develop if nothing changes in current mobility patterns (business as usual) and one that explores how zero-growth in car traffic potentially can be achieved; projecting a theoretical development of what this entails for future mobility across demographic divides.

#### *4.3.4.1 Business as usual*

The business as usual (BAU) scenario set essentially serves as a reference point for this thesis' efforts in projecting sustainable mobility. In it, current mobility trends, i.e. the RVU data and the estimations are treated as constant and the only variable involved is the projected population increase. The mode substitution factors and the logistical growth model are not applied to the scenarios within this set, which means there is no need to account for varying rates of logistical growth and mode substitutions here. Rather, the idea is to illustrate how Oslo mobility will develop if nothing happens to current mobility habits, providing an indication of the challenges faced towards the year 2040 in reaching sustainable mobility. BAU also allows for estimating how many car trips need to be substituted away onto other modes if the zero-growth objective is to be met. This provides interesting talking points as it tracks the projected demographic development in Oslo and the implications this can have on mobility if current mobility trends within the various demographics remain dominant.

#### *4.3.4.2 Towards zero-growth in car traffic*

The zero-growth scenario set seeks to project a sustainable alternative to the BAU scenario in which public transport, walking and cycling are set to grow while car use is not. To do so, it takes into consideration mode substitution factors and growth rates; simulating the various demographics switching between modes of transport and setting targets for each mode's share of overall mobility that reflect sustainable mobility. In a nutshell, BAU tracks current trajectories while the zero-growth scenarios project trajectories where shifts away from cars and onto sustainable modes could potentially happen. The takeaway from this exercise is not the face-value of the exact number of trips projected in the future on the various modes, but rather that due to differing population growth and travel habits between the demographic groups their *rates* of substitution onto sustainable modes will vary. This means some demographics will need to have higher growth rates in public transport, cycling and walking than others if the zero-growth objective is to be met. The takeaway from this exercise is thus to identify the varying levels of change needed across demographic groups for reaching sustainable mobility towards 2040.

### 4.3.5 Framework limitations and data weaknesses

As stressed multiple times through this chapter, the scenarios presented in this thesis are not predictive of Oslo's mobility development. Rather, they should be seen as a *what if* approach to reaching sustainable mobility; projecting futures in which current trends either remain or are altered. Beyond this reservation, the framework applied does have some more limitations and data weaknesses. First, it breaks down travel patterns into five-year age increments and generalises the same travel behaviour for all of Oslo's population in this way. The behavioural cohorts are static and as people age, the model assumes people adopt the travel behaviour of the new age cohort they find themselves in. This is one of the main reason why it was opted to add a back-casting analysis atop the scenario projections because it allows for discussing sustainable mobility in a more fluid and theory-based way and to counterweight the rigorous traits of the DEMOTRIPS framework. Second, while current mobility figures for car, car-passenger, public transport, walking and cycling are well-founded and based in RVU, those for EL-car, EL-cycling and car-sharing are based on estimates. The resolve to this has been to treat the latter as subsets of the former which makes it possible to analyse their results both on their own and to re-merge the estimates' shares into their parent mode without affecting the mobility outputs of the remaining modes. Third, there is a staggering lack of empirical data onto which the mode substitution factors plotted in DEMOTRIPS can be based. The best option found for resolving this information vacuum was to calculate the substitution factors based on the likelihood of the RVU modes replacing one another, and to provide reasonable estimates for the remaining modes.

Issues relating to establishing mode substitution factors (chapter 4.3.2) constitutes the main weakness of this thesis' framework. Not only is there limited empirical backing, making a workaround necessary. An additional drawback is that the mode substitution factors are kept static as time progresses. This is fine for developments that closely resemble today's modal distribution but problematic when a development is being steered towards sustainable mobility, because as the mobility system changes one would be justified in assuming that the mode substitution factors should change with it. At present, DEMOTRIPS does not allow for re-estimating these factors following alterations to the overall modal distribution. This means that the rationales behind them, which are based on trip purposes from RVU, become more and more diluted the farther Oslo's mobility is projected to develop from its current state. This is a key reason why the zero-growth scenario results, again, must not be mistaken as forecasts of actual future development.

## 4.4 Method summary

The approach sought to answer this thesis' research questions, as described at considerable length in this chapter, can be summarised in the flowchart shown in figure 4-3. The quantitative backbone of the thesis is tied to utilising current mobility data on travel habits from RVU and estimates. When plotted in DEMOTRIPS and combined with population growth projections, they in sum generate the BAU scenario set. Further introducing mode substitution factors, desired modal growth rates and capacities allow for generating the zero-growth scenario set. The disparities between demographic groups in shifts towards sustainable modes as

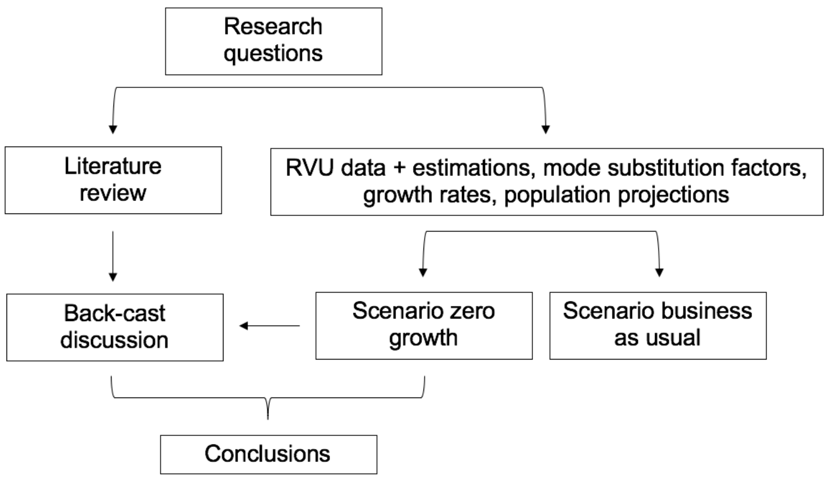


*Figure 4-3: Simplified flowchart of thesis structure*

projected in the zero-growth scenarios feed into a back-cast discussion that assumes empirical data and theoretical underpinnings to explore the application of car-sharing, ridesharing and cycling as means of furthering sustainable mobility. The discussion findings along with the scenario results serve as the basis for drawing conclusions on the obtainability of sustainable mobility in Oslo, and for answering the research questions posed.

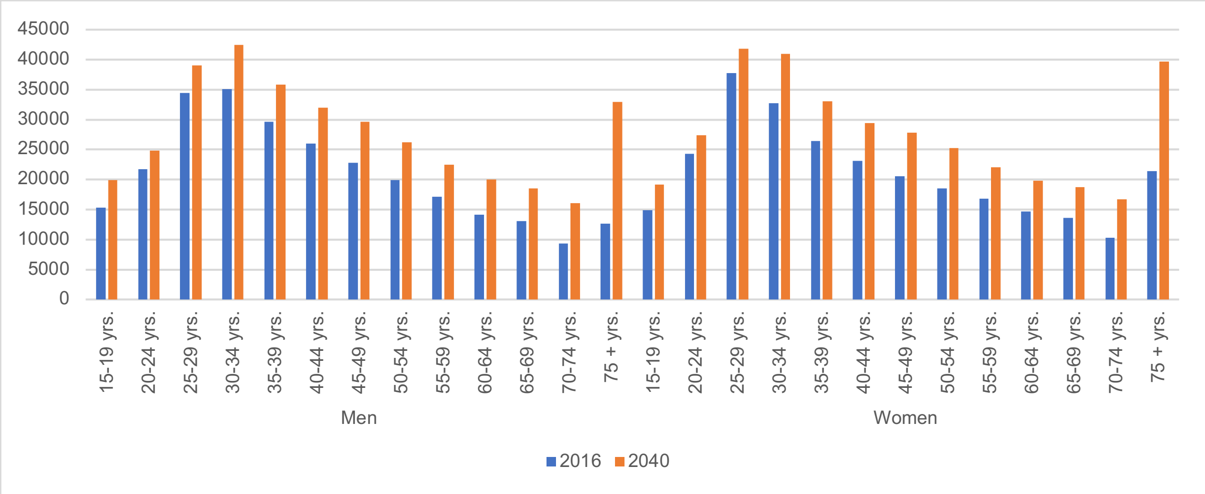
# 5 Scenarios and analyses

This chapter presents the scenario results for both the BAU and zero-growth scenario sets. Results from the different trip lengths are presented in their own sub-chapters and their respective results and key takeaways are analysed. As is evident from the rundown in chapter 0, a large amount of quantitative data serves as background for the scenarios presented – far too much to include in its entirety in this chapter while at the same time providing a clear and orderly analysis of all the six scenarios assumed. Therefore, the underlying data material is included as appendices to this thesis and all figures and graphs presented in this chapter stem from this data material. The appendices include the following:

1. Oslo population projections (appendix A)
2. Distribution of current mean number of daily trips on the various modes split by gender, age cohorts and trip length (i.e. the RVU data + estimates that when multiplied with the population projections generate the number of daily trips) (appendix B)
3. Mode substitution factors plotted for all age cohorts and genders split by trip length used to generate scenarios in scenario set B (appendix C)

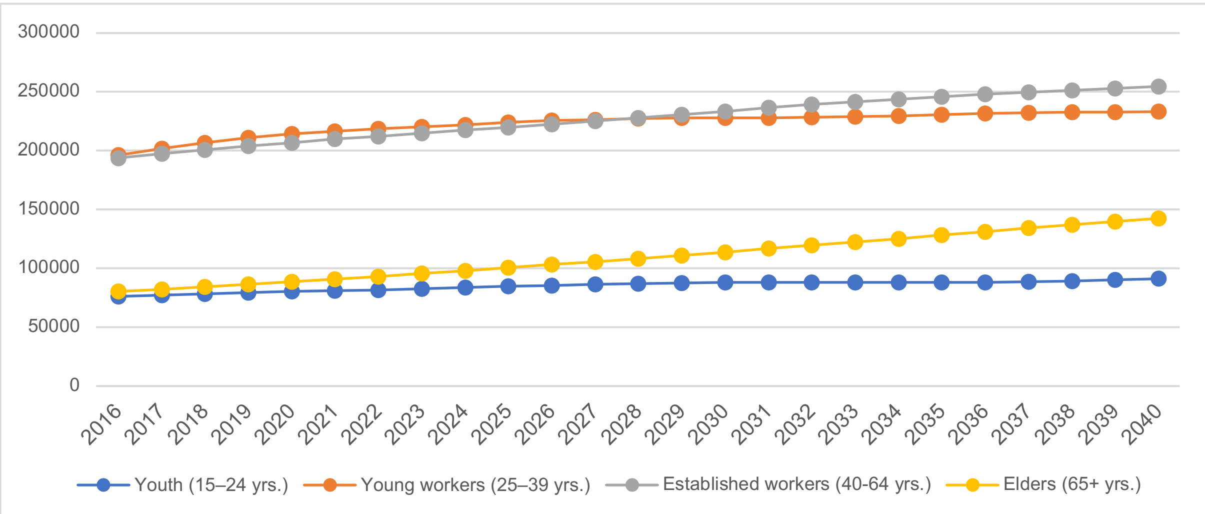
## 5.1 Population projections

As points of context, it is useful to start by presenting and visualising some key details from the Oslo population projections. Demographic changes are an important driving factor for the scenario results and constitute a core element of the analysis. The population projections are also universal throughout the scenario sets. Therefore, rather than repeating this data for all six scenarios some key developments are summarised here.




*Graph 5-1: Oslo population by gender and age cohorts, 2016 vs. 2040*

Graph 5-1 demonstrates quite clearly the demographic shift Oslo is facing, according to Statistics Norway's projections. By 2040, people older than 75 years will go from constituting a relatively small share of the population to becoming one of the largest demographic groups. Out of Oslo's population, 75+-year-olds will account for 10% of it by 2040 compared to 6% in 2016. Moreover, the share of Oslo's "retired" population (65 years and upwards) will grow from 14.7% to 19.8% by 2040. That being said, this age wave is not strong enough so that elders will make up the majority of the population by 2040. The most populous single five-year-span age cohorts will remain 25–29 and 30–34-year-olds. Moreover, the graphical spread in population distribution for 2016 and 2040 show strong overall similarities – with the notable exception of the spike in 75+-year olds projected by 2040.

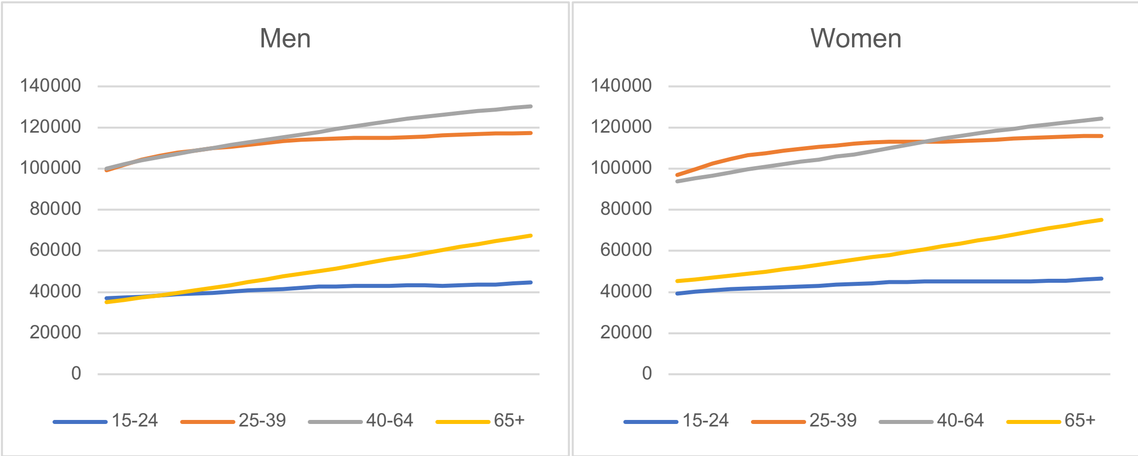



*Graph 5-2: Oslo demographic categories' population growth, 2016–2040*

Graph 5-2 shows both genders merged, groups the age cohorts into broader demographic categories and plots their associated population projections year-by-year. The spike in the 75+ population is mirrored by *elders* (65+-year-olds) demonstrating accelerating population growth in the years going forward; increasing by a total of 77% over the 24-year period. A different, albeit more modest trait of Oslo's ageing population is seen in that by 2028, *established workers* (40–64-year-olds) will overtake *young workers* (25–39-year-olds) in total population. Young workers' growth trajectory is also projected to stagnate at around the same year. As for *youth* (15–24-year-olds), their population development is projected to be relatively stable; increasing at an even and modest pace towards 2040.

The reason these broader demographic categories are interesting to consider in addition the five-year increments is that they are reflective of various life stages associated with differing travel patterns. The mobility needs of, for example, a newly graduated student that has started her first job would be expected to be different from that of a seasoned worker with children, which in turn differs from that of a retiree. Keeping this in mind, the fact that the relative size of these broader demographic groups is projected to shift will have implications for future mobility unless changes are made to their travel habits, as will become apparent from the scenario results. The general tendency, is that established workers and elders will make up a larger share of the overall population, which in turn means that their mobility patterns can be projected influence overall Oslo mobility to a greater extent towards 2040.

What will also become apparent in the scenarios, is that there are large deviations between the genders' mobility patterns. Graph 5-3 subdivides the same broad demographic groups introduced in graph 5-2 into men and women:




*Graph 5-3: Oslo demographic groups' population growth, men vs. women*

Much of the overall tendencies remain the same between the genders, but the established workers group will overtake the young workers in population size much earlier in men than in women. Moreover, the 2040 disparity between youth and elders is larger in women than in men. Women are projected to have a larger share of elders than men by 2040, while men are projected to have a larger share of established workers than women. These disparities all feed into the scenario results and will also amplify the deviations in mobility patterns between the genders that are already present.

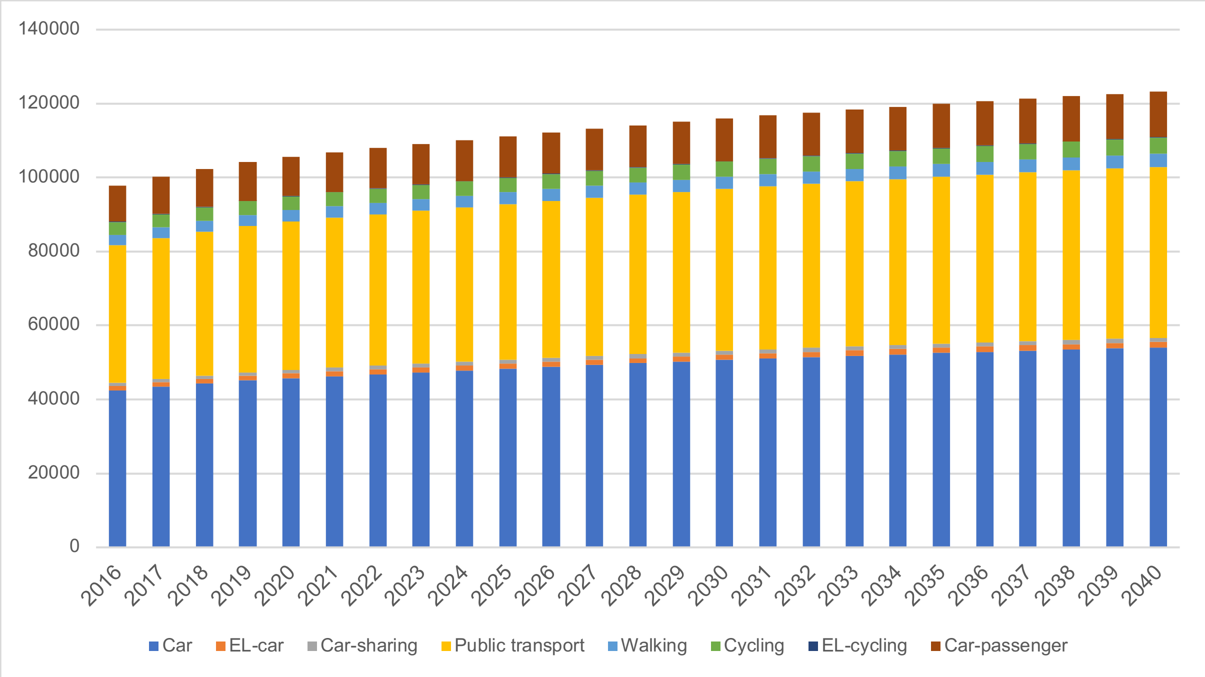
## 5.2 Scenario set A: Business as usual

The BAU developments projected for short, medium and long trips towards 2040 is presented in this chapter. The same graphical representations and data are by and large presented in all three scenarios to make it easier to compare their results. The first scenario explains and lays out the context of the data presented in a bit more detail than the other two, so that explanations on, for example, what the various graphs represent do not need to be repeated in detail.

### 5.2.1 Long trips

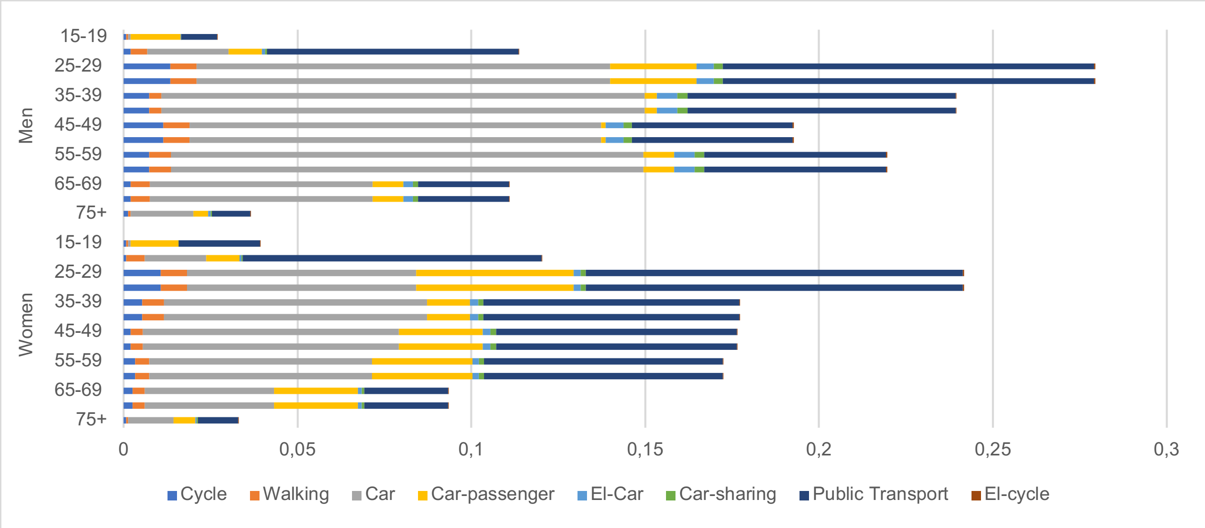
*Table 5-1: BAU long trips: Modes' percentage share of overall mobility, 2016 vs. 2040*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **2016** | 3.5% | 2.9% | 43.4% | 10% | 1.2% | 0.9% | 38% | 0.1% |
| **2040** | 3.5% | 2.9% | 43.8% | 10% | 1.2% | 0.9% | 37.5% | 0.1% |




*Graph 5-4: BAU long trips: Total trips 2016–2040*

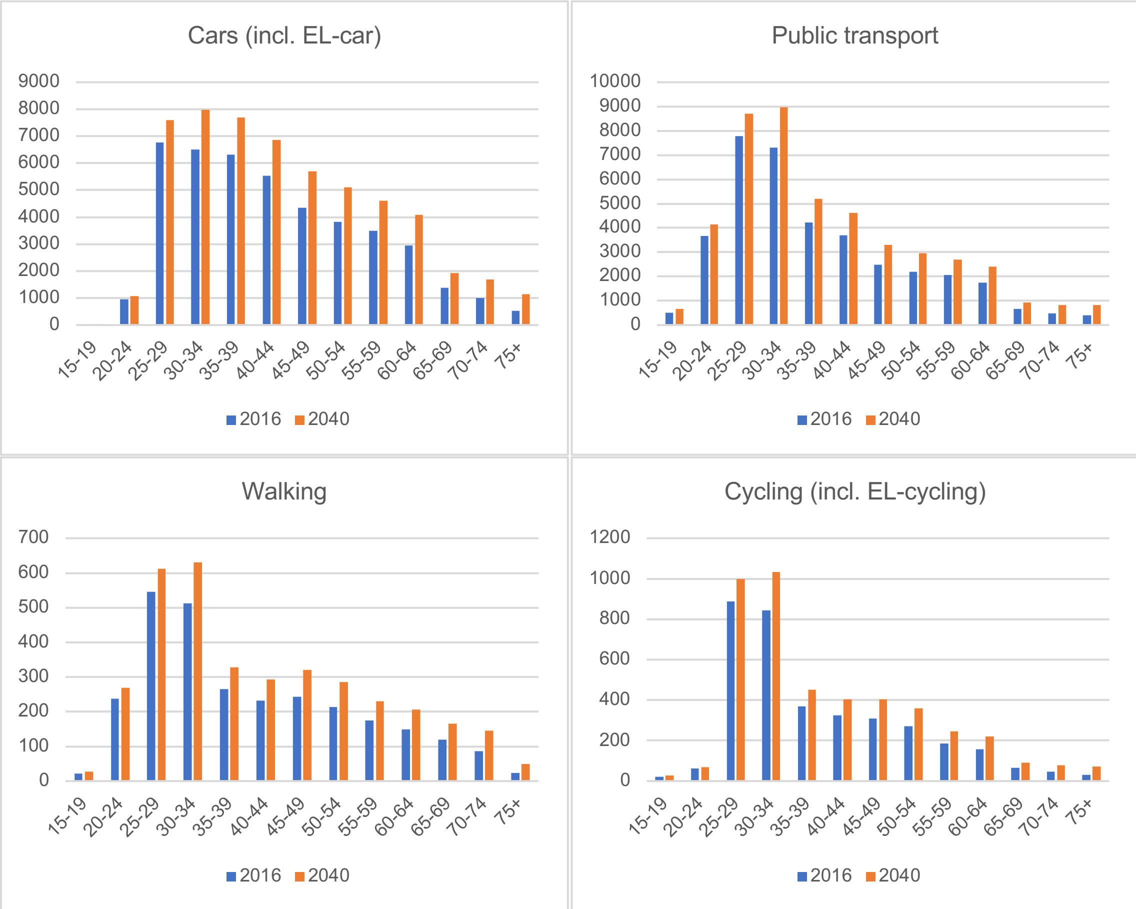
The overall development projected in BAU long trips is that all modes grow in ridership towards 2040, albeit at slightly varying rates. The number of daily car trips increases from **42,416** to **54,018**; corresponding to a **27.4%** growth. In comparison, public transport sees a total ridership increase of 24.3% (37,202 to 46,224), cycling 24.5% (3,470 to 4,321) and walking 26% (2,826 to 3,561). In other words, these modes' growth rates are relatively even which is also reflected in the development of their shares of overall mobility. Car, for example, accounted for 43.4% of all trips in 2016 and 43.8% in 2040. Moreover, the total number of long daily trips on all modes combined was 97,834 in 2016 and is projected to be 123,205 in BAU by 2040, representing a 27% increase. Over the same time period, Oslo's population is projected to increase from 546,536 to 721,572 which corresponds to a 32% increase. This means that the average number of daily trips per inhabitant at the aggregate level; i.e. overall rate of mobility is projected to fall slightly towards 2040. The reason for this is found in the aforementioned demographic changes and the various age cohorts' mobility patterns:




*Graph 5-5: Oslo mean number of daily long trips per capita*

Graph 5-5 illustrates an excerpt of the mobility data provided in appendix B, denoting the mean number of daily *long* trips each age cohort currently conducts on different modes of transport, according to the RVU data and the estimates. What immediately stands out is that men are much more car dependent than women on long trips. Moreover, 25–34-year-olds are reported to carry out a relatively high number of daily long-distance trips, while 75+-year-olds carry out very few relative to the other age cohorts. As explained in chapter 4.3.1, these mean numbers of daily trips are kept constant by DEMOTRIPS. The number of trips projected by the BAU scenarios are therefore solely driven by the year-to-year population growth and how this is distributed across the various age cohorts. The reason why overall mobility is falling is that the median age of the population is moving upwards, and the older age cohorts are reported to conduct fewer daily long-distance trips than younger age cohorts. The fall in mobility this causes is, however, countered by the general population increase, resulting in the total number of outputted trips increasing. Graph 5-5 shows that the disparity between elders' mean number of daily long trips and that of the young- and established workers' is relatively stark. In light of this, the fact that overall mobility per capita only falls by 5% means that the general population growth projected for Oslo necessarily is relatively strong in order to counter elders' low mean number of daily long-distance trips.

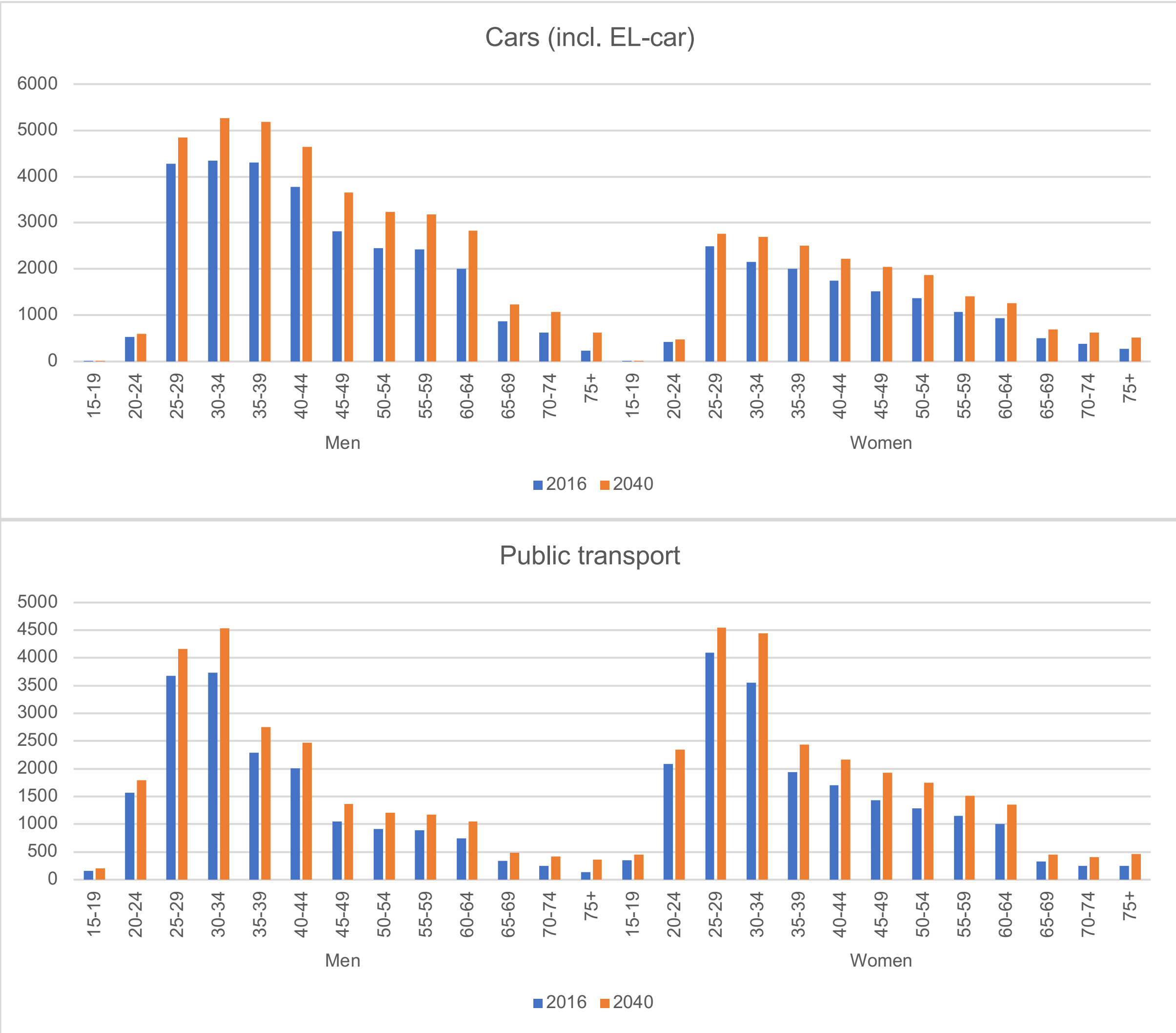
In fact, traffic was not reported to fall in a single mode for any age cohort from 2016 to 2040. Graph 5-6 plots the overall developments of the four modes of interest in the BAU framework, namely cars (incl. EL-car), public transport, walking and cycling (incl. EL-cycling):




*Graph 5-6: Number of long car, public transport, walking and cycling trips, 2016 vs. 2040*

It is apparent that all the modes in question grow in this scenario, but what is interesting is at which rate, by how much between the different age cohorts, and how the shifting median age affects this. As is apparent from graph 5-6, in 2016 25–34-year-olds were reported to make use of active modes, i.e. walking and cycling far more than the other age cohorts. The same is true for public transport, albeit to a slightly lesser extent. The general spike seen across modes in 25–34-year-olds' number of trips is reflective of these age cohorts being the most populous in 2016, cf. graph 5-2. If this is taken into account, it becomes apparent that car trips were more evenly distributed across the age cohorts than the three other modes. Because the median age is moving upwards this translates to diminishing growth for active modes relative to cars, as the demographic groups that currently make use of walking and cycling for long trips the most (25–34-year-olds) will constitute a smaller share of the total population by 2040. This explains why the number of car trips grew by a higher percentage over this time period than the sustainable ones and represents an accelerating problem for zero-growth goal obtainment.

Circling back to graph 5-5, it is evident that across age cohorts, cars have a larger modal share of daily long trips for men than for women, while the reverse is true for public transport. Men were in general also reported to conduct more daily long trips overall than women. Graph 5-7 illustrates how this is projected to play out by plotting 2016 and 2040 figures for cars and public transport for the two genders separately:




*Graph 5-7: Long trips cars and public transport, men vs. women*

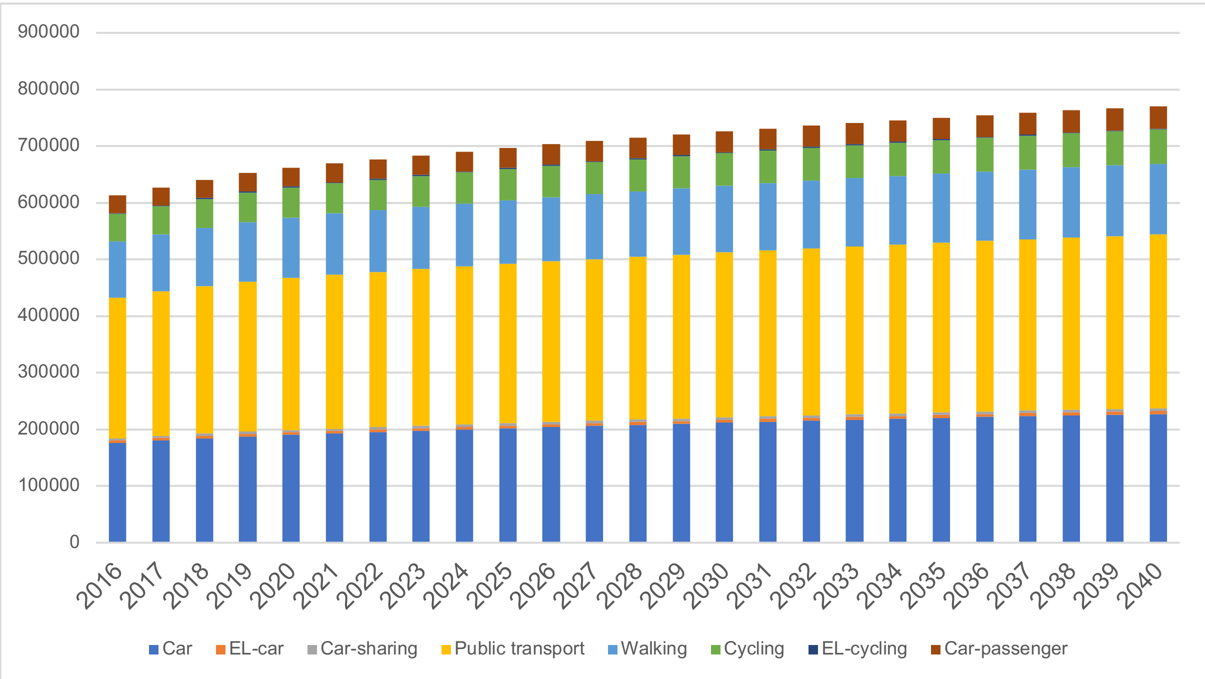
The disparity in the number of long distance car trips, both in 2016 and 2040, is stark between the genders while the reverse relationship for public transport is not as strong, meaning men travel at a higher rate on long daily trips than women. The implications of this, in a BAU framework, is that men's travel habits and population projections will to a greater extent influence overall mobility on long trips than women's. In terms of car travel, this is negative for the zero-growth objective because men are more car dependent than women according to the current modal distribution. However, as the population's median age shifts towards the older demographics, overall mobility falls on account of the mean number of trips data shown in graph 5-5. Still, towards 2040 car traffic grows more in relative terms than public transport.

Before moving onto analysing the results from BAU medium trips, a word on the modes to be assessed in the back-casting discussion, namely car-sharing, ridesharing and cycling: What has been mentioned before is evident from the aggregate data shown in graph 5-4; namely that these modes constitute a very small portion of overall mobility both now and in 2040. The reason is of course that their current modal share is dwarfed by other more established modes in the BAU scenario. With the exception of cycling, these modes are not set to grow in the zero-growth scenarios either, seeing that the zero-growth objective makes no mention of them. This is why car-sharing and ridesharing's future applications are to be projected through the back-cast discussion instead; atop the scenario projections.

### 5.2.2 Medium trips

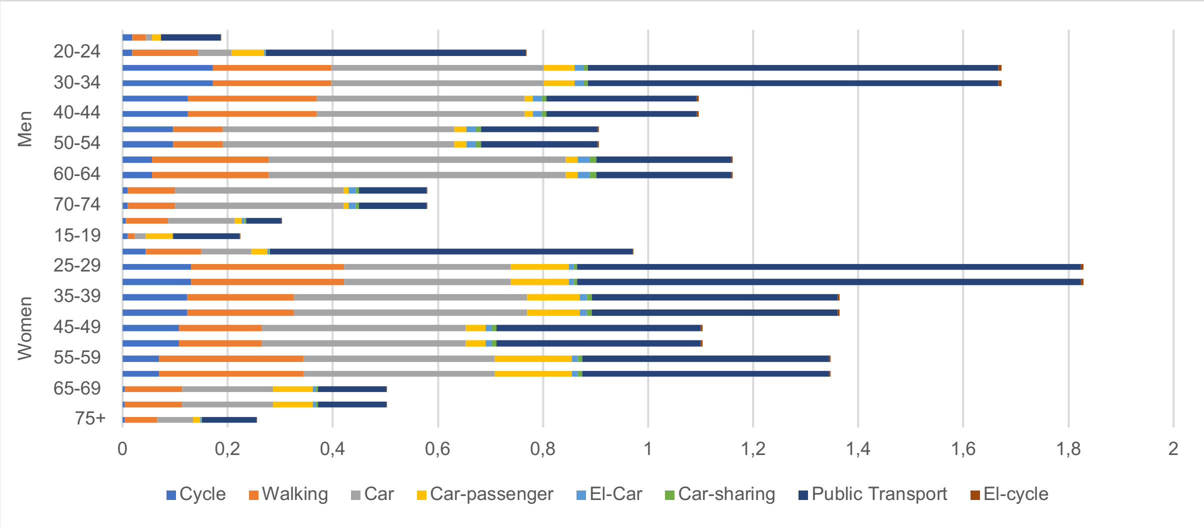
*Table 5-2: BAU medium trips: Modes' percentage share of overall mobility, 2016 vs. 2040*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **2016** | 8% | 16.1% | 28.8% | 5.1% | 0.7% | 0.6% | 40.6% | 0.2% |
| **2040** | 7.8% | 16.3% | 29.5% | 5.1% | 0.7% | 0.6% | 39.8% | 0.2% |



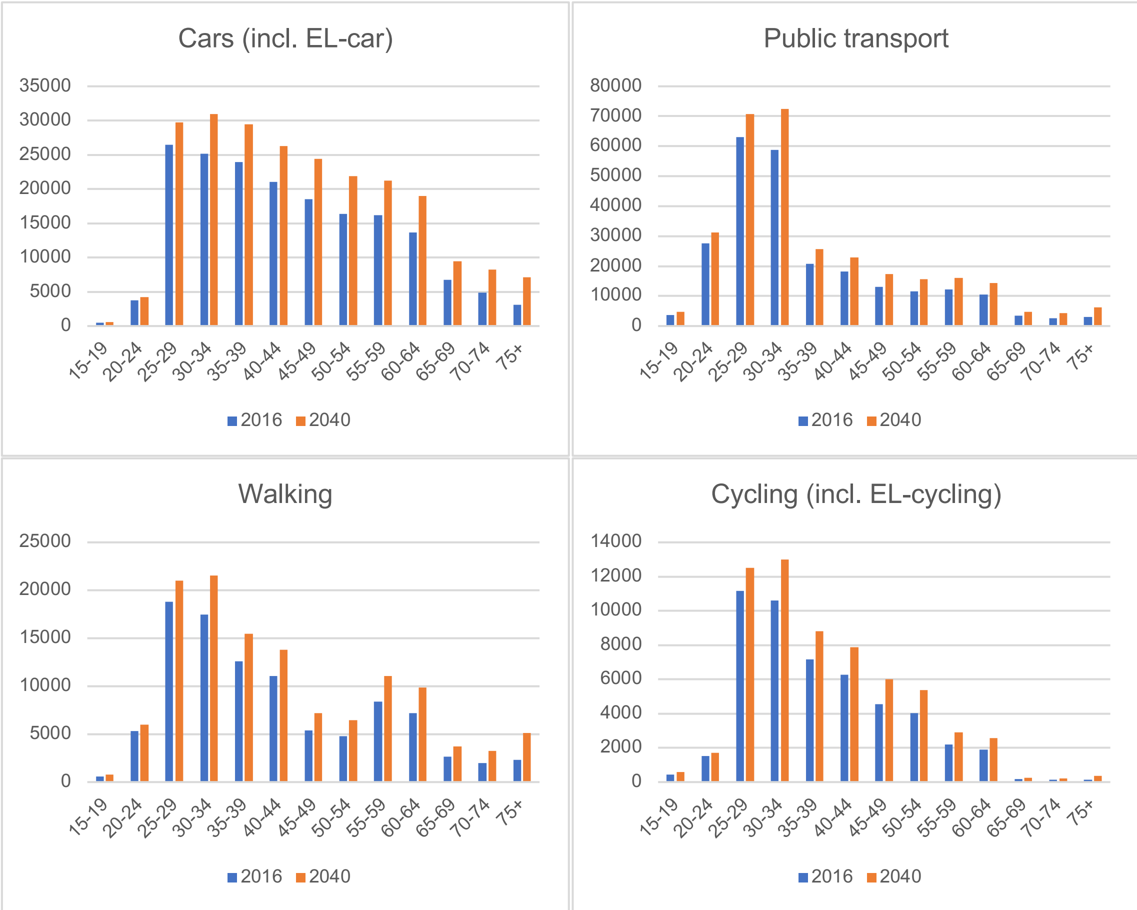

*Graph 5-8: BAU medium trips: Total trips 2016–2040*

Medium trips differ from long trips in that public transport at present actually has a relatively high modal share compared to cars. Still, car travel grows at a disproportionally high rate when comparing with the sustainable modes; from **176,250** in 2016 to **227,129** corresponding to **28.9%**. In comparison, public transport grows by 23.2% (248,813 to 306,532), walking by 27% (98,581 to 125,198) and cycling by 23.6% (48,755 to 60,282). The aggregate number of trips grows by 25.7% (612,804 to 770,411). As was the case in long trips, overall mobility per capita is down seeing that total population growth from 2016 to 2040 is at 32%.



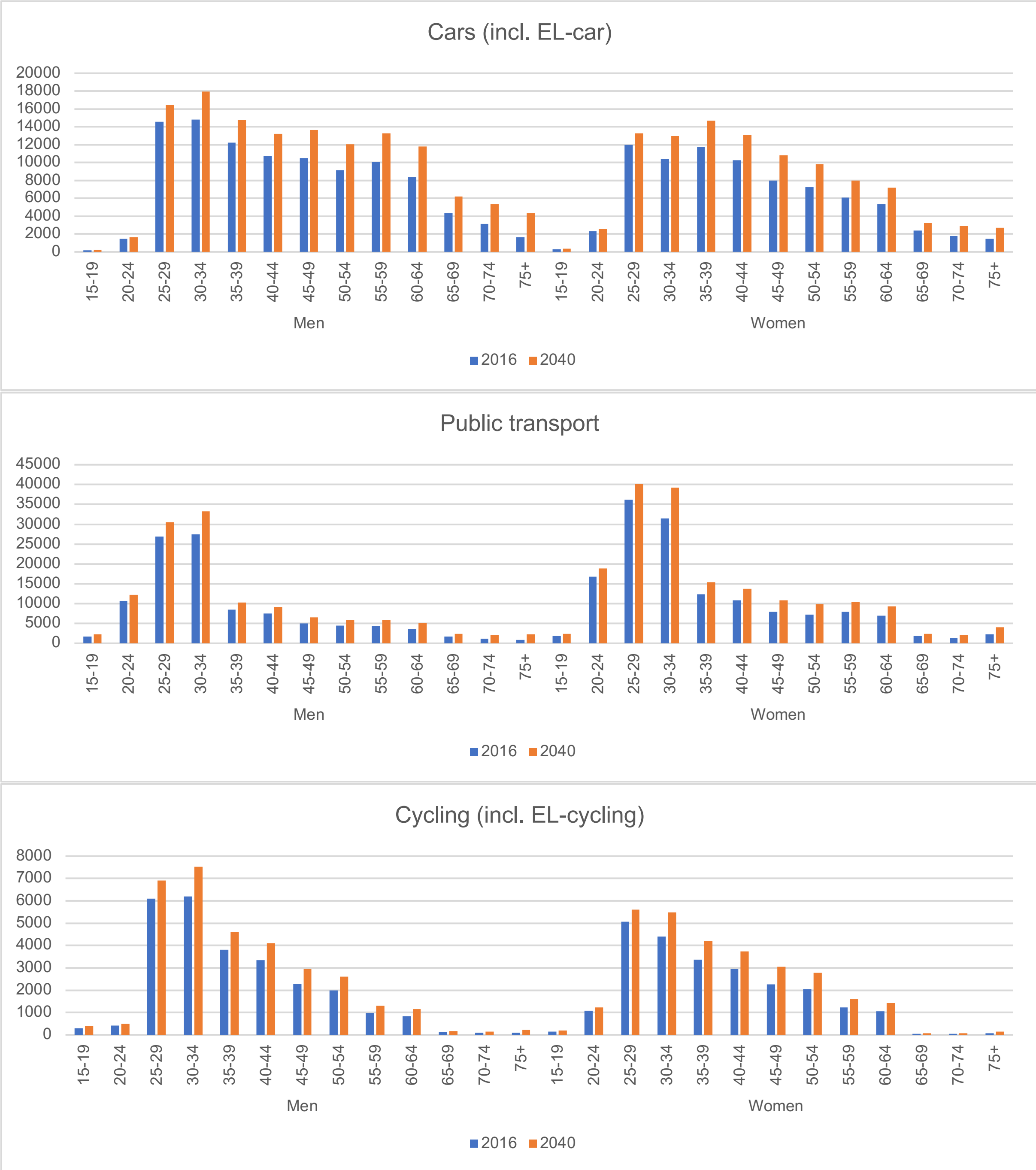

*Graph 5-9: Oslo mean number of daily medium trips per capita*

Graph 5-9 demonstrates clearly that public transport has a much wider market penetration in medium trips than in long trips. Again, 25–34-year-olds have the highest rates of mobility and unlike in the other scenarios, women have the highest number of mean daily trips. The graph's profile resembles that of long trips which means the same mechanisms are at play, namely that overall mobility falls as a result of the median age shifting towards age cohorts with lower rates of mobility. What is also similar is that the older age cohorts are relatively more car dependent than the younger ones and less reliant on public transport. There can, however, be read some deviations between the genders: Women have a much higher public transport modal share than men across the board and the difference in car dependence between men and women is also furthered by women being car-passengers at a much higher rate than men.




*Graph 5-10: Number of medium car, public transport, walking and cycling trips, 2016 vs. 2040*

The 2040 implications of the age cohorts' modal distributions are seen in graph 5-10. Car ridership is more evenly distributed on medium trips than what is the case on short and long ones, while public transport and cycling has the same spike amongst 25–34-year-olds seen in short trips. The distribution in walking is interesting in that it has a sharp uptake amongst 55–64-year-olds. In terms of relative growth towards 2040, the aggregates presented earlier are echoed in that public transport is projected to grow more moderately than cars – not a good development, in terms of reaching a sustainable mobility future.



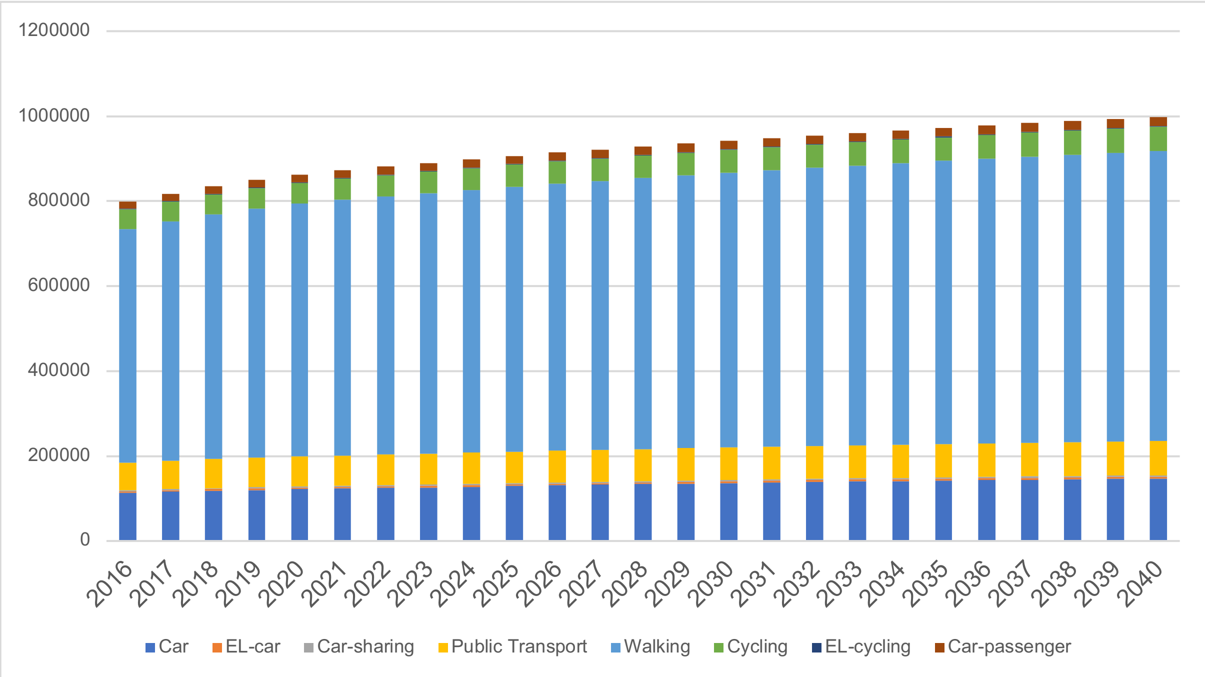

*Graph 5-11: Medium trips cars, public transport and cycling, men vs. women*

When subdividing for genders, it becomes clear that men and women have similar car mobilities in medium trips in terms of distribution across age cohorts. Yet women lack the 25–34-year-old car spike seen in men. This is however present in public transport, where women output considerable more trips at the aggregate than men, illustrating that in the medium trip length men are much more car dependent than women. However, the fact that the number of car trips is relatively high in the elder age cohorts as well as amongst 25–34-year-olds for both genders is challenging with respect to the zero-growth objective. An evenly high distribution of car ridership combined with a distribution of sustainable mode ridership being skewed towards the younger age cohorts translates into increased car dependence in the years to come due to the population's rising median age.

### 5.2.3 Short trips

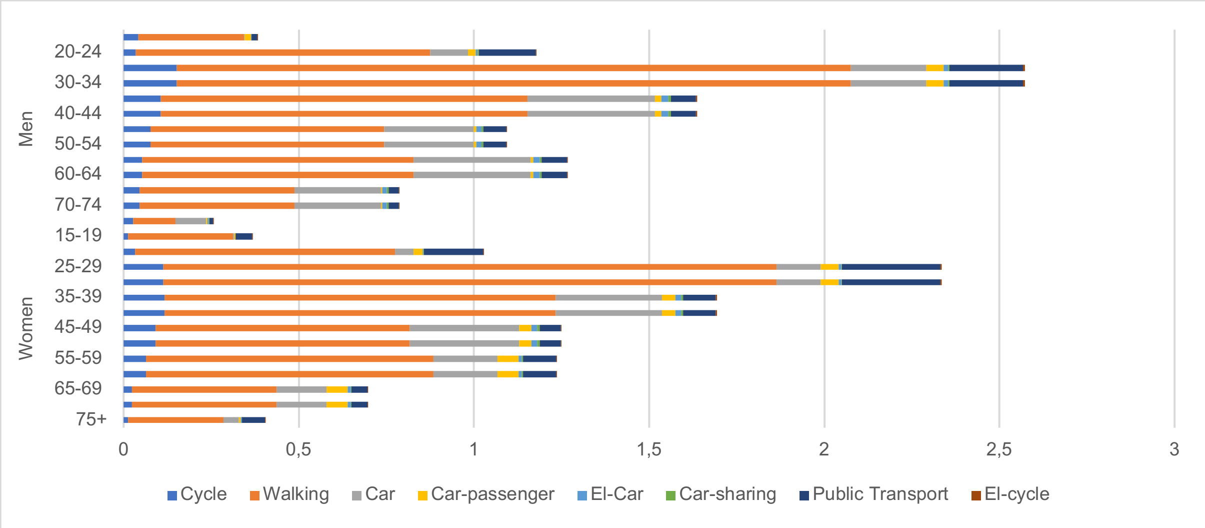
*Table 5-3: BAU short trips: Modes' percentage share of overall mobility, 2016 vs. 2040*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **2016** | 5.7% | 68.9% | 14.2% | 2.1% | 0.4% | 0.3% | 8.2% | 0.2% |
| **2040** | 5.7% | 68.4% | 14.7% | 2.1% | 0.5% | 0.3% | 8.1% | 0.2% |



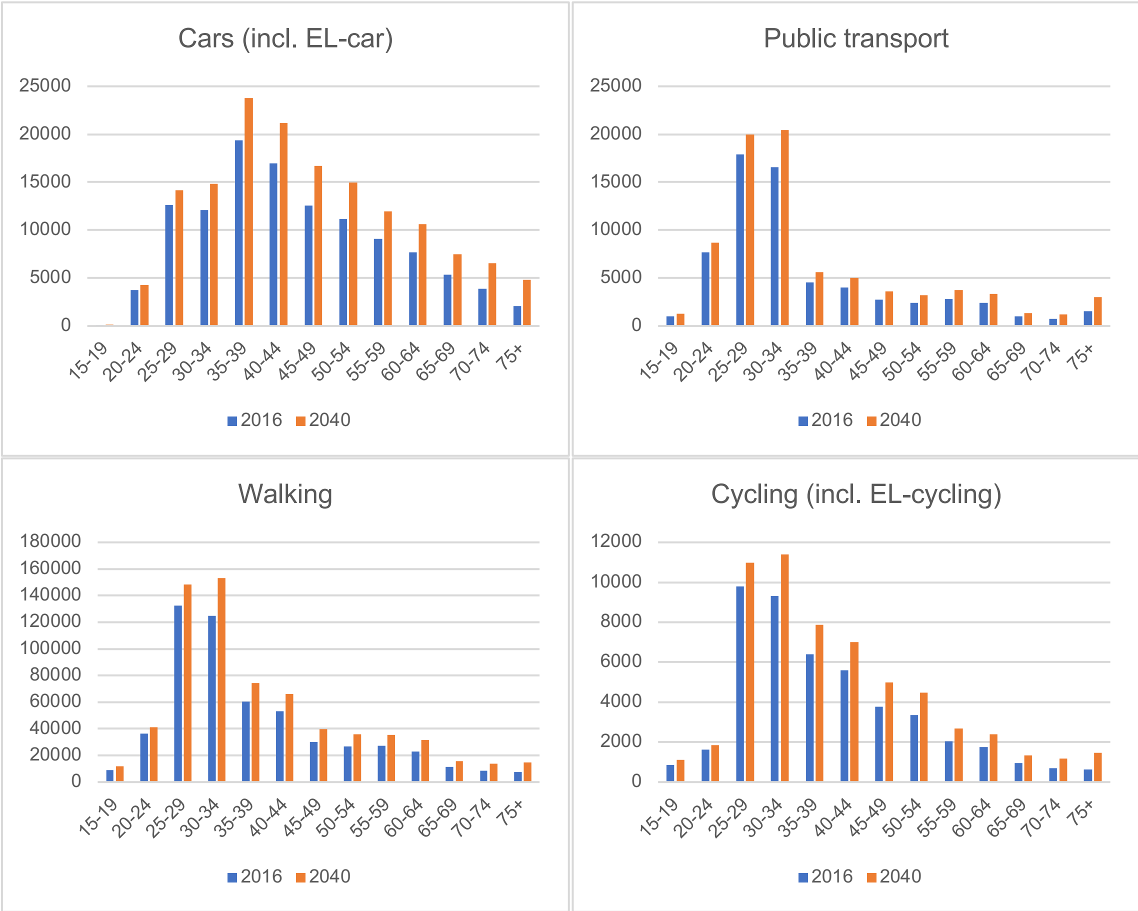

*Graph 5-12: BAU short trips: Total trips 2016–2040*

Overall mobility and its development in BAU short trips is very different from long and medium trips in that walking completely dominates as the mode of choice for daily trips. Still though, car is the second most popular mode and the difference between car and public transport modal shares is larger here than in the other trip lengths. Car trips grows from **113,286** in 2016 to **146,819** in 2040; corresponding to a **29.6%** increase as opposed to the aggregate trip growth of 25% (798,538 to 998,071). Here, as in the other BAU scenarios, overall mobility is down (cf. the 32% population growth) but car traffic again grows at a disproportional rate relative to the other modes. In comparison, public transport grows by 23.1% (65,397 to 80,530), walking by 24.1% (550,152 to 682,868) and cycling by 25.6% (45,397 to 57,034).




*Graph 5-13: Oslo mean number of daily short trips per capita*

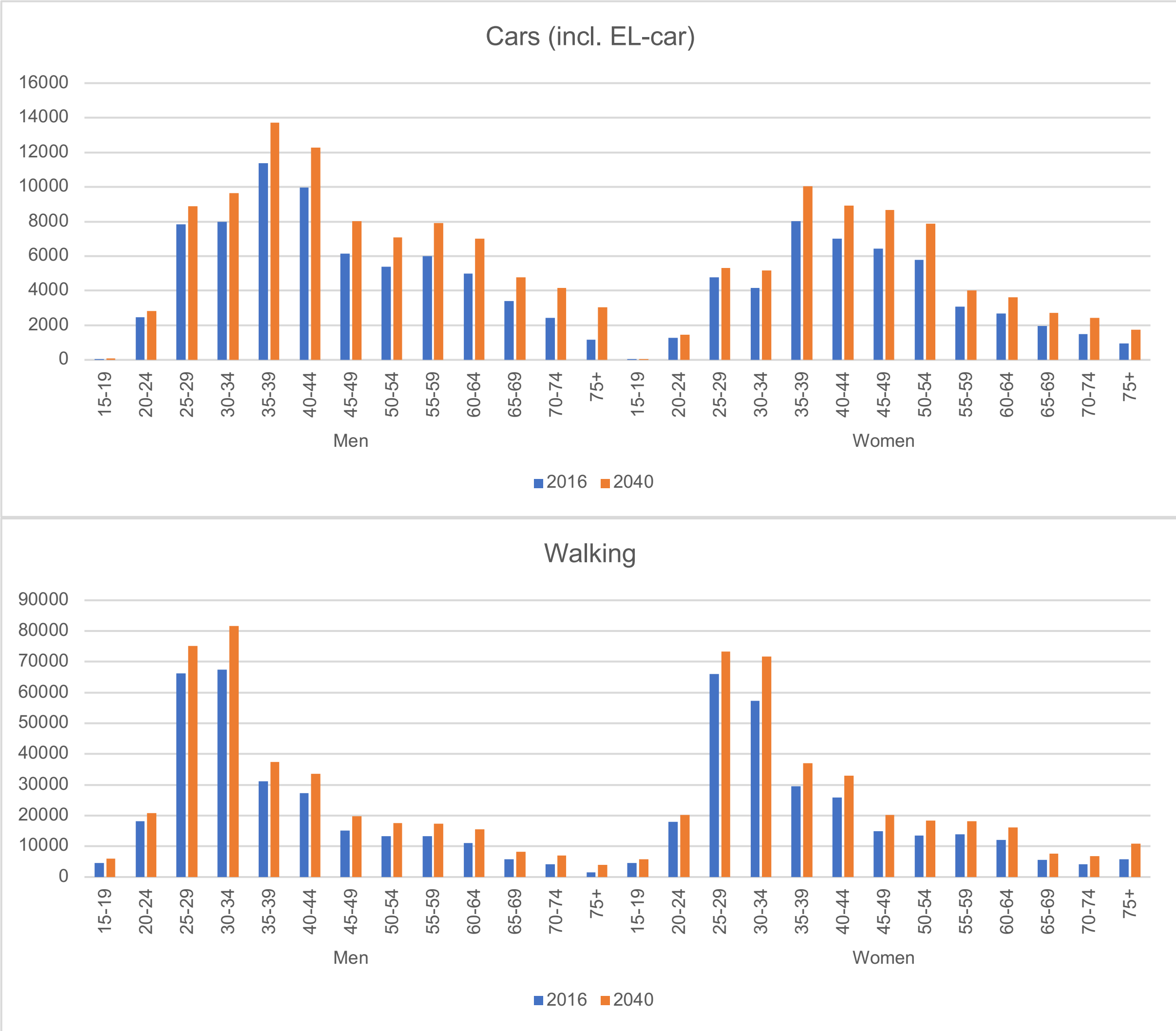
Graph 5-13 shows that much of the mobility patterns in terms of number of daily trips are similar to that in long and medium trips. In both genders, 25–34-year-olds have the highest rate of mobility and the falling overall mobility rate has the same explanation as in the other trip lengths, namely that the median age of the population is increasing and that the older age cohorts by 2040 account for a larger share of overall mobility. In short trips however, the older age cohorts' dependence on cars vis-à-vis the other trip lengths is particularly strong, as is evident from graph 5-13. This affects the various age cohorts' projected growth in cars, public transport, walking and cycling shown in graph 5-14:




*Graph 5-14: Number of short car, public transport, walking and cycling trips, 2016 vs. 2040*

Cars are clearly more evenly distributed across age cohorts than the other modes. Public transport and walking in particular stands out in having a spike in ridership amongst 25–34-year-olds, while cycling has a surprisingly even profile if one compares it to what is reported in the other trip lengths. This is reflected in the low aggregate growth rates projected for public transport and walking as opposed to cars; the disparity of which is the strongest in BAU short trips. This is somewhat concerning with respect to the zero-growth objective because it means that in a BAU development, the relative uptake in car trips will be the highest in short-distance trips. Such a trajectory does not fare well for Oslo's urban environment if it was to become reality.

As is the case in the other scenarios, when subdividing for the genders the mobility picture becomes more nuanced – there are deviations in men and women's mobility patterns in short trips as well. Seeing that walking is the predominant mode in BAU short trips, its development rather than that of public transport is compared cars' in graph 5-15:




*Graph 5-15: Short trips cars and walking, men vs. women*

When juxtaposed graphically, it becomes clear that men drive a lot more short-distance than women. It also becomes clear that there is a spike in car ridership amongst men aged 35–44 while for women, this spike is spread out over a larger age span (35–54-year-olds). The implications of this is seen in that the increasing median age brings with it a higher relative growth in car traffic for women amongst established workers than what is the case for men. This can be seen in that car traffic at the aggregate level grows by 30.1% for women (from 47,681 to 62,044) and 29.2% for men (from 69,175 to 89,389). The distribution in walking trips, on the other hand, is surprisingly similar between the two genders although overall walking mobility is also higher amongst men than women. The only deviation that stands out is that 75+-year-old women walk considerably more than men.

With respect to the zero-growth objective, both genders' mobility patterns will result in a strong relative increase in car ridership vis-à-vis other modes, but in different ways: Women have a broader age cohort spike in car ridership than men, which means that even though the population median age is projected to move upwards, it will still fall within one of the age cohorts where car ridership is high. For men, the ridership spike is narrower (consigned to 35–44-year-olds) but the elder demographics in men that today constitute a smaller share of the overall population are even more car dependent than 35–44-year-olds, according to current mobility distributions (cf. graph 5-13). The influx of more 45+-aged males will thus increase cars' overall modal share for men as well relative to other modes.

### 5.2.4 BAU summary

According to the BAU trajectories presented, car travel in total is expected to rise by **28.9%** from 2016 to 2040 which means that **96,014** daily long, medium and short car trips need to be substituted onto either walking, cycling or public transport by 2040 if the zero-growth objective is to be met. This number accounts for five percent of *all* trips expected to be conducted on a daily basis in 2040.

There are, however, both positive and negative traits that can be drawn from the BAU scenarios with respect to the zero-growth objective. On a positive note, overall mobility per capita is projected to fall which means each individual will carry out slightly fewer daily trips in 2040 than in 2016. This is derived from the population being projected to grow by more than the overall number of trips, the reason being that the median age is expected to rise. Across all scenarios, 25–34-year-olds conduct the highest number of daily trips and an ageing population means that these demographics will constitute a smaller share of the overall population, resulting in lower rates of mobility. This, of course, assuming that the age cohorts' rates of mobility remain constant towards 2040. As for negative implications, the projected car traffic growth is disproportionally high relative to the projected growth in sustainable modes of transport across trip lengths. This is because cars in general make up a larger share of overall mobility amongst the elder age cohorts. A rising median population age combined with a general population influx thus translates into elders' travel habits increasingly affecting overall mobility, making Oslo mobility more car-oriented.

## 5.3 Scenario set B: Towards zero-growth in car traffic

This chapter presents the zero-growth scenarios, i.e. trajectories where the sustainable modes identified by NTP have been set to grow and where mode substitution factors have been introduced to the model framework. Like in the BAU set, the scenarios are subdivided into short, medium and long trips. The goal here is to analyse how a zero-growth development in car traffic could unfold with an emphasis on the different demographic groups' responses to the growth rates and constraints set in terms of their projected mobility outputs. The results will be presented in a similar fashion to the BAU scenarios with much of the same graphs, tables and talking points being repeated inn all three trip lengths as points of comparison between them.

### 5.3.1 Long trips

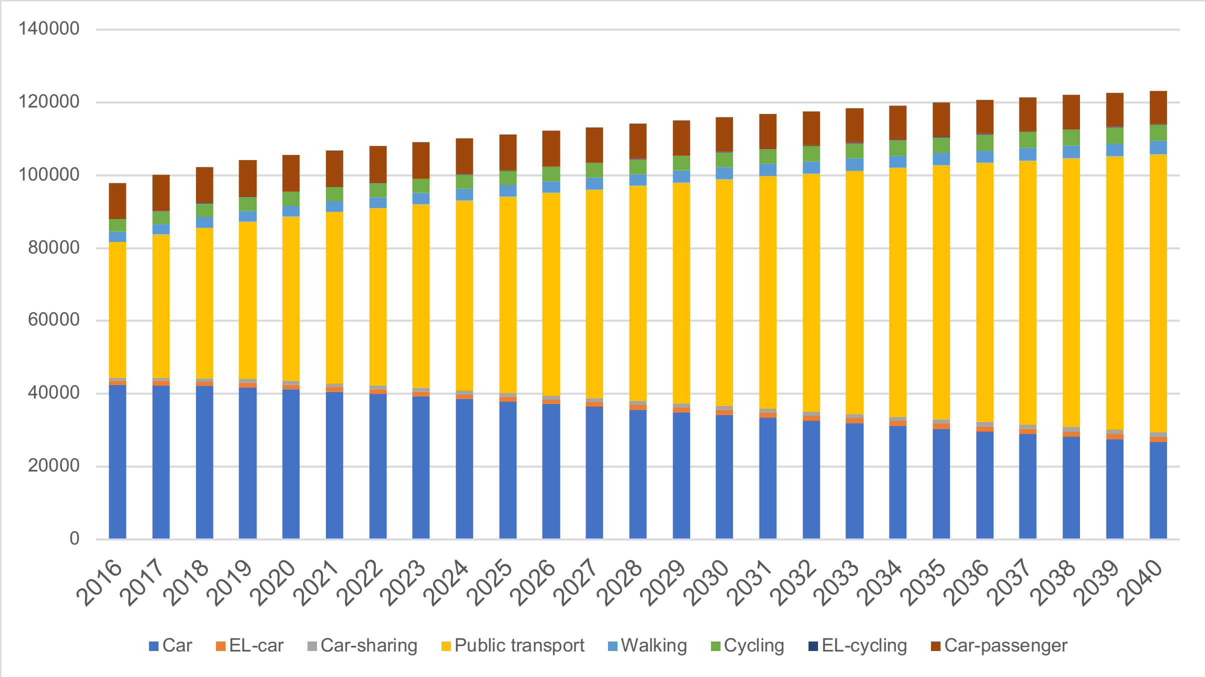
*Table 5-4: Zero-growth long trips: Yearly growth rates and capacities plotted*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **Growth** | 4% | 3% | 0% | 0% | 0% | 0% | 7% | 4% |
| **Capacity** | 7% | 5.8% | 43.4% | 10% | 1.2% | 0.9% | 76% | 0.2% |

For trips longer than 7.5 km, public transport is likely to have the highest potential for growth. It has therefore been given the maximum yearly growth rate of 7%. EL-cycling and cycling are both set to grow at a yearly rate of 4%. While EL-cycling arguably increases the range of cycling as a mode of transport for a number of people, its cost-to-entry barrier makes it unevenly applicable and since the same growth rate is plotted across age cohorts (cf. chapter 4.3.3), it was found better to keep its growth at-level with conventional cycling. Moreover, seeing that cycling overall also is to be assumed in this scenario due to the insecurities arising from the mobility estimates for EL-cycling, differentiating the two's growth rates was opted against. Walking was determined the least applicable mode of transport for long trips and thus given the lowest yearly growth rate at 3%.

*Table 5-5: Zero-growth long trips: Modes' percentage share of overall mobility, 2016 vs. 2040*

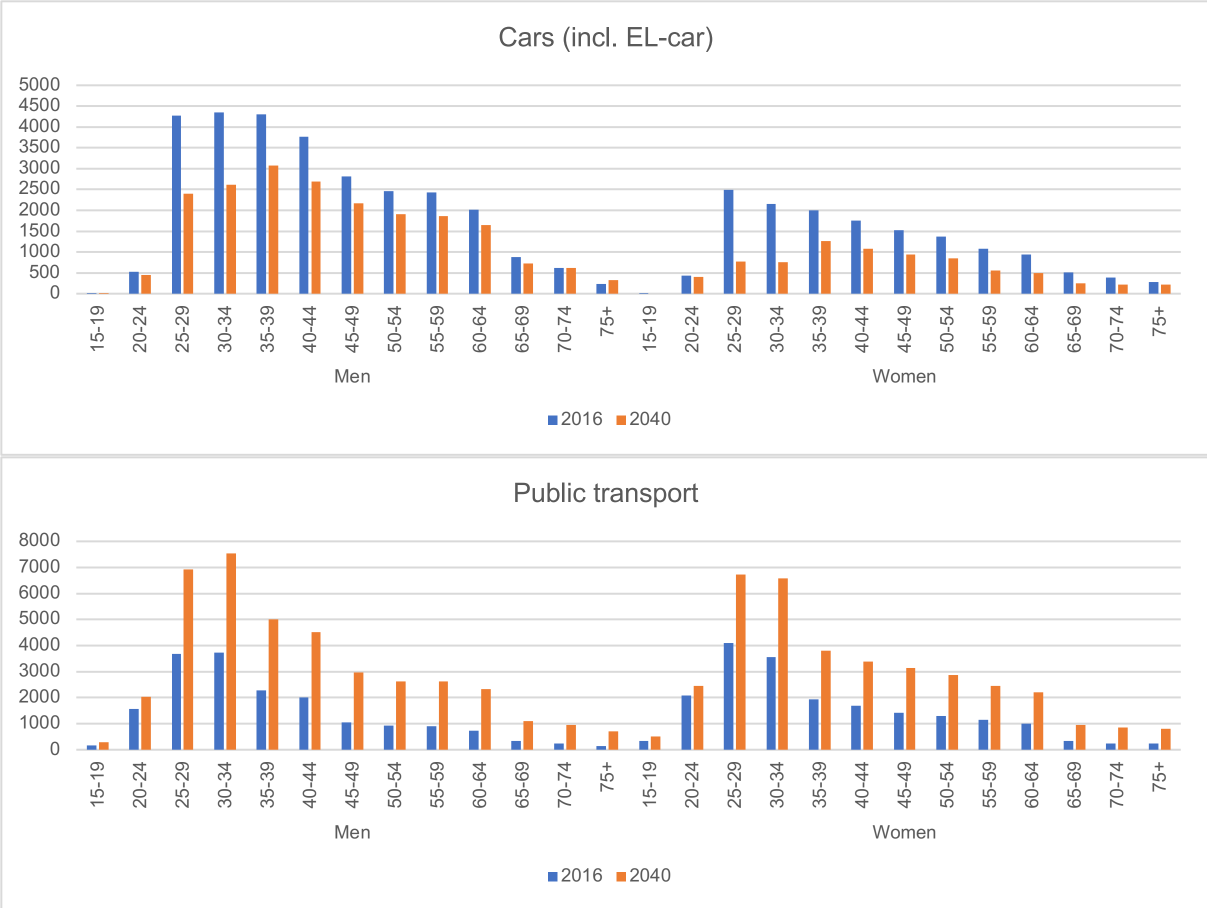
| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **2016** | 3.5% | 2.9% | 43.4% | 10% | 1.2% | 0.9% | 38% | 0.1% |
| **2040** | 3.6% | 2.9% | 21.8% | 7.5% | 1.2% | 0.9% | 61.9% | 0.1% |




*Graph 5-16: Zero-growth long trips: Total trips 2016–2040*

Table 5-5 and graph 5-16 show the aggregate development for long trips in the zero-growth scenario. It is apparent that almost all shifts away from car travel will be absorbed by public transport. From 2016 to 2040, daily car trips fell from **42,416** to **26,819**; or by **-36.8%**. This scenario therefore more than qualifies in reaching the zero-growth objective at the aggregate level as the total number of car trips falls. Public transport on the other hand grows by 105.1% (37,202 to 76,317), walking by 27.8% (2,826 to 3,611) and cycling by 26.8% (3,470 to 4,401). The population growth is the same as in BAU; 32%.

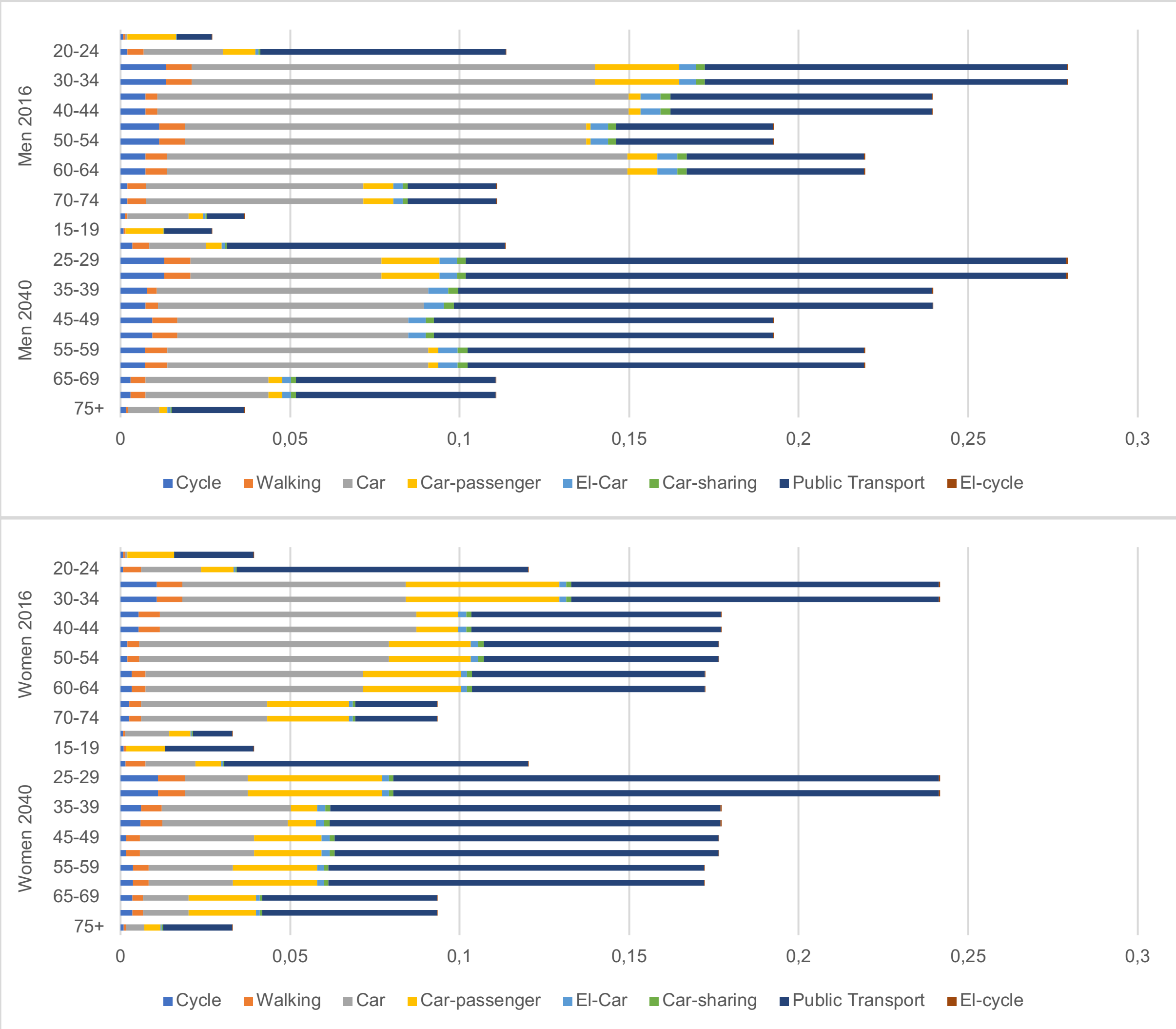
The main point of interest, however, is not the aggregate but rather how the decline in car ridership is projected to be distributed across age cohorts. Keep in mind that the exact same growth factors and associated capacities on the various modes have been plotted for all of them. Because public transport is the mode that was considered the best suited absorbent for car traffic growth in long trips and was given the highest growth rate, graph 5-17 illustrates how daily car and public transport ridership differs between them, juxtaposing figures from 2016 and 2040:




*Graph 5-17: Car and public transport mobility in zero-growth long trips, 2016 vs- 2040*

At least amongst men, one clear trend emerges: from 25-year-olds and onwards, the number of trips transferred away from cars becomes relatively weaker in increasing age. In other words, the older the population, the stronger the rates of transfer needed to secure zero-growth in car traffic – to the point where men older than 75 years actually have more car trips in 2040 than in 2016 despite car travel being set to not grow. This development should not be mistaken as a result of trips not being transferred onto the sustainable modes. The lower panel in graph 5-17 demonstrates clearly that public transport is absorbing would-be car trips for all demographics. The differing rates of car ridership transfers between the age cohorts is a result of two factors: The population increase and its associated rising median age, and the mode substitution factors' effect on altering mobility habits.

The population development's effect can be understood from looking at graph 5-1. It illustrates quite clearly how the projected population increase for 75+-year-olds in particular differs from what is projected for the rest of the population. It will grow by 113.2% towards 2040 compared to the overall population's 32%. This comparatively large influx of people therefore in effect counters some of the effect yielded by the growth rates set for the sustainable modes. In other words, the main “problem” for the elder cohorts in general and 75+ men in particular is not that trips are not transferred away from cars but rather that the population increase is so massive in this demographic that the overall number of trips conducted for *all* modes will grow despite the transfers set. Keeping in mind the notion of an ageing population, this effect turns out to become stronger in increasing age.




*Graph 5-18: Oslo mean number of daily long trips per capita; current vs. 2040 mobility distribution*

Graph 5-18 underscores the point made above as it shows how the mode substitution factors have altered the modal distribution within the population’s mean number of daily trips by 2040. The upper half of each panel shows the distribution as plotted in BAU (current distribution according to RVU and the estimates) while the lower half shows the projections for 2040 after the growth rates and mode substitution factors have been applied. Note that the number of mean daily trips per capita is the same in both 2016 and 2040 for all age cohorts; the only thing that is changed is the modal distribution through substitution. It is evident that by 2040, public transport has taken over large chunks of cars' modal share for all age cohorts; including the older ones. This is due to the substitution factors taking effect towards 2040, shifting patronage from car travel and onto the NTP modes. Table 5-6 shows how the growth rates and mode substitution factors have affected the modal shares of the four modes in question by contrasting 2016 mobility with that projected for 2040. The population is here subdivided into the broader demographic categories introduced in chapter 5.1.

*Table 5-6: Zero-growth long trip modal shares, 2016 vs. 2040, for broader demographic categories*

| | Car/EL-car | | Public transport | | Walking | | Cycling/EL-cycling | |
|---|---|---|---|---|---|---|---|---|
| | ***2016*** | ***2040*** | ***2016*** | ***2040*** | ***2016*** | ***2040*** | ***2016*** | ***2040*** |
| **Youth** | 15% | 12% | 65% | 71% | 4% | 4% | 1% | 2% |
| **Young workers** | 41% | 19% | 40% | 64% | 3% | 3% | 4% | 4% |
| **Established workers** | 54% | 29% | 32% | 59% | 3% | 3% | 3% | 3% |
| **Elders** | 50% | 25% | 27% | 56% | 4% | 3% | 2% | 3% |

The results above are interesting, because they mean that it is not only the population increase amongst the older age cohorts that causes transfers from cars to weaken in increasing age. The mode substitution factors also contribute to this effect. The overall modal share for public transport in 2040, cf. table 5-5, is projected to 61%. The deviations from this shown above indicate that there is a lower level of probability for elders to shift onto public transport in long trips than what is the case for the younger age cohorts. The implication of this is that the habitual change needed to substitute public transport for car travel becomes even higher in increasing age. This further underline the issue that when steering equally across all demographics towards modal shifts, their rates of transfer from cars onto sustainable modes of transport are bound to vary considerably when population growth and mode substitution factors are taken into account. As such, the takeaway is that for long trips, increasing age warrants increasing growth rates in sustainable modes and stronger habitual changes if the entire population is to reach zero-growth in car traffic; at least according to these projections.

### 5.3.2 Medium trips

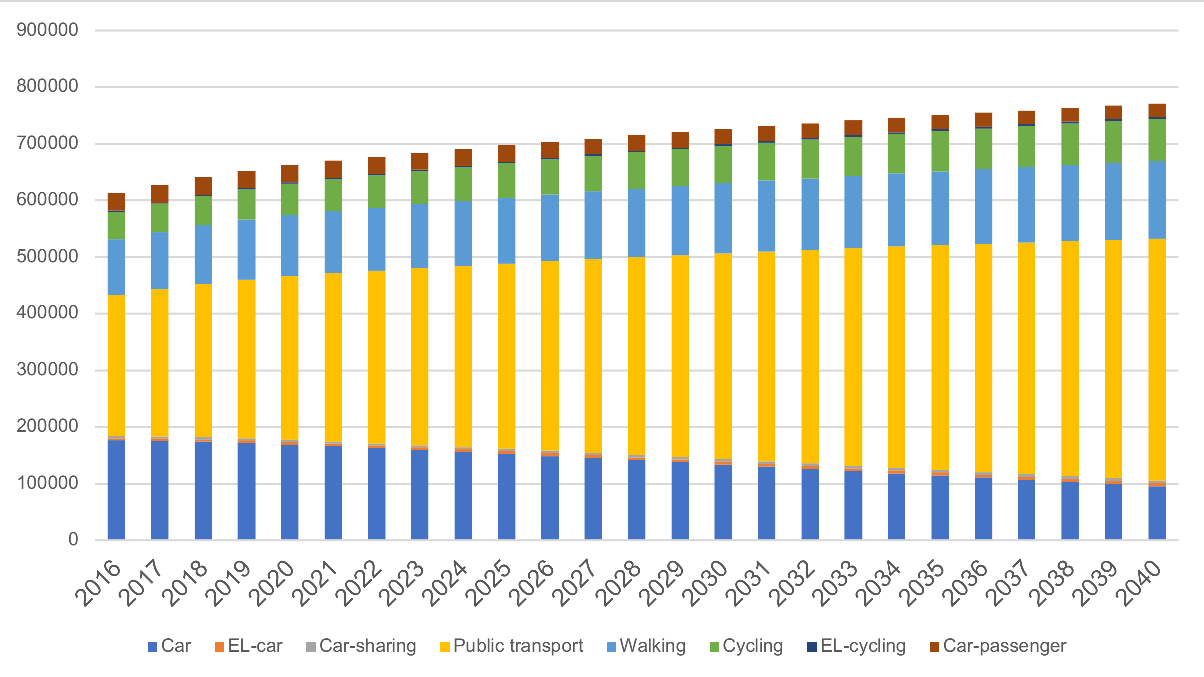
*Table 5-7: Zero-growth medium trips: Yearly growth rates and capacities*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **Growth** | 7% | 4% | 0% | 0% | 0% | 0% | 6% | 7% |
| **Capacity** | 16.4% | 28% | 36.4% | 3.4% | 1.2% | 0.8% | 71.4% | 0.6% |

For medium trips, cycling (incl. EL-cycling) is considered the mode with the highest growth potential towards 2040 and is therefore awarded a yearly growth rate of 7%. However, it is not applicable to everyone. For some, cycling is not an option at this trip interval and seeing that 2.5–7.5 km is still relatively far in terms of walking daily, public transport was given a high growth rate here as well at 6%. Walking was set to 4%; meaning it is deemed somewhat suited for the trip length but less so than cycling and public transport.

*Table 5-8: Zero-growth medium trips: Modes' percentage share of overall mobility, 2016 vs. 2040*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **2016** | 8% | 16.1% | 28.8% | 5.1% | 0.7% | 0.6% | 40.6% | 0.2% |
| **2040** | 9.8% | 17.7% | 12.4% | 3% | 0.7% | 0.6% | 55.4% | 0.4% |

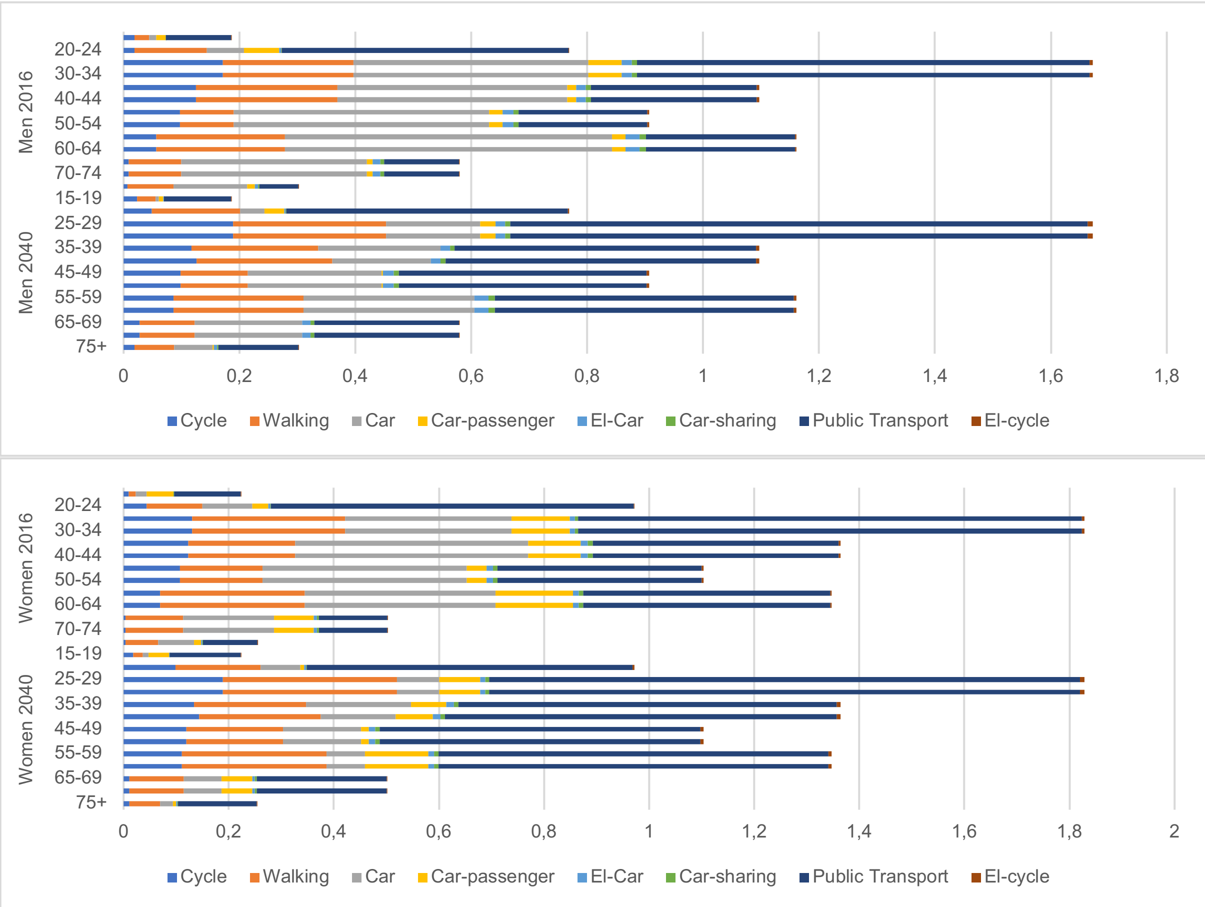



*Graph 5-19: Zero-growth medium trips: Total trips 2016–2040*

Overall, the medium trips scenario sees a car traffic decline from **176,250** daily trips in 2016 to **95,525** in 2040, corresponding to **-45.8%**. Cycling overall (modes *cycling* and *EL-cycling*) which was given the highest yearly growth rate of 7% sees ridership increase by 56.5% (50,263 to 78,641). Public transport, at a 6% yearly growth rate increases by 71.6% (248,813 to 426,867) and walking increases by 38.1% (98,581 to 136,164). In other words, although cycling was given the highest yearly growth rate out of the sustainable modes, public transport surpassed its growth at the aggregate level. This is because, as mentioned, that in addition to the growth rate set the mode substitution factors also play a role in determining mobility developments.


*Graph 5-20: Car, cycling and public transport mobility in zero-growth medium trips, 2016 vs- 2040*

Similar to what was shown in long trips, on medium trips there is a decreasing rate of relative transfers away from car travel in older age. The total number of car trips is up for both 70–74 and 75+-year-old men in 2040 compared to 2016. Women also demonstrate the same tendency, but the overall number of car trips still falls across all women age cohorts. The same mechanisms are at play here as in long trips; the projected population growth, skewed towards the older age cohorts, results in these demographics outputting much more trips than before. Note that amongst 25–34-year-olds, the relative decline in car trips is much stronger for women than for men. As is apparent from the lower panels in graph 5-20, these trips are by and large substituted onto public transport and cycling. The same transfers happen to a lesser extent for men, but women in this age cohort seems particularly transferrable away from cars and onto the modes set to grow in this scenario. Overall, however, the relative decline in car trips achieved in medium trips across age cohorts is smaller than what is the case in long trips. The rates of substitution are therefore weaker here which is interesting, considering that the sum of the yearly growth rates set for the sustainable modes in this scenario was higher than in long trips. Medium trips thus prove to be less transferrable than long ones, according to the scenario framework.




*Graph 5-21: Oslo mean number of daily medium trips per capita; current vs. 2040 mobility distribution*

The mode substitution factors have had a considerable effect on the age cohorts' modal distributions in this scenario as well, but the difference in rates of negative transfers from cars and onto the sustainable modes is clearly visible between the genders in graph 5-21. Most age cohorts in women have gone from being relatively car dependent to relying on public transport, cycling and walking for most trips by 2040, but the same cannot be said for men. Middle aged and older men are projected to remain car dependent on account of their mode substitution factors which explains the strong discrepancies in rates of negative transfers seen in graph 5-20. Because this effect is amplified by the ageing median population it is safe to conclude that medium trips represent the trip interval among the zero-growth scenarios wherein the weakest shifts onto sustainable mobility are projected as a whole.

*Table 5-9: Zero-growth medium trip modal shares, 2016 vs. 2040, for broader demographic categories*

| | Car/EL-car | | Public transport | | Walking | | Cycling/EL-cycling | |
|---|---|---|---|---|---|---|---|---|
| | *2016* | *2040* | *2016* | *2040* | *2016* | *2040* | *2016* | *2040* |
| **Youth** | 9% | 7% | 67% | 63% | 13% | 17% | 4% | 9% |
| **Young workers** | 24% | 10% | 46% | 58% | 16% | 17% | 9% | 11% |
| **Established workers** | 39% | 17% | 30% | 51% | 17% | 18% | 9% | 10% |
| **Elders** | 43% | 21% | 27% | 50% | 21% | 21% | 1% | 5% |

First, it is interesting that the walking modal share on daily medium trips is actually increasing in age by quite a lot. Second, there is a clear generation gap in terms of car dependency from the get-go in medium trips where car ridership increases in age while public transport ridership decreases. In terms of mobility towards 2040, when merging the genders and assuming the broader demographic categories, the difference in relative rates of substitution away from cars between the genders seen in graph 5-20 is evened out; resulting in that all four demographic categories see a similar percentage reduction in car ridership. But because elders currently have the highest car dependency, their end-point becomes much higher than that of the younger cohorts while the reverse is true for public transport. If compared with the substitution seen in long trips however, it is clear that the relative percentage decrease in cars' modal share towards 2040 is much weaker in medium trips. In conclusion, genders combined actually see even and moderate relative substitution away from cars as a result of the growth rates and mode substitution factors plotted for medium trips. Though if dividing men and women, it becomes clear that this is due to women being relatively easily transferred while men are not.

### 5.3.3 Short trips

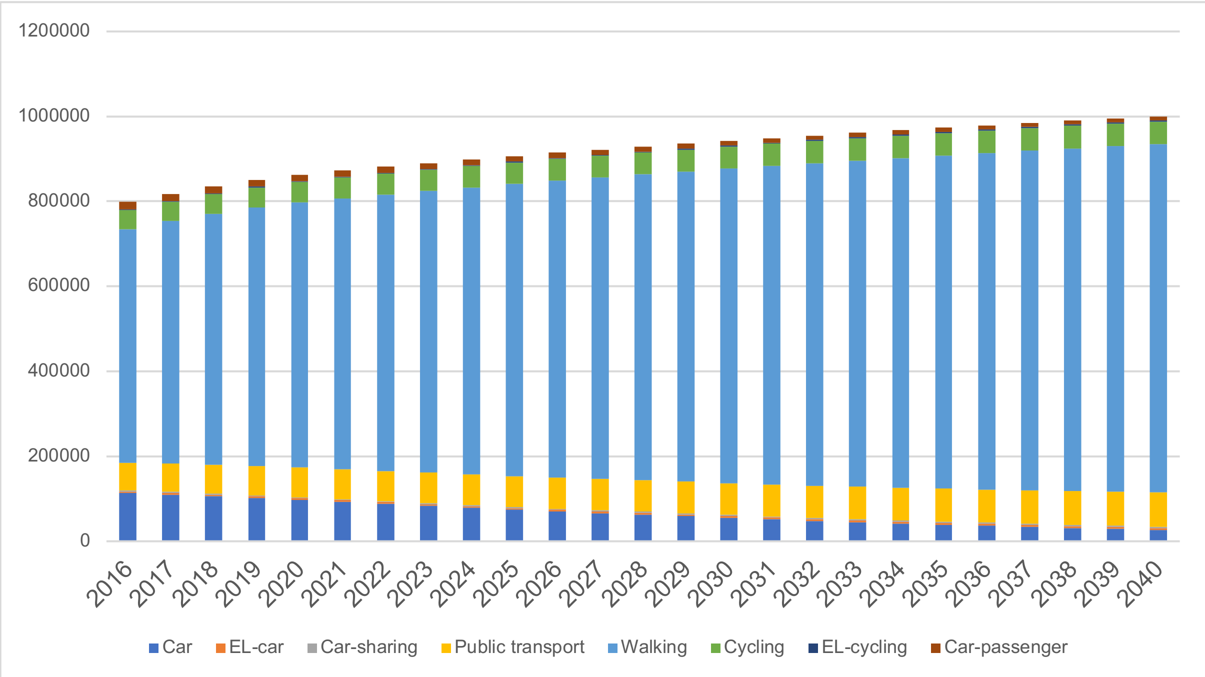
*Table 5-10: Zero-growth short trips: Yearly growth rates and capacities*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **Growth** | 7% | 5% | 0% | 0% | 0% | 0% | 3% | 7% |
| **Capacity** | 11.4% | 100% | 14.2% | 2.1% | 0.4% | 0.3% | 16.4% | 0.4% |

Following to the arguments made in long and medium trips, walking should be given the highest growth rate is short trips, but this was decided against. Walking already completely dominates this trip length with a 2016 modal share of 68.9%. A growth rate of 7% would therefore result in a very inflated development; pushing the walking modal share north of 90% in 2040. Cycling on the other hand has a more modest 2016 modal share of 5.7% and has ample applications for trip lengths up to 2.5 km. Cycling (incl. EL-cycling) was therefore given a growth rate of 7% here as well, while walking was set to 5%. Public transport was considered the least suited mode for growth in short trips, and therefore given a growth rate of 3%.

*Table 5-11: Zero-growth short trips: Modes' percentage share of overall mobility, 2016 vs. 2040*

| | Cycling | Walking | Car | Car-passenger | EL-car | Car-sharing | Public transport | EL-cycle |
|---|---|---|---|---|---|---|---|---|
| **2016** | 5.7% | 68.9% | 14.2% | 2.1% | 0.4% | 0.3% | 8.2% | 0.2% |
| **2040** | 5.3% | 82% | 2.7% | 0.8% | 0.5% | 0.3% | 8% | 0.3% |

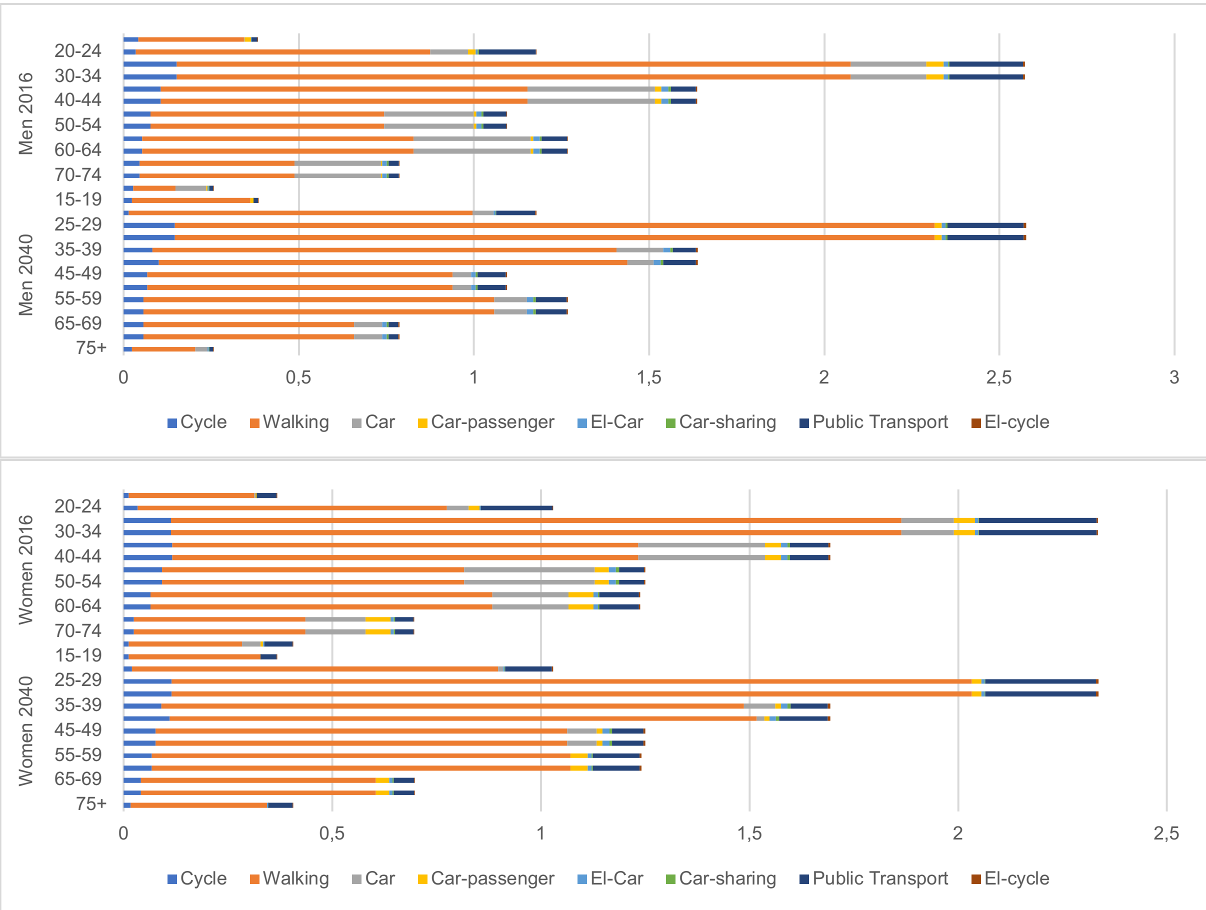



*Graph 5-22: Zero-growth short trips: Total trips 2016–2040*

Starting with the aggregate, the zero-growth scenario for short trips results in car traffic falling from **113,289** to **26,635** (**-76.5%**). Cycling overall, i.e. the modes set to have the highest growth rate grows by 20.6% (46,801 to 56,456), walking by 49% (550,152 to 819,574) and public transport by 22.9% (65,397 to 80,342). This development shows why walking was not given a higher yearly growth rate than 5% because its dominant modal share and favourable mode substitution factors would dwarf the other modes' growth trajectories.


*Graph 5-23: Car, cycling and walking mobility in zero-growth short trips, 2016 vs- 2040*

The decreasing relative rate of negative transfers from cars and onto sustainable modes in age is also present in short trips, but only for men. Here, 75+-year-olds end up having slightly more car trips in total in 2040 than in 2016; again, partially as a result of these age cohorts' relatively high population growth. This development is however not at all present in the same way amongst women, where car ridership falls considerably for all age cohorts. Both in men and women, the relative fall in car ridership is the strongest amongst 25–34-year-olds who seem to be particularly ready to substitute cars for sustainable modes in short trips. 40–44-year-old women also demonstrate this tendency. It is also worth noting that the total-number-of-trips-spike characterising 25–34-year-olds across scenarios is not as clearly present amongst women drivers on short-distance trips – trips are instead more evenly distributed and women in general conduct much fewer daily short-distance car trips than men. Regarding trip growth in the modes set to grow, it too is very evenly distributed relative to 2016 mobility when compared to the negative transfers from cars. However, in the youngest age cohorts for men, the number of cycling trips actually falls from 2016 to 2040 – despite cycling being set to grow. This is on account of the mode substitution factors plotted where walking and cycling function as near substitutes, causing them to counter each other's growth. The relatively high modal share of walking as opposed to cycling means the former "wins" this tug-of-war.




*Graph 5-24: Oslo mean number of daily short trips per capita; current vs. 2040 mobility distribution*

The effect of the mode substitution factors and growth rates on the population's short trip modal distribution can be summarised as walking going from dominating- to completely overshadowing the other modes' rates of mobility towards 2040. Car ridership has been nearly decimated by 2040 amongst 25–34-year-olds, as reflected in graph 5-24, and has been greatly reduced in the other age cohorts as well. Despite its high growth rate, however, cycling has not been able to absorb that much mobility, being dwarfed by walking's dominant modal share and matching relative growth. Table 5-12 shows how this has plaid out for the different broader demographic categories:

*Table 5-12: Zero-growth short trip modal shares, 2016 vs. 2040, for broader demographic categories*

| | Car/EL-car | | Public transport | | Walking | | Cycling/EL-cycling | |
|---|---|---|---|---|---|---|---|---|
| | *2016* | *2040* | *2016* | *2040* | *2016* | *2040* | *2016* | *2040* |
| **Youth** | 6% | 3% | 14% | 9% | 73% | 85% | 4% | 2% |
| **Young workers** | 10% | 2% | 9% | 9% | 73% | 83% | 6% | 6% |
| **Established workers** | 23% | 5% | 6% | 7% | 63% | 81% | 6% | 6% |
| **Elders** | 25% | 6% | 7% | 7% | 59% | 78% | 5% | 7% |

In contrast with what was the case in longer trips, elders seem to be more readily transferred onto sustainable modes in short trips on account of their mode substitution factors; almost to the same extent as younger cohorts. Across all demographic categories, cars' modal share is down in single digits by 2040 and walking is within the 78–85% range. This development is interesting because the 2016 modal share for cars varied considerably between the groups. As such, the relative decline in car ridership is actually stronger amongst elders than the younger cohorts, in contrast with what is the case for longer trips.

### 5.3.4 Results summary

As the results from the six scenarios above were presented and analysed through extensive use of graphs, numbers and tables, it seems like a nice change of pace to summarise the main findings in bullet point form. The BAU scenarios found that:

1. The total number of daily car trips will increase by 96,014 within 2040 if nothing changes to current mobility. If the zero-growth objective is to be met at the aggregate level, these trips need to be substituted onto either public transport, walking or cycling

2. 25–34-year-olds have the highest rates of mobility across trip lengths. Because the median age within the population is shifting towards older age cohorts, the overall mobility rate is projected to fall relative to the population increase

3. The older age cohorts are more car dependent than the younger ones. A rising median age therefore means that cars are projected constitute a larger share of overall mobility in the years to come if current mobility trends remain constant

The zero-growth scenarios found that:

1. There is a clear general tendency that growth rates for sustainable modes need to be stronger in older age cohorts than in younger ones to achieve zero-growth in car traffic for them all. This applies across all trip lengths

2. Three factors cause the above effect: Older people in general being more car dependent than younger people, the demographic shift in terms of an ageing population, and elders having weaker mode substitution factors from cars onto sustainable modes on some trip lengths. The population effect in particular will make it hard for elders to maintain overall car travel at today's levels

3. The age cohorts corresponding to established workers in general have a high car dependency per capita both now and in 2040. However, this demographic can still be projected to achieve zero-growth in car traffic because its population growth is expected to be somewhat weaker than what is the case for the oldest age cohorts

4. In general, men prove harder to shift away from cars and onto sustainable modes than women, in part due to men being more car dependent than women. This is particularly true for medium trips (2.5–7.5 km)

5. 25–34-year olds, while having the highest rates of mobility out of all age cohorts, are relatively easily transferred onto sustainable modes on account of their mode substitution factors and in-general low car dependence. Successfully shifting this demographic goes a long way in reaching the zero-growth objective at the aggregate level because they constitute a large part of overall daily mobility

6. The rising median age, however, counters some of the effect in ease of shifting 25–34-year-olds onto sustainable modes because by 2040, this group will constitute a smaller share of Oslo's overall population and number of daily trips than what is the case today

# 6 Discussion

This chapter provides points of discussion derived from the scenario results presented in the previous chapter. It starts by very briefly contrasting the results from BAU and the zero-growth scenarios before moving on to the back-cast discussion. This starts by distancing current mobility from the future one and establishing a sustainable mobility future as the vantage point for discussion. The chapter goes on to identify for whom a change in mobility is needed and by how much through leaning on the findings in the zero-growth scenarios. It also provides a brief re-introduction to the modes in question: Car-sharing, ridesharing and cycling. Unlike the scenario analyses, the back-cast discussion on these modes' application for sustainable mobility obtainment is more unstructured in the sense that there is no chapter subdivision on trip length, demographics or modes assessed. Rather, the approach is more holistic, serving as a counterweight to the somewhat atomistic approach sought in the scenario analyses. The end goal of this discussion is to identify the potential applications of car-sharing, ridesharing and cycling in furthering a sustainable Oslo mobility.

## 6.1 Contrasting the two scenario worlds

The BAU and zero-growth scenarios represent two very different worlds. In BAU, the current socio-technical system remains more or less untouched with only slight deviations to current modal distribution. Car traffic remains dominant within the demographic groups and trip lengths it dominates today and although public transport, walking and cycling ridership grows as well, it is not due to structural changes in the mobility system. Rather, it us due to an increasing population with a shifting age distribution. Extrapolating such a trajectory is very useful when assessing sustainable mobility because it benchmarks the "worst case" future as being a one that echoes the present – illustrating quite clearly that change is needed if the zero-growth objective is to be met. BAU found that in total, there will be 96,014 more daily car trips in 2040 compared with today. Considering that Oslo's population is projected to increase by 175,036 people over the same period, this means that each additional Oslo resident in the years moving forward will contribute to 0.55 daily car trips being added to Oslo's traffic. This comes in addition to the growth projected for other modes of transport which will also see increased ridership as a result of the population influx.

The zero-growth scenarios on the other hand represent a break with the current socio-technical system in that mobility is set to move away from car traffic across demographic groups and trip lengths. Car travel is thus set to develop from being a backbone mode of transport to becoming marginalised by letting the modes identified by NTP (public transport, walking and cycling) take over the lion share of Oslo mobility. In this effort, the zero-growth scenarios demonstrate that the extent by which this could be projected, when giving sustainable modes the same growth rates across age cohorts, varies which is the main takeaway from their results and what feeds into this discussion going forward. The need for further discussion is due to the fact that unlike BAU, the face-value of the zero-growth scenario results lack context. They are merely a product of the growth and non-growth inputs plotted which say nothing about how the results may be accomplished in real life. Moreover, the zero-growth scenarios did not succeed on projecting zero-growth in car traffic for all age cohorts because the older demographics proved harder to shift due to a combination of strong population growth and high baseline car dependency. This chapter sets out to remedy both these issues, providing the appropriate theoretical context for real-life obtainment of sustainable mobility and to explore how this can be achieved for all age cohorts by introducing car-sharing, ridesharing and cycling to Oslo mobility.

## 6.2 Distancing current mobility from sustainable mobility

Although the zero-growth scenarios represent a break away from current mobility, residues of current travel trends remain in them. First, the current mobility patterns of the various age cohorts stay constant in the sense that they start out representing current mobility habits and are altered by applying mode substitution factors. The implication of this is that as people age, they are assumed to adopt the travel habits of their "new" age cohort. As the scenario results show, this becomes increasingly problematic in older age but beyond that, it is very unlikely that such strict divisions exist between the age cohorts in real life. Second, much of the projected hardships in shifting the oldest age cohorts onto sustainable modes have to do with this demographic's extremely rapid population growth. Its total number of outputted car trips thus more easily surpasses current levels solely due to this, which is an important caveat to the scenario results presented. Third, the scenarios are extrapolations of today's mobility and although the zero-growth ones assume shifts occurring, they still follow a trend-line originating from current mobility. In other words, they do not account for disruptions or shocks occurring at some point down the timeline to Oslo mobility but represent an even growth trajectory envisioned on the basis of current mobility.

Dreborg (1996) argues that a back-casting approach is a well-suited alternative to scenario extrapolations because when faced with long-term problem solving where the outcome is uncertain, a normative approach wherein a goal is identified first provides a problem-solving framework that is independent of current trends. Vergragt & Quist (2011) also support this notion and note that the concept of sustainability is inherently normative, arguing that "as back-casting is about desirable futures – the futures we would like to get – it has a strongly normative nature too, and therefore it is especially well equipped to be applied to sustainability issues". Such an approach thus allows for distancing the goal of sustainable mobility from the constraints of current mobility which the scenario projections are somewhat dependent on. That being said, the back-cast discussion will still lean on the zero-growth scenario findings in identifying key barriers and opportunities for goal obtainment, as the two are not considered competing frameworks of analysis but complementary. While the zero-growth scenarios provide potential pathways towards the zero-growth objective, the forthcoming discussion seeks to theorise filling the scenarios' identified sustainability gaps by applying car-sharing, ridesharing and cycling.

To that end, the sub-chapters below will briefly formulate a goal for future Oslo mobility, present which demographic groups need to change travel habits and by how much according to the scenario projections and lay out the modes of transport that are to play a role in reaching the mobility goal. The point of this is to pool some key takeaways from various parts of this thesis to serve as a benchmark for starting the back-cast discussion.

### 6.2.1 What is the goal for Oslo mobility?

Throughout this thesis the terms *zero-growth objective* and *sustainable mobility* have been used somewhat interchangeably. Both represent a goal for Oslo mobility. The zero-growth objective refers to the goal put forward in NTP where car traffic is to be kept at today's levels and future traffic growth is to be absorbed by public transport, walking and cycling. Sustainable mobility is a broader and looser defined term but corresponds here to developments away from car dependency; potentially in part by steering it towards car-sharing, ridesharing and cycling. As such, the zero-growth objective can be understood to represent the foundation upon which sustainable mobility in Oslo is to be built. The goal is therefore a future in which personal car travel no longer constitutes a backbone mode of transport by 2040.

#### 6.2.2 Who needs to change and by how much?

The scenario frameworks demonstrated that all demographic groups in Oslo will have to change their travel habits if the sustainable mobility future outlined above is to become a reality, but by how much varies between them. In general terms, men were reported to be both more car dependent and harder to shift onto sustainable modes than women. In terms of age cohorts, those corresponding to established workers and elders (from 40-year-olds and upwards) have the highest car dependency. Elders are more car dependent than established workers on short and medium trips, while the reverse is true for long trips. Elders still have the strongest need for habitual change overall if their aggregate outputted car ridership is to be kept at today's levels because this demographic group is set to see a massive population increase in the years to come. The younger cohorts, several of whom have high rates of mobility, are less car dependent and also appear to be more readily transferred onto the NTP modes on account of their mode substitution factors. Thus, when considering the zero-growth scenario results, successfully transferring the elder age cohorts and men in particular onto sustainable modes will yield the most benefit on reaching the goal outlined above.

#### 6.2.3 What is the starting point for discussion?

The starting point for the back-cast discussion is a mobility future similar to that projected in 2040 by the zero-growth scenarios wherein public transport dominates alongside an uptake in walking and cycling use. This has led cars to no longer having a dominant position in Oslo mobility compared with today. The points of discussion are car-sharing, ridesharing and cycling's role and compatibility in such a future and how or whether they can function as agents for securing its obtainment for all demographic groups in Oslo – filling the voids and challenges identified in the scenarios.

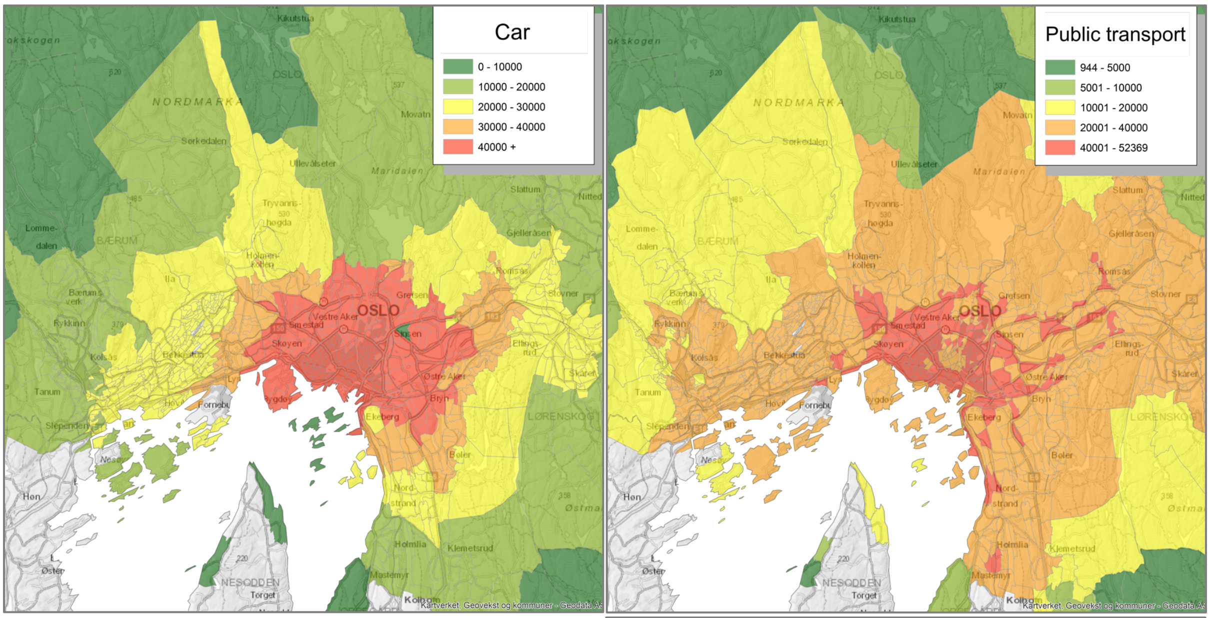
## 6.3 Assessing the applicability of car-sharing, ridesharing and cycling

In this chapter, the assessments for the modes' applicability are made based on the empirical and theoretical information presented in chapter 3 as well as the scenario results generated in chapter 0. The assessments are subdivided into four subchapters: Where the various modes might be applicable, for whom they might work as substitutes for car travel, in which situations they may or may not work, and how they might be applied in a way that shifts ridership onto them from conventional car travel.

### 6.3.1 Where

Car-sharing, ridesharing and cycling can be said to be applicable for different trip lengths and purposes. Car-sharing and ridesharing should be considered a modal improvement of conventional car owner- and ridership in the sense that they provide many of the same benefits that cars do. Opting for making use of a car-sharing or ridesharing service does therefore not imply the same level modal shift as moving from car ridership to cycling. The current modal distributions across long, medium and short trips speak towards the modes having differing application depending on trip length. Cars being more used for longer trips make sense both because walking or cycling might be too strenuous but also because travellers want or need a certain level of flexibility, and therefore opt for driving over utilising public transport. Car-sharing allows for this flexibility in a way that ridesharing and public transport cannot, which arguably makes it the closest substitute to conventional car ridership on longer trips. That being said, car-sharing is only an agent for achieving sustainable mobility if a shift from cars onto it results in people driving less. In this context it is therefore applicable as a substitute on occasion for current drivers, while the majority of would-be car trips ideally would shift onto public transport. The best application would thus be people using car-sharing in situations where flexibility is needed, and public transport when it is not. Ridesharing also provides similar potential on long trips, arguably for commuters in particular, but as pointed out by Amundsen (2016) it has proven difficult to pair drivers with passengers on a large and consistent scale. This really applies to all trip lengths in terms of formalised settings and, as will be discussed further in chapter 6.3.3, aiming for a general uptake in car occupancy might be a better approach for promoting ridesharing as a means for furthering sustainable mobility. As for cycling, the aspect of strenuousness makes it more applicable to medium and short distance trips, at least on a daily basis, which is also mirrored by the mode's current modal share. Opting for an EL-cycle over a conventional one does arguably increase potential range, or rather the mode's relative advantage as per the DOI "checklist" (Rogers & Shoemaker, 1971). However, in terms of daily trips, for distances greater than 7.5 km (which corresponds to the long trips interval) cycling in any form will probably not be as appealing an alternative as public transport. This is particularly true for the older age cohorts which is why the applicability of cycling can be assessed to be best on short and medium distances.

Chapter 3.1.1 spoke about the current socio-technical system being characterised by- and geared towards cars. This does not only apply to user patterns but infrastructure as well. The current modal distributions across the different trip lengths should be understood as partial results of land-use policies that for decades have solidified the existing travel habits – which now are sought to be changed. In the past, Oslo land-use policies had a tendency to favour car-based travel which has resulted in parts of the city being engineered to efficiently cater to car travel needs (Olsen, Julsrud, Ramjerdi, & Gundersen, 2017). Policy-makers have only recently started to push away from this by improving conditions for public transport, cycling and walking at the cost of conventional car ridership (Sweco, 2017). The effect of past policies is, however, still being felt when it comes to the level of utility and accessibility yielded from the various modes of transport. Figure 6-1 maps Oslo's workplace accessibility when travelling by car, public transport and walking/cycling in terms of number of workplaces reached within one hour of travel:




Note that while the colour coding is the same in all three maps, the legend in terms of number of workplaces reached differs. The maps denote accessibility during rush hour and demonstrate quite clearly that cars still provide a higher level of accessibility in the city centre than public transport. Conversely, public transport is reported to provide a higher workplace accessibility in the more suburban boroughs of Nordre Aker, Bjerke, Grorud, Stovner and Alna. This speaks towards public transport having a good

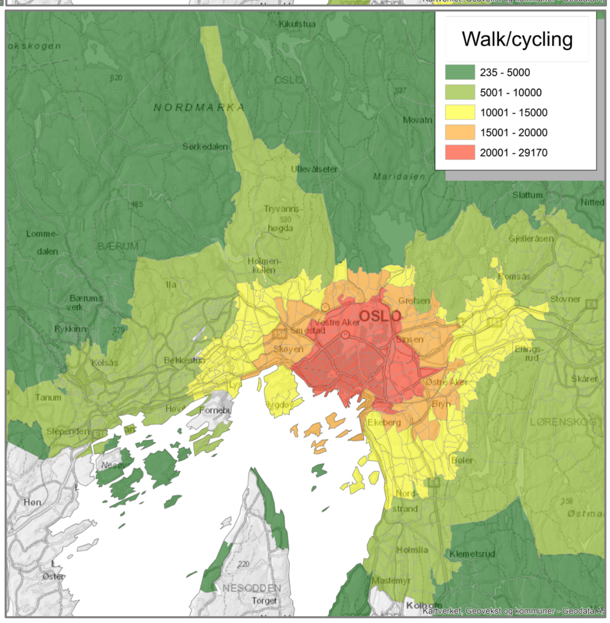



*Figure 6-1: Workplace accessibility on different modes. Source: Rambøll*

potential for absorbing the shorter segments of daily long-distance trips, particularly for those who live in these suburbs and commute downtown for work. It is worth noting that cars' superior workplace accessibility is constrained to a relatively small area in and around the downtown core. If one compares this to where walking and cycling has the best accessibility, it becomes clear that these two modes definitely have the potential of absorbing daily car traffic due to considerable overlap. Currently, of course, the number of workplaces reached within one hour is lower by walking and cycling than by driving. However, the fact that the geographical area in question is relatively dense means that it might be easier for policy-makers to target these shifts. The maps shown in figure 6-1 do therefore, in general terms, support the arguments put forward earlier for which trip lengths correspond best to the various sustainable modes: Public transport as the main alternative to car travel on within-city long distances with the occasional use of car-sharing when flexibility is needed, cycling/EL-cycling for some and public transport for others on medium trips, and walking or cycling on short trips.

Tying this to the rates of transferability onto sustainable modes identified by the zero-growth scenarios, it was found that medium trips overall were less transferrable than short and long trips. In the scenario, this was due to the mode substitution factors but there is also empirical backing for such a development. As Fearnley (2016) pointed out, relative market shares play a role in mode substitution. He noted that if the mode policy-makers want to shift traffic towards has a high market share, its relative traffic growth following restrictions being put on an undesirable mode will be low. Conversely, if the desirable mode has a low market share its relative growth will be larger. On medium trips, public transport does have a very large market share, currently at 40.6% according to RVU. This means that the projected low transfer rates onto it retains support in Fearnley's findings. If these then are drawn to their logical conclusion, they mean that modes that currently have lower market shares on medium trips have the potential for relatively high growth provided they are seen as real alternatives to, in this case, car ridership. Car-sharing, ridesharing and cycling certainly meet the requirement of having low market shares, but it remains to be seen whether they can be seen as real alternatives for car ridership for a broad cross-section of the population. This chapter has identified which trip distances they conceivably could serve but for now, they remain niche modes of transport. As noted in the MLP framework (Geels, 2002), their innovative aspects (such as EL-cycling removing the strenuousness of cycling) could potentially cause reconfiguration in the sense that they become applicable to markets that they currently do not serve. For such a regime crack to happen however, the new modes must provide a certain level of utility for people, and for whom this might be the case will be discussed in the following chapter.

### 6.3.2 For whom

The zero-growth scenario results suggest that it will be increasingly hard in age to achieve the zero-growth objective identified in NTP, while the younger age cohorts are more readily transferred onto sustainable modes. The implication of such a reality would be that elders (particularly men) constitute the laggards in shifting towards sustainable mobility, while the most transferrable – 25–39-year-olds – constitute early adopters, as per the DOI framework (Rogers E. M., 2003). Empirical evidence however suggests that the current travel habits of car-sharing, cycling and EL-cycling differ from the tendencies projected in the scenarios, providing opportunities for the less transferrable demographics to adopt these modes instead as a means of furthering overall sustainable mobility (see among others: Amundsen, 2016; Fyhri & Sundfør, 2014; Julsrud, 2012). As mentioned in chapter 3.3.1, the typical car-sharing user in Oslo at present is a 40-year-old man with a relatively high income and level of education. The same demographic also constitutes Oslo's typical daily cyclist, according to Oslo kommune (2014). Fyhri & Sundfør (2014) found that in general, younger demographics express more interest in buying an EL-cycle while the older demographics have the highest willingness to pay for one. However, those who now only occasionally cycle expressed the most interest in buying an EL-cycle – much more, in fact, than those who currently cycle often, which is indicative of EL-cycling having the potential to absorb trips from other modes.

The above can be seen as positive signs for car-sharing, cycling and EL-cycling potentially having a role to play in filling sustainable mobility gaps. In terms of car-sharing and cycling usage, today's 40-something-year-olds will be 2040's elders, i.e. the demographic that is projected to find it most difficult to reach the zero-growth objective. As mentioned previously, the scenario projections' model framework stipulates that in increasing age, people will simply adopt the travel habits of their "new" age cohort. This is not necessarily the case and an argument could be made that if today's established workers can find utility in, and therefore shift towards the sustainable modes, they might hold on to these travel habits in increasing age. If the right individuals or groups do this – influencers acting as opinion leaders – it might very well resonate with the broader population and steer its mobility in a direction that could mitigate the negative mobility effects the ageing population is projected to have in the zero-growth scenarios. In other words, the applicability of car-sharing, ridesharing and cycling as means of sustainable mobility obtainment is not limited to only the oldest age cohorts but also the wider population so as to solidify travel habits that differ from current trends. The question is then which demographics car-sharing, ridesharing and cycling can provide a certain level of utility for, and whom shifting towards them will benefit overall sustainable mobility obtainment the most. Julsrud (2012) identified three categories of travellers particularly partial to car ridership whose habits are thought hard to shift: Habitual car commuters, frequent professional drivers, and locally-mobile elders. The only one of the three modes that seem applicable to any of these categories is ridesharing for habitual car commuters. This would, however, require them to overcome the coordination issues associated with organising ridesharing on a large scale. Even if this is possible, it is arguably better from a sustainability standpoint for these commuters to substitute driving with public transport instead of ridesharing. But for those unwilling or unable, ridesharing has the potential of reducing the number of cars on the road. Frequent professional drivers and locally-mobile elders could potentially opt for car-sharing over car ownership, but such a shift alone would not do much in reducing the number of cars on the road unless it causes less driving. One can appreciate why Julsrud identifies these groups as avid car users whose habits in all likelihood will be hard to change. Rather than elders in general, these traveller categories are more likely to constitute the laggards in reaching sustainable mobility because they do not stand to gain much utility from changing travel behaviour; at least not from shifting towards either car-sharing, ridesharing or cycling. For them, these modes lack both relative advantage and compatibility from the DOI "checklist".

The implication of the above is that the three modes arguably have a certain level applicability for the *age cohorts* the scenarios identified as least transferrable onto sustainable modes but lacks this for the most car dependent *traveller categories* identified by Julsrud (2012). This is somewhat disheartening because it indicates that they have less potential where it would help the most in terms of reaching sustainable mobility. That being said, there is potential elsewhere. More broadly speaking, car-sharing could be an option as an alternative to car ownership for both people who have yet to acquire one, and for people who only occasionally need the flexibility a car provides. This would, in theory, include a large cross-section of Oslo's population. Ridesharing too has a similarly broad theoretical appeal, as is the case with cycling. Removing the strenuousness, EL-cycling also has the potential to make this mode available to older age cohorts or other demographics who are unable or unwilling to make use of a conventional bicycle. These modes being theoretically applicable to a wide range of demographics does not, however, mean that all will – or should – shift mobility towards them. There needs to be something causing this to happen. Though, as will be discussed below, there are important limitations to the scope of ridership on the three modes if they are to remain agents of sustainable mobility obtainment.

### 6.3.3 When

The use of two of the three modes assessed face a dilemma if they are to be considered agents of achieving sustainable mobility, namely that increased usage of them has negative effects from a sustainability standpoint. This particularly applies to car-sharing as a substitute for conventional car travel, because if the former replaces the latter 1:1, it does not further sustainable mobility as the number of cars on the road will remain the same. The problem is therefore that car-sharing can only be an agent for sustainable mobility if it is used less than conventional cars. This means that 1) car-sharing can only be used occasionally, because 2) it becoming a widely popular alternative to car ownership is problematic in its own right, which means that 3) it is only applicable alongside other sustainable modes if serving daily mobility. Acknowledging this, it seems difficult for car-sharing to mature beyond its current status as a niche mode of transport in the mobility system envisioned here. A socio-technical system shift wherein people substitute car ownership with car-sharing is, after all, unaligned with the zero-growth objective. This is why public transport, as mentioned before, necessarily constitutes the backbone in such a mobility system. But as a niche mode of transport, car-sharing can still serve a purpose in achieving sustainable mobility. For one, if its occasional use will allow the most car dependent portions of the population to shift onto public transport for the lion share of their daily trips, an uptake in car-sharing serves a purpose. It can secure a certain level of flexibility on occasion and thereby potentially lower the barrier for a sustainable transition amongst laggards. In a systemic perspective its potential role should therefore be seen as an intermediary for transition towards the modes identified in NTP, functioning as a tool aiding this transition in becoming more covetable for habitual drivers. The pay-as-you-go plans that are currently commonplace for car-sharing providers (Millard-Ball, Murray, Schure, Fox, & Burkhardt, 2005) could help push towards such a development, as it makes fiscal sense to only make use of car-sharing when the flexibility the mode brings with it is necessary. The condition still remains, however, that this can only be an option if most daily trips are successfully transferred from car travel and onto other sustainable modes of transport, from a zero-growth- and sustainable mobility perspective.

Ridesharing as a means of furthering sustainable mobility also faces a dilemma similar to that of car-sharing. As mentioned, the mobility system envisioned here assumes that cars no longer constitute a backbone mode in Oslo mobility, stipulating that public transport, walking and cycling assume this role. In such a reality, the already identified problems with large-scale organised ridesharing become bigger because reduced car mobility means fewer potential drivers matching passengers' mobility needs. As such, a socio-technical shift in the direction of public transport absorbing car ridership is also somewhat incompatible with a large-scale uptake in organised ridesharing, which means that it too necessarily remains a niche mode of transport on daily trips. The same is true for real-time ridesharing which by definition is occasional and thus is bound to yield little effect on Oslo's daily trips (Amundsen, 2016). That being said, even if travel progresses as projected in the zero-growth scenarios it does not mean that car travel is completely removed from Oslo mobility. A more suited focus for the application of ridesharing as an agent of furthering sustainability is therefore to instead look at vehicle occupancy. As found by Hjorthol, Engebretsen & Uteng (2014) this is relatively low on daily trips at 1.55 on average throughout Norway. Increasing this on the daily car trips that do remain will undoubtedly aid sustainable mobility in the sense that it both secures better resource utilisation for a car trip that would be conducted anyway, and by relieving pressure on the public transport system which is set to carry the bulk of Oslo's mobility in this envisioned future. Both an uptake in informal ridesharing and real-time ridesharing could potentially aid such a development, while more formalised or steered approaches like slugging would likely remain hard to implement in practice due to a lower number of drivers on the road being a stipulated necessity for this thesis' take on sustainable mobility.

The only one of the three modes that does not face any sustainable mobility dilemma arising from increased usage is cycling. In contrast with the other two, it can also "hold its own" on daily trips and is not necessarily dependent on being used occasionally or in combination with other modes. In the zero-growth scenarios however, cycling did not see a particularly strong projected growth compared to the other modes set to grow – despite being given the highest growth rate for both short and medium trips. This speaks towards the current socio-technical system favouring cycling less as an alternative to cars than public transport and walking on account of the mode substitution factors plotted. Much of the potential for realising further growth and usage of cycling is therefore arguably found in recent innovations, seeing that conventional cycling is projected to play a somewhat limited role through the zero-growth scenarios. As already mentioned, the introduction of EL-cycles may expand this mode's applicability to a broader demographic, but what is yet to be considered is the application of Oslo's city bike scheme. As Amundsen (2016) pointed out, city bikes are often used for "last mile" travel and serve as an extension of the public transport system. If strategically located, city bikes may make public transport a more viable option for demographics and geographical areas that are underserved by the mainline public transport network, essentially functioning as a feeder mode to and from transport hubs.

A prerequisite for this to become viable at a large scale is arguably some level of integration between the city bike scheme and the public transport network. To that end, it is worth briefly entertaining the idea of a development towards Mobility as a service (MaaS). It is a relatively new approach to mobility and describes a shift away from vehicle ownership and towards *consuming* mobility as one would with any other service (Aarhaug, 2017). While the workings of such a thought mobility system is complex and debatable – fully accounting for it would warrant a thesis of its own – a key aspect is the integration of public and private transport into a unified ticketing system so that different modes of transport can be consumed seamlessly. Travellers can thus plan their journey through, for example, an app and book "door-to-door" across various modes of transport through the same innovative service. Merging the access to service providers in this way could potentially make using the city bike scheme interesting to a broader demographic because currently, city bike access and public transport tickets are managed through separate platforms – which means that people have to discover the "link" between the two themselves. As a side-note, MaaS can also encompass car-sharing and real-time ridesharing but such a development is not in-line with the sustainable mobility scenario envisioned here because the goal is to steer a reduction in overall car ridership. This is also why MaaS, although interesting and very relevant when envisioning future mobility, has not been given greater attention by this thesis.

Bar cycling, the above indicates that although car-sharing and ridesharing have some potential areas of applicability, there are important constraints to consider with respect to the extent by which they may be put to use in a sustainable mobility future – at least one that is based on the rationale of zero-growth in car traffic. This begs the question of whether car-sharing and ridesharing can reach widespread enough adoption to self-sustain as strategic niches in a sustainable mobility future. According to the DOI framework, an innovation first reaches self-sustainability at some point along the Gaussian curve shown in graph 3-1 when enough people have adopted it (Rogers E. M., 2003). Essentially, this conflict between diffusion of innovative modes of transport and policy wants translates to a balancing act that someone or something has to enforce and implement if the modes are to play a role in furthering sustainable mobility; the means by which will be discussed below.

#### 6.3.4 How

The "how" is probably the toughest question to answer when assessing whether car-sharing, ridesharing and cycling have a role to play in furthering sustainable mobility. The empirical evidence gathered in the literature review has focused on policies and the role policy-makers play in steering for desirable developments. Seeing that the zero-growth objective is a political goal and one that serves as the foundation for the sustainable mobility future envisioned here, it makes sense to consider their role in bringing about these modes' future applications. As mentioned, Fearnley et al. (2016) argue that the most effective policy approach when steering shifts from a mode (i.e. cars) is to target it directly rather than improving the modes onto which mobility is to shift. In other words, they argue for restrictive-based policies over incentive-based ones. Simultaneously, Fearnley (2016) note that the ridership growth in competing modes with initial low modal shares will be stronger than in those with a high initial market share. The latter point is relevant for achieving an uptake in car-sharing, ridesharing and cycling in the sustainable mobility future envisioned because at some point, growth in public transport at the cost of cars will become saturated if Fearnley's findings are drawn to their logical conclusion. Thus, the same restrictive policies that shift travellers away from cars and onto public transport can arguably also shift travellers onto car-sharing, ridesharing and cycling, particularly if these modes are able to provide a level of utility that public transport cannot, assuming this is the reason why laggards opt out of making the shift towards public transport. Such a development – the three modes absorbing car traffic *after* shifts onto the NTP modes are exhausted – would in theory be beneficial for the sustainable mobility system envisioned: The bulk of future car traffic growth would shift onto the NTP modes (similar to what was projected in the zero-growth scenarios) while those demographics proving harder to shift might find utility in either car-sharing, ridesharing and various subsets of cycling instead. This potentially both limits the three modes' market within the constraints put forward by the zero-growth objective and secures their positions as agents for achieving sustainable mobility – shifting traffic away from conventional car ridership.

That is not to say that people always act the way policy-makers want. Oslo's cycling strategy is a good example of just that, where policies did not yield the uptake in cycling at the expense of cars policy-makers set out to achieve (Oslo kommune, 2014). Seeing that they were unable to act as effective agents of change, one should recognise that policy efforts alone cannot reliably bring about modal shifts – people's individual mobility needs and preferences also play a role and should be fulfilled. Car-sharing, ridesharing and cycling have, as mentioned before, different sets of assets and drawbacks. This in turn means that their positions as potential substitutes for car travel necessarily vary depending on trip purposes. Rather than working towards a blanket mobility shift, which is the case in Oslo's cycling strategy, a more targeted approach could be to identify the car trip purposes that utility-wise correspond the best to the assets of the alternative modes. Trip purposes can in turn arguably be linked to demographic groups, because similar demographics are likely to have similar mobility needs (Julsrud, 2012). As such, if the "right" individuals within a demographic group whose mobility needs are not met by the NTP modes can find utility in shifting onto either car-sharing, ridesharing or cycling instead, the modes have further potential as agents for sustainable mobility. This is because as the DOI framework points out, the characteristics of social systems are important drivers for the diffusion of innovations (Rogers E. M., 2003). Demographics sharing both mobility needs and population traits could be construed as a type of social system wherein the modes can be diffused. According to Rogers (2003), the role of opinion leaders is central in such a process which refers to individuals or sub-groups within a social system that yield influence over other members' decision making. Whether the opinion leaders have a positive or a negative impression of an innovation (or mode of transport for that matter) is thus thought to affect the overall social system's willingness to adopt it. This perspective provides an additional layer of understanding of the traveller categories identified by Julsrud (2012); particularly those found hard to shift away from cars: Their unwillingness to shift may not only be due to lack of utility derived from alternative modes, but also due to resistance towards these modes from opinion leaders. As such, if novelties like car-sharing, ridesharing or cycling in certain situations can prove acceptable alternatives to conventional car travel, and the opinion leaders agree, then the modes certainly serve a purpose – particularly in social systems characterised by high car dependency and resistance towards the NTP modes.

While juxta-positioned above, policy efforts and consumer needs or wants need not be understood as mutually exclusive. When considering the diffusion of car-sharing, ridesharing and cycling it is instead important to understand that policy-wants and consumer interests do interact, which is evident by how they are able to exert pressure on a mobility regime. As argued before, policy-makers aiming for sustainable mobility seek either modal improvements or modal shifts brought on by either restrictive or incentive-based policies. Consumers (i.e. travellers) on the other hand, can opt to either accept or reject these policies due to whatever reason, as is also the case with opinion leaders. Rejecting change could be seen as a symptom of a stable socio-technical system from an MLP perspective, while acceptance indicates cracks to it occurring. Nonetheless, such differing levels of traveller acceptance for policy interactions is in essence what was projected through the zero-growth scenarios, albeit on an aggregate scale. Considering the stark differences in rates of substitution shown there, it appears important that policy-makers acknowledge that the same policy will yield varying real-life results across a population – even more so when factoring in the role opinion leaders have, according to the DOI framework. In light of this, one could argue that in addition to targeting cars through restrictive policies as suggested by Fearnley (2012), it is also important to secure sustainable modes a relative advantage over cars. This is undoubtedly already being done for the NTP modes through favourable landscape policies, infrastructure improvements and other means (NTP, 2017) but these efforts do not take into account that these modes might still be perceived to have limited applications for certain travellers: Even if a public transport system works excellent at what it is sets out to do, it does not help if opinion leaders believe public transport in general cannot fulfil their mobility needs. The same is true for walking and cycling, being limited in trip application by their very nature. Introducing car-sharing and ridesharing to the mobility system would therefore add more utility options that opinion leaders and laggards can chose from, arguably increasing the likelihood that shifts away from conventional car travel can happen for these demographics. The challenge remains, however, that shifts towards car-based modes like car-sharing and ridesharing cannot surpass a certain level if a sustainable mobility future based on the zero-growth rationale is to become reality. Their application, at least on daily trips, should therefore be sought targeted and limited to demographics with the strongest propensities towards conventional car travel. One way of achieving this could be, as mentioned above, to promote these modes only when shifts onto the NTP modes appear to stagnate, thereby offering a "solution" to opinion leaders and laggards resisting the NTP modes. In such a scenario and if applied as prescribed, the role of car-sharing, ridesharing and cycling in achieving sustainable mobility is a positive one. It also exemplifies how a balanced compromise potentially can be struck between policy- and consumer wants.

## 6.4 Systemic and individual applications: MLP and DOI

Considering the takeaways on the where, the for whom, the when and the how from above, a conclusion can be drawn that while there are potential applications for car-sharing, ridesharing and cycling to further sustainability, the modes face some clear limitations in the mobility picture envisioned. From an MLP perspective, what has been described both through discussion and through the zero-growth scenarios is a socio-technical system change wherein mobility develops away from being dominated by cars and towards public transport. In such a new system where constraints are put on car ridership, furthering car-sharing and ridesharing necessarily becomes a balancing act. They are after all car-based modes – a mode that, according to the stipulations put forward, is not to grow beyond today's levels. This limits their ability to rise to prominence because the socio-technical system at large, following the scenario pathways envisioned towards the zero-growth objective, necessarily shifts in a direction that is unfavourable for car-based modes. If the zero-growth scenario projections were to become reality, it would necessarily warrant system alterations wherein both policy and the physical landscape shift away from catering to car-based transport and towards favouring public transport, walking and cycling. Not necessarily as a result of implementing restrictive policies on cars to make the shift happen, but at the bare minimum due to the physical need of supporting the projected increase in ridership on the sustainable modes. Following such a regime shift, the windows of opportunity through which car-sharing and ridesharing can achieve widespread adoption narrow because the socio-technical system no longer favours car-based modes. This is why a sustainable mobility future built on the zero-growth objective is somewhat incompatible with these two modes, which may also help explain why policy makers have not actively sought to promote them (Hald, Christiansen, & Nenseth, 2011). Car-sharing and ridesharing will therefore arguably remain novelties existing outside the mainstream zero-growth socio-technical system, yet still serving a purpose because if applied "correctly" (chapter 6.3.3) they are still better alternatives than private car ridership from a sustainability standpoint. Such a development correlates somewhat with the de-alignment and re-alignment pathway from MLP: The NTP modes alongside car-sharing and ridesharing compete in a regime pressured towards structural changes. Due to actor and policy-maker preferences towards the zero-growth objective, the NTP modes "win" and the mobility system is re-stabilised around these, whereas car-sharing and ridesharing missed their window of opportunity for wide-spread adoption.

Cycling on the other hand benefits from both being actively supported by policy-makers and landscape pressures developing in its favour. A socio-technical system change in the direction envisioned does cater to it – the question is only whether these pressures are enough for cycling to develop from essentially being a novelty with a narrow market penetration today to becoming a widespread mode of choice for daily travel. It is interesting to note that efforts initiated through for example Oslo's cycling plan have not resonated with the wider travelling public. This means that although socio-technical system conditions are increasingly in favour of a mode, an uptake in it does not necessarily happen. While MLP does not seem to point to any clear culprit for as to why this is the case beyond there necessarily being some differences between actors in the socio-technical system preventing internal shifts to occur (Frans, Smith, & Stirling, 2003), DOI provides a more individualistic approach and is less concerned with policy-makers' role in altering structural conditions. The emphasis on opinion leaders' role instead, and particularly their potential opposition to the agents of change (policy-makers) does lend some insights into why modal shifts that seem clear-cut "on paper" from a structural perspective do not happen in real life. Keep in mind that any resistance opinion leaders have towards modal shifts need not be rational. The modes' appeal as well as individual preferences and needs also factor into the decision-making process (Rogers E. M., 2003). Therefore, while MLP provides a foundation for understanding the systemic conditions within which various modes of transport can or cannot thrive, DOI in contrast provides a framework of understanding why or why not individuals chose to adopt certain modes.

Both MLP and DOI are useful to consider when discussing how modal shifts can be brought about, as they offer different frameworks of understanding that can result in conflicting conclusions. This should be evident from the points of discussion above: In the sustainable mobility future envisioned which is based on the zero-growth objective, applying car-sharing and ridesharing is a mismatch from a systemic point of view. This is because if the socio-technical system moves away from supporting car-based travel and towards the NTP modes, innovative albeit car-based modes are likely to remain niches according to the arguments put forward following MLP. At the same time, the discussion derived from the DOI framework points out that system changes initiated by agents of change do not necessarily resonate equally in the travelling public. Opinion leaders might resist them outright, which can cause their corresponding social groups to remain using means of mobility that lie outside the new socio-technical system. Put more simply, they stick with the car despite policy-maker efforts. These groups, rejecting the NTP modes that serve as the foundation for the new mobility system, are the ones for whom a shift from conventional car travel and onto car-sharing and ridesharing would further sustainable mobility. As such, while MLP allows little application for these modes due to the systemic mismatch, the DOI view does allot them a potential role, albeit only as strategic niche modes of transport for certain parts of the population.

# 7 Conclusion

This thesis has not aspired to provide the solution to Oslo's mobility problem. Rather, it has sought to shed light on what needs to change if for the zero-growth objective and sustainable mobility is to become a reality in the future, and to identify some potentially overlooked key caveats that are important to take into consideration for those planning for these goals. By contrasting mobility pathways, projecting the obtainability of the zero-growth objective across demographic divides, and by assessing new and innovative modes of transport's potential role in furthering sustainable mobility, this thesis has sought answers to the following questions:

> *What will Oslo's mobility distribution look like by 2040 if current travel habits remain unchanged?*

Very similar to today which, according to policy makers, is problematic. Cars will remain a dominant mode of transport for many people and Oslo's projected population growth will contribute to further solidifying its position. In addition to a general population increase outputting more car trips than today, Oslo's median age is projected to move towards an age group that is more car dependent than the current one. This means that car travel is likely to grow at a faster rate than travel on other modes. Combined, these factors are projected to add an additional 96,014 daily car trips to Oslo mobility by 2040 compared to current levels.

> *How can the zero-growth objective for car traffic conceivably be met by 2040, for all demographic groups in Oslo, through shifts onto public transport, walking and cycling?*

When projecting the same growth rates for sustainable modes of transport across demographic divides, it becomes clear that vastly different growth rates are necessary between them if all are to reach the zero-growth objective by 2040. The reason for this is twofold: First, Oslo's population growth is projected to be heavily skewed towards the older generation. This means that this demographic will see a relatively rapid population growth that causes its travel habits to yield more influence on overall Oslo mobility than what is the case today. Second, the demographic groups' mode substitution factors, i.e. their likely willingness to switch modes, also vary. Accounting for these factors, it was found that women are projected to be overwhelmingly more transferrable from car travel and onto sustainable modes than men. Moreover, the younger demographics, particularly 25–39-year-olds, are more easily transferred than the older ones. The implication of these findings is that while certain travel growth targets for-, and rates of substitution onto public transport, walking and cycling more than satisfy the zero-growth objective for some demographic groups they do not for others. This means that efforts in zero-growth goal obtainment likely will need to be differentiated in intensity between demographic groups in order to prove successful for all, because their required levels of habitual change vary considerably.

> *Could the introduction of new and innovative modes of transport like car-sharing, ridesharing and cycling have a role in furthering sustainable mobility and the zero-growth objective?*

Arguably to some extent, but the roles these modes can and should play depend on how sustainable mobility is envisioned. Here, the foundation is the zero-growth objective which stipulates that car traffic is not to exceed today's levels in the future. Seeing that both car-sharing and ridesharing are car-based modes, their use necessarily needs to remain limited in order to secure that particular mobility picture. Cycling on the other hand is a different story in that it benefits from both policy-maker approval through NTP and its innovative aspects. EL-cycling expands the mode's range and removes its associated strenuousness, making it available to a larger cross-section of the population while Oslo's city bike scheme has potential as a feeder mode, making the public transport system accessible to those living beyond walking distance from any of its hubs. As for car-sharing and ridesharing, they also have potential as agents for bringing about sustainable mobility despite being limited by the zero-growth policy. First, they provide a different set of utilities than the sustainable modes identified by NTP. This means that those unwilling to adopt any of the NTP modes might be persuaded to shift away from conventional car travel after all if introduced to either car-sharing or ridesharing, which can be a positive development from a sustainability standpoint. Second, the modes' current typical user corresponds to the demographic groups projected to be hard to shift onto sustainable modes by 2040. If they can find utility in using these modes over conventional car ridership, their potential role is a beneficial one in furthering sustainable mobility. Importantly though, this is only the case if the modes are applied after shifts onto the NTP modes have been exhausted and so long as their adoption does not cause overall car traffic to rise. At any rate, it will likely be important for policy-makers to recognise that achieving sustainable mobility involves a balancing act between policy wants and widely varying consumer needs. Differentiating their actions accordingly and striking the right balance between policy goals and travellers day-to-day needs is therefore important if Oslo is to successfully move towards a mobility system that is both sustainable and caters to its traveller's needs.

## 7.1 Suggestions for further research

The work resulting in this thesis has, as mentioned previously, uncovered a major lack of empirical data and research on cross-modal relationships, i.e. the rates of substitution between modes of transport. The fact that there is a general knowledge gap on where travellers end up following policy efforts aiming for modal shifts means that policies employed run the risk of being much less targeted than intended. Seeing that the entire zero-growth objective rest on the rationale that travellers can be steered onto alternative modes, this constitutes a very real problem for those trying to make this happen. Here, a work-around was utilised wherein trip purposes where construed as mode substitution factors, but this thesis would very much welcome further empirical research to uncover which measures can be taken in order to successfully steer travel development, and to map out demand interactions between various modes of transport.

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# Appendix A: Oslo population projections

| | | | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Oslo** | Men | **15-19** | 15284 | 15509 | 15870 | 16302 | 16547 | 16779 | 17176 | 17655 | 17962 | 18283 | 18545 | 18697 | 18708 | 18509 | 18335 | 18208 | 18121 | 18097 | 18302 | 18504 | 18786 | 19120 | 19418 | 19669 | 19876 |
| | | **20-24** | 21683 | 21739 | 21768 | 22008 | 22215 | 22304 | 22342 | 22449 | 22753 | 22888 | 23020 | 23359 | 23834 | 24184 | 24534 | 24844 | 24972 | 25057 | 24844 | 24610 | 24442 | 24322 | 24290 | 24535 | 24780 |
| | | **25-29** | 34457 | 35550 | 36604 | 37082 | 37220 | 37207 | 37195 | 37147 | 37203 | 37350 | 37388 | 37221 | 37098 | 37248 | 37259 | 37277 | 37653 | 38138 | 38569 | 39047 | 39450 | 39611 | 39720 | 39421 | 39066 |
| | | **30-34** | 35046 | 36061 | 36784 | 37711 | 38785 | 39504 | 40172 | 40828 | 41041 | 41121 | 41177 | 41238 | 41222 | 41202 | 41291 | 41285 | 41006 | 40748 | 40801 | 40786 | 40758 | 41119 | 41550 | 41988 | 42478 |
| | | **35-39** | 29691 | 30145 | 30900 | 31441 | 31764 | 32089 | 32477 | 32733 | 33276 | 34084 | 34780 | 35417 | 36017 | 36224 | 36306 | 36349 | 36388 | 36359 | 36310 | 36350 | 36320 | 36058 | 35811 | 35825 | 35786 |
| | | **40-44** | 26022 | 26462 | 26584 | 26798 | 26809 | 26957 | 27045 | 27422 | 27692 | 27911 | 28189 | 28567 | 28830 | 29336 | 30045 | 30670 | 31229 | 31754 | 31933 | 31997 | 32020 | 32050 | 32018 | 31967 | 32001 |
| | | **45-49** | 22819 | 23299 | 23920 | 24301 | 24664 | 24822 | 24969 | 24876 | 24937 | 24896 | 25019 | 25102 | 25445 | 25681 | 25874 | 26126 | 26465 | 26705 | 27174 | 27821 | 28403 | 28930 | 29413 | 29588 | 29648 |
| | | **50-54** | 19895 | 20519 | 20891 | 21390 | 21715 | 22205 | 22564 | 23053 | 23309 | 23566 | 23665 | 23731 | 23573 | 23571 | 23503 | 23581 | 23647 | 23951 | 24161 | 24326 | 24546 | 24868 | 25110 | 25559 | 26177 |
| | | **55-59** | 17105 | 17317 | 17670 | 18033 | 18517 | 18829 | 19385 | 19731 | 20190 | 20511 | 20945 | 21262 | 21692 | 21893 | 22078 | 22131 | 22122 | 21918 | 21877 | 21780 | 21829 | 21878 | 22153 | 22341 | 22497 |
| | | **60-64** | 14180 | 14508 | 14845 | 15215 | 15489 | 15887 | 16086 | 16399 | 16733 | 17175 | 17488 | 18000 | 18323 | 18749 | 19053 | 19429 | 19710 | 20082 | 20239 | 20376 | 20394 | 20348 | 20124 | 20067 | 19973 |
| | | **65-69** | 13066 | 12705 | 12579 | 12515 | 12640 | 12909 | 13203 | 13519 | 13855 | 14119 | 14474 | 14660 | 14936 | 15231 | 15633 | 15924 | 16381 | 16686 | 17075 | 17353 | 17684 | 17928 | 18256 | 18382 | 18477 |
| | | **70-74** | 9327 | 10574 | 11335 | 11752 | 11818 | 11830 | 11515 | 11412 | 11369 | 11497 | 11758 | 12040 | 12340 | 12665 | 12921 | 13259 | 13440 | 13700 | 13975 | 14355 | 14649 | 15085 | 15378 | 15761 | 16028 |
| | | **75 +** | 12674 | 12910 | 13383 | 14125 | 15175 | 16118 | 17438 | 18504 | 19525 | 20463 | 21265 | 22086 | 22873 | 23643 | 24474 | 25307 | 26173 | 26992 | 27804 | 28631 | 29530 | 30308 | 31134 | 31980 | 32927 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Women | **15-19** | 14887 | 15245 | 15686 | 16023 | 16376 | 16558 | 17001 | 17323 | 17602 | 17882 | 18141 | 18140 | 18189 | 18079 | 17852 | 17509 | 17429 | 17418 | 17574 | 17788 | 18146 | 18469 | 18754 | 18999 | 19192 |
| | | **20-24** | 24342 | 24774 | 25123 | 25351 | 25360 | 25391 | 25312 | 25336 | 25467 | 25671 | 25785 | 26189 | 26534 | 26839 | 27175 | 27515 | 27572 | 27675 | 27542 | 27289 | 26942 | 26877 | 26860 | 27053 | 27341 |
| | | **25-29** | 37737 | 38987 | 40031 | 40542 | 40673 | 40439 | 40324 | 40292 | 40213 | 40188 | 40238 | 40054 | 39923 | 39982 | 40100 | 40146 | 40541 | 40925 | 41320 | 41764 | 42191 | 42266 | 42377 | 42187 | 41848 |
| | | **30-34** | 32786 | 33888 | 34900 | 36383 | 37552 | 38680 | 39321 | 39708 | 39801 | 39803 | 39685 | 39721 | 39786 | 39730 | 39721 | 39747 | 39519 | 39336 | 39352 | 39436 | 39464 | 39807 | 40137 | 40510 | 40929 |
| | | **35-39** | 26409 | 26943 | 27575 | 27862 | 28206 | 28463 | 29015 | 29553 | 30517 | 31373 | 32291 | 32875 | 33254 | 33382 | 33408 | 33333 | 33374 | 33436 | 33393 | 33382 | 33392 | 33196 | 33039 | 33049 | 33101 |
| | | **40-44** | 23114 | 23202 | 23248 | 23392 | 23515 | 23808 | 24087 | 24484 | 24639 | 24872 | 25085 | 25541 | 26014 | 26837 | 27577 | 28375 | 28908 | 29263 | 29386 | 29428 | 29371 | 29409 | 29461 | 29431 | 29429 |
| | | **45-49** | 20597 | 21142 | 21574 | 21973 | 22226 | 22399 | 22354 | 22272 | 22299 | 22345 | 22566 | 22823 | 23186 | 23335 | 23547 | 23740 | 24143 | 24576 | 25331 | 26021 | 26769 | 27288 | 27625 | 27767 | 27803 |
| | | **50-54** | 18574 | 19055 | 19490 | 19851 | 20256 | 20562 | 21015 | 21370 | 21675 | 21868 | 21994 | 21908 | 21789 | 21790 | 21795 | 21992 | 22221 | 22567 | 22704 | 22907 | 23096 | 23481 | 23894 | 24612 | 25274 |
| | | **55-59** | 16833 | 16982 | 17185 | 17339 | 17789 | 18203 | 18644 | 19053 | 19402 | 19788 | 20070 | 20491 | 20820 | 21082 | 21241 | 21329 | 21214 | 21065 | 21042 | 21025 | 21189 | 21402 | 21726 | 21858 | 22055 |
| | | **60-64** | 14684 | 14979 | 15198 | 15583 | 15776 | 16031 | 16145 | 16319 | 16472 | 16905 | 17296 | 17719 | 18113 | 18442 | 18803 | 19072 | 19456 | 19749 | 19973 | 20098 | 20159 | 20026 | 19862 | 19820 | 19790 |
| | | **65-69** | 13641 | 13329 | 13347 | 13424 | 13610 | 13734 | 14000 | 14195 | 14543 | 14722 | 14964 | 15081 | 15246 | 15405 | 15799 | 16171 | 16560 | 16933 | 17249 | 17579 | 17825 | 18174 | 18437 | 18611 | 18722 |
| | | **70-74** | 10323 | 11568 | 12280 | 12689 | 12776 | 12802 | 12519 | 12543 | 12630 | 12826 | 12962 | 13221 | 13413 | 13746 | 13923 | 14160 | 14288 | 14455 | 14611 | 14996 | 15351 | 15737 | 16105 | 16419 | 16732 |
| | | **75 +** | 21360 | 21180 | 21375 | 21761 | 22463 | 23300 | 24400 | 25328 | 26152 | 26937 | 27768 | 28541 | 29418 | 30228 | 31122 | 31921 | 32810 | 33684 | 34635 | 35452 | 36294 | 37048 | 37843 | 38697 | 39642 |

*From Statistics Norway table 11168: Population projections 1 January, by sex and age, in 9 variants (M) (UD) 2016 – 2040.*

# Appendix B: Mode mobility data (RVU + estimates)

**LONG TRIPS**

| Men | Cycle | Walking | Car | Car-passeng | El-Car | Car-sharing | Public Transp | El-cycle |
|---|---|---|---|---|---|---|---|---|
| 15-19 | 0,000668 | 0,000688 | 0,000647 | 0,014453 | 0,000028 | 0,000014 | 0,010323 | 0,000021 |
| 20-24 | 0,002003 | 0,004818 | 0,02329 | 0,009635 | 0,000991 | 0,000496 | 0,072264 | 0,000062 |
| 25-29 | 0,013352 | 0,007571 | 0,119036 | 0,024776 | 0,005065 | 0,002533 | 0,106676 | 0,000413 |
| 30-34 | 0,013352 | 0,007571 | 0,119036 | 0,024776 | 0,005065 | 0,002533 | 0,106676 | 0,000413 |
| 35-39 | 0,007343 | 0,003441 | 0,139092 | 0,003441 | 0,005919 | 0,002959 | 0,077082 | 0,000227 |
| 40-44 | 0,007343 | 0,003441 | 0,139092 | 0,003441 | 0,005919 | 0,002959 | 0,077082 | 0,000227 |
| 45-49 | 0,011349 | 0,007571 | 0,11839 | 0,001376 | 0,005038 | 0,002519 | 0,046111 | 0,000351 |
| 50-54 | 0,011349 | 0,007571 | 0,11839 | 0,001376 | 0,005038 | 0,002519 | 0,046111 | 0,000351 |
| 55-59 | 0,007343 | 0,006194 | 0,135857 | 0,008947 | 0,005781 | 0,002891 | 0,052306 | 0,000227 |
| 60-64 | 0,007343 | 0,006194 | 0,135857 | 0,008947 | 0,005781 | 0,002891 | 0,052306 | 0,000227 |
| 65-69 | 0,002003 | 0,005506 | 0,064047 | 0,008947 | 0,002725 | 0,001363 | 0,026153 | 0,000062 |
| 70-74 | 0,002003 | 0,005506 | 0,064047 | 0,008947 | 0,002725 | 0,001363 | 0,026153 | 0,000062 |
| 75+ | 0,001335 | 0,000688 | 0,018114 | 0,004129 | 0,000771 | 0,000385 | 0,011012 | 0,000041 |

| Women | Cycle | Walking | Car | Car-passeng | El-Car | Car-sharing | Public Transp | El-cycle |
|---|---|---|---|---|---|---|---|---|
| 15-19 | 0,000666 | 0,000687 | 0,000652 | 0,013736 | 0,000021 | 0,000014 | 0,023352 | 0,000021 |
| 20-24 | 0,000666 | 0,005495 | 0,017617 | 0,009615 | 0,000556 | 0,000371 | 0,085852 | 0,000021 |
| 25-29 | 0,010659 | 0,007555 | 0,0659 | 0,04533 | 0,002081 | 0,001387 | 0,108516 | 0,00033 |
| 30-34 | 0,010659 | 0,007555 | 0,0659 | 0,04533 | 0,002081 | 0,001387 | 0,108516 | 0,00033 |
| 35-39 | 0,00533 | 0,006181 | 0,075687 | 0,012363 | 0,00239 | 0,001593 | 0,073489 | 0,000165 |
| 40-44 | 0,00533 | 0,006181 | 0,075687 | 0,012363 | 0,00239 | 0,001593 | 0,073489 | 0,000165 |
| 45-49 | 0,001999 | 0,003434 | 0,073729 | 0,024038 | 0,002328 | 0,001552 | 0,069368 | 0,000062 |
| 50-54 | 0,001999 | 0,003434 | 0,073729 | 0,024038 | 0,002328 | 0,001552 | 0,069368 | 0,000062 |
| 55-59 | 0,003331 | 0,004121 | 0,063942 | 0,028846 | 0,002019 | 0,001346 | 0,068681 | 0,000103 |
| 60-64 | 0,003331 | 0,004121 | 0,063942 | 0,028846 | 0,002019 | 0,001346 | 0,068681 | 0,000103 |
| 65-69 | 0,002665 | 0,003434 | 0,037191 | 0,024038 | 0,001174 | 0,000783 | 0,024038 | 0,000082 |
| 70-74 | 0,002665 | 0,003434 | 0,037191 | 0,024038 | 0,001174 | 0,000783 | 0,024038 | 0,000082 |
| 75+ | 0,000666 | 0,000687 | 0,013049 | 0,006181 | 0,000412 | 0,000275 | 0,011676 | 0,000021 |

**MEDIUM TRIPS**

| Men | Cycle | Walking | Car | Car-passeng | El-Car | Car-sharing | Public Transp | El-cycle |
|---|---|---|---|---|---|---|---|---|
| 15-19 | 0,018714 | 0,025723 | 0,01209 | 0,016077 | 0,000514 | 0,000257 | 0,11254 | 0,000579 |
| 20-24 | 0,018714 | 0,125402 | 0,063473 | 0,061093 | 0,002701 | 0,00135 | 0,495177 | 0,000579 |
| 25-29 | 0,171543 | 0,22508 | 0,405016 | 0,057878 | 0,017235 | 0,008617 | 0,78135 | 0,005305 |
| 30-34 | 0,171543 | 0,22508 | 0,405016 | 0,057878 | 0,017235 | 0,008617 | 0,78135 | 0,005305 |
| 35-39 | 0,124759 | 0,244373 | 0,395949 | 0,016077 | 0,016849 | 0,008424 | 0,286174 | 0,003859 |
| 40-44 | 0,124759 | 0,244373 | 0,395949 | 0,016077 | 0,016849 | 0,008424 | 0,286174 | 0,003859 |
| 45-49 | 0,096688 | 0,093248 | 0,441286 | 0,022508 | 0,018778 | 0,009389 | 0,221865 | 0,00299 |
| 50-54 | 0,096688 | 0,093248 | 0,441286 | 0,022508 | 0,018778 | 0,009389 | 0,221865 | 0,00299 |
| 55-59 | 0,056141 | 0,221865 | 0,565209 | 0,022508 | 0,024051 | 0,012026 | 0,257235 | 0,001736 |
| 60-64 | 0,056141 | 0,221865 | 0,565209 | 0,022508 | 0,024051 | 0,012026 | 0,257235 | 0,001736 |
| 65-69 | 0,009357 | 0,090032 | 0,320386 | 0,009646 | 0,013633 | 0,006817 | 0,128617 | 0,000289 |
| 70-74 | 0,009357 | 0,090032 | 0,320386 | 0,009646 | 0,013633 | 0,006817 | 0,128617 | 0,000289 |
| 75+ | 0,006238 | 0,080386 | 0,126945 | 0,012862 | 0,005402 | 0,002701 | 0,067524 | 0,000193 |

| Women | Cycle | Walking | Car | Car-passeng | El-Car | Car-sharing | Public Transp | El-cycle |
|---|---|---|---|---|---|---|---|---|
| 15-19 | 0,01 | 0,0137457 | 0,01958763 | 0,05154639 | 0,00061856 | 0,00041237 | 0,12714777 | 0,00030928 |
| 20-24 | 0,04333333 | 0,10652921 | 0,09467354 | 0,03092784 | 0,00298969 | 0,00199313 | 0,69072165 | 0,00134021 |
| 25-29 | 0,13 | 0,29209622 | 0,31666667 | 0,10996564 | 0,01 | 0,00666667 | 0,95876289 | 0,00402062 |
| 30-34 | 0,13 | 0,29209622 | 0,31666667 | 0,10996564 | 0,01 | 0,00666667 | 0,95876289 | 0,00402062 |
| 35-39 | 0,12333333 | 0,20274914 | 0,44398625 | 0,09965636 | 0,01402062 | 0,00934708 | 0,46735395 | 0,00381443 |
| 40-44 | 0,12333333 | 0,20274914 | 0,44398625 | 0,09965636 | 0,01402062 | 0,00934708 | 0,46735395 | 0,00381443 |
| 45-49 | 0,10666667 | 0,1580756 | 0,38848797 | 0,03780069 | 0,01226804 | 0,00817869 | 0,38831615 | 0,00329897 |
| 50-54 | 0,10666667 | 0,1580756 | 0,38848797 | 0,03780069 | 0,01226804 | 0,00817869 | 0,38831615 | 0,00329897 |
| 55-59 | 0,07 | 0,27491409 | 0,36237113 | 0,14776632 | 0,0114433 | 0,00762887 | 0,47079038 | 0,00216495 |
| 60-64 | 0,07 | 0,27491409 | 0,36237113 | 0,14776632 | 0,0114433 | 0,00762887 | 0,47079038 | 0,00216495 |
| 65-69 | 0,00333333 | 0,10996564 | 0,17302405 | 0,07560137 | 0,00546392 | 0,00364261 | 0,13058419 | 0,00010309 |
| 70-74 | 0,00333333 | 0,10996564 | 0,17302405 | 0,07560137 | 0,00546392 | 0,00364261 | 0,13058419 | 0,00010309 |
| 75+ | 0,00333333 | 0,06185567 | 0,0685567 | 0,0137457 | 0,00216495 | 0,0014433 | 0,10309278 | 0,00010309 |

**SHORT TRIPS**

| Men | Cycle | Walking | Car | Car-passeng | El-Car | Car-sharing | Public Transp | El-cycle |
|---|---|---|---|---|---|---|---|---|
| 15-19 | 0,042174 | 0,300725 | 0,00337 | 0,018116 | 0,000181 | 0,000072 | 0,018116 | 0,001304 |
| 20-24 | 0,035145 | 0,84058 | 0,107826 | 0,021739 | 0,005797 | 0,002319 | 0,163043 | 0,001087 |
| 25-29 | 0,151123 | 1,923913 | 0,215652 | 0,050725 | 0,011594 | 0,004638 | 0,210145 | 0,004674 |
| 30-34 | 0,151123 | 1,923913 | 0,215652 | 0,050725 | 0,011594 | 0,004638 | 0,210145 | 0,004674 |
| 35-39 | 0,105435 | 1,047101 | 0,363913 | 0,018116 | 0,019565 | 0,007826 | 0,072464 | 0,003261 |
| 40-44 | 0,105435 | 1,047101 | 0,363913 | 0,018116 | 0,019565 | 0,007826 | 0,072464 | 0,003261 |
| 45-49 | 0,077319 | 0,666667 | 0,256087 | 0,007246 | 0,013768 | 0,005507 | 0,065217 | 0,002391 |
| 50-54 | 0,077319 | 0,666667 | 0,256087 | 0,007246 | 0,013768 | 0,005507 | 0,065217 | 0,002391 |
| 55-59 | 0,052717 | 0,775362 | 0,333587 | 0,007246 | 0,017935 | 0,007174 | 0,072464 | 0,00163 |
| 60-64 | 0,052717 | 0,775362 | 0,333587 | 0,007246 | 0,017935 | 0,007174 | 0,072464 | 0,00163 |
| 65-69 | 0,045688 | 0,442029 | 0,245978 | 0,003623 | 0,013225 | 0,00529 | 0,028986 | 0,001413 |
| 70-74 | 0,045688 | 0,442029 | 0,245978 | 0,003623 | 0,013225 | 0,00529 | 0,028986 | 0,001413 |
| 75+ | 0,028116 | 0,119565 | 0,087609 | 0,003623 | 0,00471 | 0,001884 | 0,01087 | 0,00087 |

| Women | Cycle | Walking | Car | Car-passeng | El-Car | Car-sharing | Public Transp | El-cycle |
|---|---|---|---|---|---|---|---|---|
| 15-19 | 0,012278 | 0,300633 | 0,002943 | 0,003165 | 0,000158 | 0,000063 | 0,047468 | 0,00038 |
| 20-24 | 0,033766 | 0,740506 | 0,052975 | 0,025316 | 0,002848 | 0,001139 | 0,170886 | 0,001044 |
| 25-29 | 0,113576 | 1,75 | 0,126551 | 0,050633 | 0,006804 | 0,002722 | 0,281646 | 0,003513 |
| 30-34 | 0,113576 | 1,75 | 0,126551 | 0,050633 | 0,006804 | 0,002722 | 0,281646 | 0,003513 |
| 35-39 | 0,116646 | 1,117089 | 0,303133 | 0,037975 | 0,016297 | 0,006519 | 0,091772 | 0,003608 |
| 40-44 | 0,116646 | 1,117089 | 0,303133 | 0,037975 | 0,016297 | 0,006519 | 0,091772 | 0,003608 |
| 45-49 | 0,092089 | 0,724684 | 0,311962 | 0,03481 | 0,016772 | 0,006709 | 0,060127 | 0,002848 |
| 50-54 | 0,092089 | 0,724684 | 0,311962 | 0,03481 | 0,016772 | 0,006709 | 0,060127 | 0,002848 |
| 55-59 | 0,064462 | 0,81962 | 0,182468 | 0,060127 | 0,00981 | 0,003924 | 0,094937 | 0,001994 |
| 60-64 | 0,064462 | 0,81962 | 0,182468 | 0,060127 | 0,00981 | 0,003924 | 0,094937 | 0,001994 |
| 65-69 | 0,024557 | 0,411392 | 0,144209 | 0,060127 | 0,007753 | 0,003101 | 0,044304 | 0,000759 |
| 70-74 | 0,024557 | 0,411392 | 0,144209 | 0,060127 | 0,007753 | 0,003101 | 0,044304 | 0,000759 |
| 75+ | 0,012278 | 0,272152 | 0,044146 | 0,006329 | 0,002373 | 0,000949 | 0,066456 | 0,00038 |

*RVU: Cycling, walking, car, car-passenger, public transport. Estimated mobility share: EL-car, car-sharing, EL-cycling.*

# Appendix C: Mode substitution factors

| Oslo | SHORT CYCLING | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | 1 | -0,78276 | -0,05126 | -0,05234 | 0 | 0 | -0,11363 | 0 |
| 20-24 | 1 | -0,78276 | -0,05126 | -0,05234 | 0 | 0 | -0,11363 | 0 |
| 25-29 | 1 | -0,68136 | -0,2331 | -0,02088 | 0 | 0 | -0,06466 | 0 |
| 30-34 | 1 | -0,68136 | -0,2331 | -0,02088 | 0 | 0 | -0,06466 | 0 |
| 35-39 | 1 | -0,68136 | -0,2331 | -0,02088 | 0 | 0 | -0,06466 | 0 |
| 40-44 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 45-49 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 50-54 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 55-59 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 60-64 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 65-69 | 1 | -0,09115 | -0,68431 | -0,13833 | 0 | 0 | -0,08621 | 0 |
| 70-74 | 1 | -0,09115 | -0,68431 | -0,13833 | 0 | 0 | -0,08621 | 0 |
| 75+ | 1 | -0,09115 | -0,68431 | -0,13833 | 0 | 0 | -0,08621 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | 1 | -0,78276 | -0,05126 | -0,05234 | 0 | 0 | -0,11363 | 0 |
| 20-24 | 1 | -0,78276 | -0,05126 | -0,05234 | 0 | 0 | -0,11363 | 0 |
| 25-29 | 1 | -0,68136 | -0,2331 | -0,02088 | 0 | 0 | -0,06466 | 0 |
| 30-34 | 1 | -0,68136 | -0,2331 | -0,02088 | 0 | 0 | -0,06466 | 0 |
| 35-39 | 1 | -0,68136 | -0,2331 | -0,02088 | 0 | 0 | -0,06466 | 0 |
| 40-44 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 45-49 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 50-54 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 55-59 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 60-64 | 1 | -0,56594 | -0,36484 | -0,03524 | 0 | 0 | -0,03397 | 0 |
| 65-69 | 1 | -0,09115 | -0,68431 | -0,13833 | 0 | 0 | -0,08621 | 0 |
| 70-74 | 1 | -0,09115 | -0,68431 | -0,13833 | 0 | 0 | -0,08621 | 0 |
| 75+ | 1 | -0,09115 | -0,68431 | -0,13833 | 0 | 0 | -0,08621 | 0 |

| Oslo | SHORT WALKING | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,32988 | 1 | -0,2112 | -0,1744 | 0 | 0 | -0,28451 | 0 |
| 20-24 | -0,32988 | 1 | -0,2112 | -0,1744 | 0 | 0 | -0,28451 | 0 |
| 25-29 | -0,21456 | 1 | -0,58982 | -0,0621 | 0 | 0 | -0,13352 | 0 |
| 30-34 | -0,21456 | 1 | -0,58982 | -0,0621 | 0 | 0 | -0,13352 | 0 |
| 35-39 | -0,21456 | 1 | -0,58982 | -0,0621 | 0 | 0 | -0,13352 | 0 |
| 40-44 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 45-49 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 50-54 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 55-59 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 60-64 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 65-69 | -0,07881 | 1 | -0,70901 | -0,13274 | 0 | 0 | -0,07944 | 0 |
| 70-74 | -0,07881 | 1 | -0,70901 | -0,13274 | 0 | 0 | -0,07944 | 0 |
| 75+ | -0,07881 | 1 | -0,70901 | -0,13274 | 0 | 0 | -0,07944 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,32988 | 1 | -0,2112 | -0,1744 | 0 | 0 | -0,28451 | 0 |
| 20-24 | -0,32988 | 1 | -0,2112 | -0,1744 | 0 | 0 | -0,28451 | 0 |
| 25-29 | -0,21456 | 1 | -0,58982 | -0,0621 | 0 | 0 | -0,13352 | 0 |
| 30-34 | -0,21456 | 1 | -0,58982 | -0,0621 | 0 | 0 | -0,13352 | 0 |
| 35-39 | -0,21456 | 1 | -0,58982 | -0,0621 | 0 | 0 | -0,13352 | 0 |
| 40-44 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 45-49 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 50-54 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 55-59 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 60-64 | -0,1635 | 1 | -0,71409 | -0,06258 | 0 | 0 | -0,05983 | 0 |
| 65-69 | -0,07881 | 1 | -0,70901 | -0,13274 | 0 | 0 | -0,07944 | 0 |
| 70-74 | -0,07881 | 1 | -0,70901 | -0,13274 | 0 | 0 | -0,07944 | 0 |
| 75+ | -0,07881 | 1 | -0,70901 | -0,13274 | 0 | 0 | -0,07944 | 0 |

| Oslo | MEDIUM CYCLING | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | 1 | -0,13315 | -0,11992 | -0,1474 | 0 | 0 | -0,59954 | 0 |
| 20-24 | 1 | -0,13315 | -0,11992 | -0,1474 | 0 | 0 | -0,59954 | 0 |
| 25-29 | 1 | -0,1415 | -0,44353 | -0,04852 | 0 | 0 | -0,36645 | 0 |
| 30-34 | 1 | -0,1415 | -0,44353 | -0,04852 | 0 | 0 | -0,36645 | 0 |
| 35-39 | 1 | -0,1415 | -0,44353 | -0,04852 | 0 | 0 | -0,36645 | 0 |
| 40-44 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 45-49 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 50-54 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 55-59 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 60-64 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 65-69 | 1 | -0,05458 | -0,61763 | -0,10684 | 0 | 0 | -0,22095 | 0 |
| 70-74 | 1 | -0,05458 | -0,61763 | -0,10684 | 0 | 0 | -0,22095 | 0 |
| 75+ | 1 | -0,05458 | -0,61763 | -0,10684 | 0 | 0 | -0,22095 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | 1 | -0,13315 | -0,11992 | -0,1474 | 0 | 0 | -0,59954 | 0 |
| 20-24 | 1 | -0,13315 | -0,11992 | -0,1474 | 0 | 0 | -0,59954 | 0 |
| 25-29 | 1 | -0,1415 | -0,44353 | -0,04852 | 0 | 0 | -0,36645 | 0 |
| 30-34 | 1 | -0,1415 | -0,44353 | -0,04852 | 0 | 0 | -0,36645 | 0 |
| 35-39 | 1 | -0,1415 | -0,44353 | -0,04852 | 0 | 0 | -0,36645 | 0 |
| 40-44 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 45-49 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 50-54 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 55-59 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 60-64 | 1 | -0,12884 | -0,60732 | -0,05176 | 0 | 0 | -0,21209 | 0 |
| 65-69 | 1 | -0,05458 | -0,61763 | -0,10684 | 0 | 0 | -0,22095 | 0 |
| 70-74 | 1 | -0,05458 | -0,61763 | -0,10684 | 0 | 0 | -0,22095 | 0 |
| 75+ | 1 | -0,05458 | -0,61763 | -0,10684 | 0 | 0 | -0,22095 | 0 |

| Oslo | MEDIUM WALKING | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,08992 | 1 | -0,162 | -0,19755 | 0 | 0 | -0,55054 | 0 |
| 20-24 | -0,08992 | 1 | -0,162 | -0,19755 | 0 | 0 | -0,55054 | 0 |
| 25-29 | -0,10693 | 1 | -0,48749 | -0,06039 | 0 | 0 | -0,34519 | 0 |
| 30-34 | -0,10693 | 1 | -0,48749 | -0,06039 | 0 | 0 | -0,34519 | 0 |
| 35-39 | -0,10693 | 1 | -0,48749 | -0,06039 | 0 | 0 | -0,34519 | 0 |
| 40-44 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 45-49 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 50-54 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 55-59 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 60-64 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 65-69 | -0,03402 | 1 | -0,68984 | -0,10184 | 0 | 0 | -0,1743 | 0 |
| 70-74 | -0,03402 | 1 | -0,68984 | -0,10184 | 0 | 0 | -0,1743 | 0 |
| 75+ | -0,03402 | 1 | -0,68984 | -0,10184 | 0 | 0 | -0,1743 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,08992 | 1 | -0,162 | -0,19755 | 0 | 0 | -0,55054 | 0 |
| 20-24 | -0,08992 | 1 | -0,162 | -0,19755 | 0 | 0 | -0,55054 | 0 |
| 25-29 | -0,10693 | 1 | -0,48749 | -0,06039 | 0 | 0 | -0,34519 | 0 |
| 30-34 | -0,10693 | 1 | -0,48749 | -0,06039 | 0 | 0 | -0,34519 | 0 |
| 35-39 | -0,10693 | 1 | -0,48749 | -0,06039 | 0 | 0 | -0,34519 | 0 |
| 40-44 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 45-49 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 50-54 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 55-59 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 60-64 | -0,09372 | 1 | -0,67208 | -0,06778 | 0 | 0 | -0,16641 | 0 |
| 65-69 | -0,03402 | 1 | -0,68984 | -0,10184 | 0 | 0 | -0,1743 | 0 |
| 70-74 | -0,03402 | 1 | -0,68984 | -0,10184 | 0 | 0 | -0,1743 | 0 |
| 75+ | -0,03402 | 1 | -0,68984 | -0,10184 | 0 | 0 | -0,1743 | 0 |

| Oslo | LONG CYCLING | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | 1 | -0,08452 | -0,30358 | -0,16498 | 0 | 0 | -0,44692 | 0 |
| 20-24 | 1 | -0,08452 | -0,30358 | -0,16498 | 0 | 0 | -0,44692 | 0 |
| 25-29 | 1 | -0,02943 | -0,55034 | -0,05284 | 0 | 0 | -0,36739 | 0 |
| 30-34 | 1 | -0,02943 | -0,55034 | -0,05284 | 0 | 0 | -0,36739 | 0 |
| 35-39 | 1 | -0,02943 | -0,55034 | -0,05284 | 0 | 0 | -0,36739 | 0 |
| 40-44 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 45-49 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 50-54 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 55-59 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 60-64 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 65-69 | 1 | -0,03587 | -0,61106 | -0,07635 | 0 | 0 | -0,27673 | 0 |
| 70-74 | 1 | -0,03587 | -0,61106 | -0,07635 | 0 | 0 | -0,27673 | 0 |
| 75+ | 1 | -0,03587 | -0,61106 | -0,07635 | 0 | 0 | -0,27673 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | 1 | -0,08452 | -0,30358 | -0,16498 | 0 | 0 | -0,44692 | 0 |
| 20-24 | 1 | -0,08452 | -0,30358 | -0,16498 | 0 | 0 | -0,44692 | 0 |
| 25-29 | 1 | -0,02943 | -0,55034 | -0,05284 | 0 | 0 | -0,36739 | 0 |
| 30-34 | 1 | -0,02943 | -0,55034 | -0,05284 | 0 | 0 | -0,36739 | 0 |
| 35-39 | 1 | -0,02943 | -0,55034 | -0,05284 | 0 | 0 | -0,36739 | 0 |
| 40-44 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 45-49 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 50-54 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 55-59 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 60-64 | 1 | -0,02164 | -0,61777 | -0,05304 | 0 | 0 | -0,30755 | 0 |
| 65-69 | 1 | -0,03587 | -0,61106 | -0,07635 | 0 | 0 | -0,27673 | 0 |
| 70-74 | 1 | -0,03587 | -0,61106 | -0,07635 | 0 | 0 | -0,27673 | 0 |
| 75+ | 1 | -0,03587 | -0,61106 | -0,07635 | 0 | 0 | -0,27673 | 0 |

| Oslo | LONG WALKING | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,03052 | 1 | -0,3419 | -0,23916 | 0 | 0 | -0,38842 | 0 |
| 20-24 | -0,03052 | 1 | -0,3419 | -0,23916 | 0 | 0 | -0,38842 | 0 |
| 25-29 | -0,03332 | 1 | -0,56682 | -0,09311 | 0 | 0 | -0,30675 | 0 |
| 30-34 | -0,03332 | 1 | -0,56682 | -0,09311 | 0 | 0 | -0,30675 | 0 |
| 35-39 | -0,03332 | 1 | -0,56682 | -0,09311 | 0 | 0 | -0,30675 | 0 |
| 40-44 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 45-49 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 50-54 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 55-59 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 60-64 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 65-69 | -0,02515 | 1 | -0,66938 | -0,11731 | 0 | 0 | -0,18815 | 0 |
| 70-74 | -0,02515 | 1 | -0,66938 | -0,11731 | 0 | 0 | -0,18815 | 0 |
| 75+ | -0,02515 | 1 | -0,66938 | -0,11731 | 0 | 0 | -0,18815 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,03052 | 1 | -0,3419 | -0,23916 | 0 | 0 | -0,38842 | 0 |
| 20-24 | -0,03052 | 1 | -0,3419 | -0,23916 | 0 | 0 | -0,38842 | 0 |
| 25-29 | -0,03332 | 1 | -0,56682 | -0,09311 | 0 | 0 | -0,30675 | 0 |
| 30-34 | -0,03332 | 1 | -0,56682 | -0,09311 | 0 | 0 | -0,30675 | 0 |
| 35-39 | -0,03332 | 1 | -0,56682 | -0,09311 | 0 | 0 | -0,30675 | 0 |
| 40-44 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 45-49 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 50-54 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 55-59 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 60-64 | -0,03069 | 1 | -0,66561 | -0,09295 | 0 | 0 | -0,21075 | 0 |
| 65-69 | -0,02515 | 1 | -0,66938 | -0,11731 | 0 | 0 | -0,18815 | 0 |
| 70-74 | -0,02515 | 1 | -0,66938 | -0,11731 | 0 | 0 | -0,18815 | 0 |
| 75+ | -0,02515 | 1 | -0,66938 | -0,11731 | 0 | 0 | -0,18815 | 0 |

| Oslo | SHORT CAR | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,09758 | -0,76493 | 1 | -0,06103 | 0 | 0 | -0,07646 | 0 |
| 20-24 | -0,09758 | -0,76493 | 1 | -0,06103 | 0 | 0 | -0,07646 | 0 |
| 25-29 | -0,10123 | -0,81337 | 1 | -0,03032 | 0 | 0 | -0,05508 | 0 |
| 30-34 | -0,10123 | -0,81337 | 1 | -0,03032 | 0 | 0 | -0,05508 | 0 |
| 35-39 | -0,10123 | -0,81337 | 1 | -0,03032 | 0 | 0 | -0,05508 | 0 |
| 40-44 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 45-49 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 50-54 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 55-59 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 60-64 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 65-69 | -0,05219 | -0,80091 | 1 | -0,09224 | 0 | 0 | -0,05466 | 0 |
| 70-74 | -0,05219 | -0,80091 | 1 | -0,09224 | 0 | 0 | -0,05466 | 0 |
| 75+ | -0,05219 | -0,80091 | 1 | -0,09224 | 0 | 0 | -0,05466 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,09758 | -0,76493 | 1 | -0,06103 | 0 | 0 | -0,07646 | 0 |
| 20-24 | -0,09758 | -0,76493 | 1 | -0,06103 | 0 | 0 | -0,07646 | 0 |
| 25-29 | -0,10123 | -0,81337 | 1 | -0,03032 | 0 | 0 | -0,05508 | 0 |
| 30-34 | -0,10123 | -0,81337 | 1 | -0,03032 | 0 | 0 | -0,05508 | 0 |
| 35-39 | -0,10123 | -0,81337 | 1 | -0,03032 | 0 | 0 | -0,05508 | 0 |
| 40-44 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 45-49 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 50-54 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 55-59 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 60-64 | -0,11658 | -0,78982 | 1 | -0,05082 | 0 | 0 | -0,04277 | 0 |
| 65-69 | -0,05219 | -0,80091 | 1 | -0,09224 | 0 | 0 | -0,05466 | 0 |
| 70-74 | -0,05219 | -0,80091 | 1 | -0,09224 | 0 | 0 | -0,05466 | 0 |
| 75+ | -0,05219 | -0,80091 | 1 | -0,09224 | 0 | 0 | -0,05466 | 0 |

| Oslo | SHORT CAR-PASSENGER | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,09423 | -0,74501 | -0,07198 | 1 | 0 | 0 | -0,08878 | 0 |
| 20-24 | -0,09423 | -0,74501 | -0,07198 | 1 | 0 | 0 | -0,08878 | 0 |
| 25-29 | -0,06923 | -0,65371 | -0,23143 | 1 | 0 | 0 | -0,04563 | 0 |
| 30-34 | -0,06923 | -0,65371 | -0,23143 | 1 | 0 | 0 | -0,04563 | 0 |
| 35-39 | -0,06923 | -0,65371 | -0,23143 | 1 | 0 | 0 | -0,04563 | 0 |
| 40-44 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 45-49 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 50-54 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 55-59 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 60-64 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 65-69 | -0,03998 | -0,56822 | -0,34954 | 1 | 0 | 0 | -0,04226 | 0 |
| 70-74 | -0,03998 | -0,56822 | -0,34954 | 1 | 0 | 0 | -0,04226 | 0 |
| 75+ | -0,03998 | -0,56822 | -0,34954 | 1 | 0 | 0 | -0,04226 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,09423 | -0,74501 | -0,07198 | 1 | 0 | 0 | -0,08878 | 0 |
| 20-24 | -0,09423 | -0,74501 | -0,07198 | 1 | 0 | 0 | -0,08878 | 0 |
| 25-29 | -0,06923 | -0,65371 | -0,23143 | 1 | 0 | 0 | -0,04563 | 0 |
| 30-34 | -0,06923 | -0,65371 | -0,23143 | 1 | 0 | 0 | -0,04563 | 0 |
| 35-39 | -0,06923 | -0,65371 | -0,23143 | 1 | 0 | 0 | -0,04563 | 0 |
| 40-44 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 45-49 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 50-54 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 55-59 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 60-64 | -0,08333 | -0,51214 | -0,37604 | 1 | 0 | 0 | -0,02849 | 0 |
| 65-69 | -0,03998 | -0,56822 | -0,34954 | 1 | 0 | 0 | -0,04226 | 0 |
| 70-74 | -0,03998 | -0,56822 | -0,34954 | 1 | 0 | 0 | -0,04226 | 0 |
| 75+ | -0,03998 | -0,56822 | -0,34954 | 1 | 0 | 0 | -0,04226 | 0 |

| Oslo | MEDIUM CAR | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,18694 | -0,15145 | 1 | -0,20303 | 0 | 0 | -0,45857 | 0 |
| 20-24 | -0,18694 | -0,15145 | 1 | -0,20303 | 0 | 0 | -0,45857 | 0 |
| 25-29 | -0,16851 | -0,24589 | 1 | -0,10582 | 0 | 0 | -0,47977 | 0 |
| 30-34 | -0,16851 | -0,24589 | 1 | -0,10582 | 0 | 0 | -0,47977 | 0 |
| 35-39 | -0,16851 | -0,24589 | 1 | -0,10582 | 0 | 0 | -0,47977 | 0 |
| 40-44 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 45-49 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 50-54 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 55-59 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 60-64 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 65-69 | -0,04685 | -0,37557 | 1 | -0,22179 | 0 | 0 | -0,3558 | 0 |
| 70-74 | -0,04685 | -0,37557 | 1 | -0,22179 | 0 | 0 | -0,3558 | 0 |
| 75+ | -0,04685 | -0,37557 | 1 | -0,22179 | 0 | 0 | -0,3558 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,18694 | -0,15145 | 1 | -0,20303 | 0 | 0 | -0,45857 | 0 |
| 20-24 | -0,18694 | -0,15145 | 1 | -0,20303 | 0 | 0 | -0,45857 | 0 |
| 25-29 | -0,16851 | -0,24589 | 1 | -0,10582 | 0 | 0 | -0,47977 | 0 |
| 30-34 | -0,16851 | -0,24589 | 1 | -0,10582 | 0 | 0 | -0,47977 | 0 |
| 35-39 | -0,16851 | -0,24589 | 1 | -0,10582 | 0 | 0 | -0,47977 | 0 |
| 40-44 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 45-49 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 50-54 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 55-59 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 60-64 | -0,20001 | -0,30799 | 1 | -0,146 | 0 | 0 | -0,346 | 0 |
| 65-69 | -0,04685 | -0,37557 | 1 | -0,22179 | 0 | 0 | -0,3558 | 0 |
| 70-74 | -0,04685 | -0,37557 | 1 | -0,22179 | 0 | 0 | -0,3558 | 0 |
| 75+ | -0,04685 | -0,37557 | 1 | -0,22179 | 0 | 0 | -0,3558 | 0 |

| Oslo | MEDIUM CAR-PASSENGER | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,08771 | -0,17478 | -0,18973 | 1 | 0 | 0 | -0,54779 | 0 |
| 20-24 | -0,08771 | -0,17478 | -0,18973 | 1 | 0 | 0 | -0,54779 | 0 |
| 25-29 | -0,08292 | -0,13711 | -0,48009 | 1 | 0 | 0 | -0,29988 | 0 |
| 30-34 | -0,08292 | -0,13711 | -0,48009 | 1 | 0 | 0 | -0,29988 | 0 |
| 35-39 | -0,08292 | -0,13711 | -0,48009 | 1 | 0 | 0 | -0,29988 | 0 |
| 40-44 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 45-49 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 50-54 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 55-59 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 60-64 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 65-69 | -0,02297 | -0,15858 | -0,62988 | 1 | 0 | 0 | -0,18856 | 0 |
| 70-74 | -0,02297 | -0,15858 | -0,62988 | 1 | 0 | 0 | -0,18856 | 0 |
| 75+ | -0,02297 | -0,15858 | -0,62988 | 1 | 0 | 0 | -0,18856 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,08771 | -0,17478 | -0,18973 | 1 | 0 | 0 | -0,54779 | 0 |
| 20-24 | -0,08771 | -0,17478 | -0,18973 | 1 | 0 | 0 | -0,54779 | 0 |
| 25-29 | -0,08292 | -0,13711 | -0,48009 | 1 | 0 | 0 | -0,29988 | 0 |
| 30-34 | -0,08292 | -0,13711 | -0,48009 | 1 | 0 | 0 | -0,29988 | 0 |
| 35-39 | -0,08292 | -0,13711 | -0,48009 | 1 | 0 | 0 | -0,29988 | 0 |
| 40-44 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 45-49 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 50-54 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 55-59 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 60-64 | -0,07524 | -0,13824 | -0,64188 | 1 | 0 | 0 | -0,14464 | 0 |
| 65-69 | -0,02297 | -0,15858 | -0,62988 | 1 | 0 | 0 | -0,18856 | 0 |
| 70-74 | -0,02297 | -0,15858 | -0,62988 | 1 | 0 | 0 | -0,18856 | 0 |
| 75+ | -0,02297 | -0,15858 | -0,62988 | 1 | 0 | 0 | -0,18856 | 0 |

| Oslo | LONG CAR | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,29238 | -0,03458 | 1 | -0,21795 | 0 | 0 | -0,4551 | 0 |
| 20-24 | -0,29238 | -0,03458 | 1 | -0,21795 | 0 | 0 | -0,4551 | 0 |
| 25-29 | -0,06271 | -0,05705 | 1 | -0,1791 | 0 | 0 | -0,70114 | 0 |
| 30-34 | -0,06271 | -0,05705 | 1 | -0,1791 | 0 | 0 | -0,70114 | 0 |
| 35-39 | -0,06271 | -0,05705 | 1 | -0,1791 | 0 | 0 | -0,70114 | 0 |
| 40-44 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 45-49 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 50-54 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 55-59 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 60-64 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 65-69 | -0,03268 | -0,10716 | 1 | -0,30297 | 0 | 0 | -0,5572 | 0 |
| 70-74 | -0,03268 | -0,10716 | 1 | -0,30297 | 0 | 0 | -0,5572 | 0 |
| 75+ | -0,03268 | -0,10716 | 1 | -0,30297 | 0 | 0 | -0,5572 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,29238 | -0,03458 | 1 | -0,21795 | 0 | 0 | -0,4551 | 0 |
| 20-24 | -0,29238 | -0,03458 | 1 | -0,21795 | 0 | 0 | -0,4551 | 0 |
| 25-29 | -0,06271 | -0,05705 | 1 | -0,1791 | 0 | 0 | -0,70114 | 0 |
| 30-34 | -0,06271 | -0,05705 | 1 | -0,1791 | 0 | 0 | -0,70114 | 0 |
| 35-39 | -0,06271 | -0,05705 | 1 | -0,1791 | 0 | 0 | -0,70114 | 0 |
| 40-44 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 45-49 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 50-54 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 55-59 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 60-64 | -0,08401 | -0,06384 | 1 | -0,20168 | 0 | 0 | -0,65047 | 0 |
| 65-69 | -0,03268 | -0,10716 | 1 | -0,30297 | 0 | 0 | -0,5572 | 0 |
| 70-74 | -0,03268 | -0,10716 | 1 | -0,30297 | 0 | 0 | -0,5572 | 0 |
| 75+ | -0,03268 | -0,10716 | 1 | -0,30297 | 0 | 0 | -0,5572 | 0 |

| Oslo | LONG CAR-PASSENGER | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,00961 | -0,03859 | -0,34773 | 1 | 0 | 0 | -0,60407 | 0 |
| 20-24 | -0,00961 | -0,03859 | -0,34773 | 1 | 0 | 0 | -0,60407 | 0 |
| 25-29 | -0,02154 | -0,03352 | -0,64061 | 1 | 0 | 0 | -0,30433 | 0 |
| 30-34 | -0,02154 | -0,03352 | -0,64061 | 1 | 0 | 0 | -0,30433 | 0 |
| 35-39 | -0,02154 | -0,03352 | -0,64061 | 1 | 0 | 0 | -0,30433 | 0 |
| 40-44 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 45-49 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 50-54 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 55-59 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 60-64 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 65-69 | -0,00959 | -0,04411 | -0,71165 | 1 | 0 | 0 | -0,23464 | 0 |
| 70-74 | -0,00959 | -0,04411 | -0,71165 | 1 | 0 | 0 | -0,23464 | 0 |
| 75+ | -0,00959 | -0,04411 | -0,71165 | 1 | 0 | 0 | -0,23464 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transp | El-cycle |
| 15-19 | -0,00961 | -0,03859 | -0,34773 | 1 | 0 | 0 | -0,60407 | 0 |
| 20-24 | -0,00961 | -0,03859 | -0,34773 | 1 | 0 | 0 | -0,60407 | 0 |
| 25-29 | -0,02154 | -0,03352 | -0,64061 | 1 | 0 | 0 | -0,30433 | 0 |
| 30-34 | -0,02154 | -0,03352 | -0,64061 | 1 | 0 | 0 | -0,30433 | 0 |
| 35-39 | -0,02154 | -0,03352 | -0,64061 | 1 | 0 | 0 | -0,30433 | 0 |
| 40-44 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 45-49 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 50-54 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 55-59 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 60-64 | -0,02536 | -0,03135 | -0,70918 | 1 | 0 | 0 | -0,23411 | 0 |
| 65-69 | -0,00959 | -0,04411 | -0,71165 | 1 | 0 | 0 | -0,23464 | 0 |
| 70-74 | -0,00959 | -0,04411 | -0,71165 | 1 | 0 | 0 | -0,23464 | 0 |
| 75+ | -0,00959 | -0,04411 | -0,71165 | 1 | 0 | 0 | -0,23464 | 0 |

| Oslo | | | | SHORT EL-CAR | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 20-24 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 25-29 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 30-34 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 35-39 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 40-44 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 45-49 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 50-54 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 55-59 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 60-64 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 65-69 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 70-74 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 75+ | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 20-24 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 25-29 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 30-34 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 35-39 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 40-44 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 45-49 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 50-54 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 55-59 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 60-64 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 65-69 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 70-74 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 75+ | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |

| Oslo | | | | SHORT CAR-SHARING | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 20-24 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 25-29 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 30-34 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 35-39 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 40-44 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 45-49 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 50-54 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 55-59 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 60-64 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 65-69 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 70-74 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 75+ | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 20-24 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 25-29 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 30-34 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 35-39 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 40-44 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 45-49 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 50-54 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 55-59 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 60-64 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 65-69 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 70-74 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 75+ | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |

| Oslo | | | | MEDIUM EL-CAR | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 20-24 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 25-29 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 30-34 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 35-39 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 40-44 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 45-49 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 50-54 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 55-59 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 60-64 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 65-69 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 70-74 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 75+ | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 20-24 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 25-29 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 30-34 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 35-39 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 40-44 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 45-49 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 50-54 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 55-59 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 60-64 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 65-69 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 70-74 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 75+ | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |

| Oslo | | | | MEDIUM CAR-SHARING | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 20-24 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 25-29 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 30-34 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 35-39 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 40-44 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 45-49 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 50-54 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 55-59 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 60-64 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 65-69 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 70-74 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 75+ | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 20-24 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 25-29 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 30-34 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 35-39 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 40-44 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 45-49 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 50-54 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 55-59 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 60-64 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 65-69 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 70-74 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 75+ | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |

| Oslo | | | | LONG EL-CAR | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 20-24 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 25-29 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 30-34 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 35-39 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 40-44 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 45-49 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 50-54 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 55-59 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 60-64 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 65-69 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 70-74 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 75+ | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 20-24 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 25-29 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 30-34 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 35-39 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 40-44 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 45-49 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 50-54 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 55-59 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 60-64 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 65-69 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 70-74 | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |
| 75+ | -0,34 | -0,33 | -0,33 | 0 | 1 | 0 | 0 | 0 |

| Oslo | | | | LONG CAR-SHARING | | | | |
|---|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 20-24 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 25-29 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 30-34 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 35-39 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 40-44 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 45-49 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 50-54 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 55-59 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 60-64 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 65-69 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 70-74 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 75+ | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 20-24 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 25-29 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 30-34 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 35-39 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 40-44 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 45-49 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 50-54 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 55-59 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 60-64 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 65-69 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 70-74 | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |
| 75+ | -0,15 | -0,15 | 0 | -0,35 | 0 | 1 | -0,35 | 0 |

| Oslo | SHORT PUBLIC TRANSPORT | | | | | | |
|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,12794 | -0,76013 | -0,0564 | -0,05552 | 0 | 0 | 1 | 0 |
| 20-24 | -0,12794 | -0,76013 | -0,0564 | -0,05552 | 0 | 0 | 1 | 0 |
| 25-29 | -0,10275 | -0,67379 | -0,20158 | -0,02188 | 0 | 0 | 1 | 0 |
| 30-34 | -0,10275 | -0,67379 | -0,20158 | -0,02188 | 0 | 0 | 1 | 0 |
| 35-39 | -0,10275 | -0,67379 | -0,20158 | -0,02188 | 0 | 0 | 1 | 0 |
| 40-44 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 45-49 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 50-54 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 55-59 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 60-64 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 65-69 | -0,04056 | -0,55352 | -0,33714 | -0,06878 | 0 | 0 | 1 | 0 |
| 70-74 | -0,04056 | -0,55352 | -0,33714 | -0,06878 | 0 | 0 | 1 | 0 |
| 75+ | -0,04056 | -0,55352 | -0,33714 | -0,06878 | 0 | 0 | 1 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,12794 | -0,76013 | -0,0564 | -0,05552 | 0 | 0 | 1 | 0 |
| 20-24 | -0,12794 | -0,76013 | -0,0564 | -0,05552 | 0 | 0 | 1 | 0 |
| 25-29 | -0,10275 | -0,67379 | -0,20158 | -0,02188 | 0 | 0 | 1 | 0 |
| 30-34 | -0,10275 | -0,67379 | -0,20158 | -0,02188 | 0 | 0 | 1 | 0 |
| 35-39 | -0,10275 | -0,67379 | -0,20158 | -0,02188 | 0 | 0 | 1 | 0 |
| 40-44 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 45-49 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 50-54 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 55-59 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 60-64 | -0,08779 | -0,53516 | -0,34591 | -0,03114 | 0 | 0 | 1 | 0 |
| 65-69 | -0,04056 | -0,55352 | -0,33714 | -0,06878 | 0 | 0 | 1 | 0 |
| 70-74 | -0,04056 | -0,55352 | -0,33714 | -0,06878 | 0 | 0 | 1 | 0 |
| 75+ | -0,04056 | -0,55352 | -0,33714 | -0,06878 | 0 | 0 | 1 | 0 |

| Oslo | SHORT EL-CYCLING | | | | | | |
|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 20-24 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 25-29 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 30-34 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 35-39 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 40-44 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 45-49 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 50-54 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 55-59 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 60-64 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 65-69 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 70-74 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 75+ | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 20-24 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 25-29 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 30-34 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 35-39 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 40-44 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 45-49 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 50-54 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 55-59 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 60-64 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 65-69 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 70-74 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 75+ | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |

| Oslo | MEDIUM PUBLIC TRANSPORT | | | | | | |
|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,19605 | -0,2669 | -0,23431 | -0,30274 | 0 | 0 | 1 | 0 |
| 20-24 | -0,19605 | -0,2669 | -0,23431 | -0,30274 | 0 | 0 | 1 | 0 |
| 25-29 | -0,16157 | -0,20153 | -0,55881 | -0,07808 | 0 | 0 | 1 | 0 |
| 30-34 | -0,16157 | -0,20153 | -0,55881 | -0,07808 | 0 | 0 | 1 | 0 |
| 35-39 | -0,16157 | -0,20153 | -0,55881 | -0,07808 | 0 | 0 | 1 | 0 |
| 40-44 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 45-49 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 50-54 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 55-59 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 60-64 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 65-69 | -0,0321 | -0,1794 | -0,66435 | -0,12416 | 0 | 0 | 1 | 0 |
| 70-74 | -0,0321 | -0,1794 | -0,66435 | -0,12416 | 0 | 0 | 1 | 0 |
| 75+ | -0,0321 | -0,1794 | -0,66435 | -0,12416 | 0 | 0 | 1 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,19605 | -0,2669 | -0,23431 | -0,30274 | 0 | 0 | 1 | 0 |
| 20-24 | -0,19605 | -0,2669 | -0,23431 | -0,30274 | 0 | 0 | 1 | 0 |
| 25-29 | -0,16157 | -0,20153 | -0,55881 | -0,07808 | 0 | 0 | 1 | 0 |
| 30-34 | -0,16157 | -0,20153 | -0,55881 | -0,07808 | 0 | 0 | 1 | 0 |
| 35-39 | -0,16157 | -0,20153 | -0,55881 | -0,07808 | 0 | 0 | 1 | 0 |
| 40-44 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 45-49 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 50-54 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 55-59 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 60-64 | -0,13362 | -0,14459 | -0,65932 | -0,06247 | 0 | 0 | 1 | 0 |
| 65-69 | -0,0321 | -0,1794 | -0,66435 | -0,12416 | 0 | 0 | 1 | 0 |
| 70-74 | -0,0321 | -0,1794 | -0,66435 | -0,12416 | 0 | 0 | 1 | 0 |
| 75+ | -0,0321 | -0,1794 | -0,66435 | -0,12416 | 0 | 0 | 1 | 0 |

| Oslo | MEDIUM EL-CYCLING | | | | | | |
|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 20-24 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 25-29 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 30-34 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 35-39 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 40-44 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 45-49 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 50-54 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 55-59 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 60-64 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 65-69 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 70-74 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 75+ | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 20-24 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 25-29 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 30-34 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 35-39 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 40-44 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 45-49 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 50-54 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 55-59 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 60-64 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 65-69 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 70-74 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 75+ | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |

| Oslo | LONG PUBLIC TRANSPORT | | | | | | |
|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,01835 | -0,04417 | -0,51174 | -0,42574 | 0 | 0 | 1 | 0 |
| 20-24 | -0,01835 | -0,04417 | -0,51174 | -0,42574 | 0 | 0 | 1 | 0 |
| 25-29 | -0,04874 | -0,03594 | -0,81626 | -0,09906 | 0 | 0 | 1 | 0 |
| 30-34 | -0,04874 | -0,03594 | -0,81626 | -0,09906 | 0 | 0 | 1 | 0 |
| 35-39 | -0,04874 | -0,03594 | -0,81626 | -0,09906 | 0 | 0 | 1 | 0 |
| 40-44 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 45-49 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 50-54 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 55-59 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 60-64 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 65-69 | -0,02108 | -0,0429 | -0,79372 | -0,1423 | 0 | 0 | 1 | 0 |
| 70-74 | -0,02108 | -0,0429 | -0,79372 | -0,1423 | 0 | 0 | 1 | 0 |
| 75+ | -0,02108 | -0,0429 | -0,79372 | -0,1423 | 0 | 0 | 1 | 0 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,01835 | -0,04417 | -0,51174 | -0,42574 | 0 | 0 | 1 | 0 |
| 20-24 | -0,01835 | -0,04417 | -0,51174 | -0,42574 | 0 | 0 | 1 | 0 |
| 25-29 | -0,04874 | -0,03594 | -0,81626 | -0,09906 | 0 | 0 | 1 | 0 |
| 30-34 | -0,04874 | -0,03594 | -0,81626 | -0,09906 | 0 | 0 | 1 | 0 |
| 35-39 | -0,04874 | -0,03594 | -0,81626 | -0,09906 | 0 | 0 | 1 | 0 |
| 40-44 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 45-49 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 50-54 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 55-59 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 60-64 | -0,05368 | -0,02594 | -0,83492 | -0,08546 | 0 | 0 | 1 | 0 |
| 65-69 | -0,02108 | -0,0429 | -0,79372 | -0,1423 | 0 | 0 | 1 | 0 |
| 70-74 | -0,02108 | -0,0429 | -0,79372 | -0,1423 | 0 | 0 | 1 | 0 |
| 75+ | -0,02108 | -0,0429 | -0,79372 | -0,1423 | 0 | 0 | 1 | 0 |

| Oslo | LONG EL-CYCLING | | | | | | |
|---|---|---|---|---|---|---|---|
| Men | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 20-24 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 25-29 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 30-34 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 35-39 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 40-44 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 45-49 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 50-54 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 55-59 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 60-64 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 65-69 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 70-74 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 75+ | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| Women | Cycle | Walking | Car | Carpassenge | El-Car | Car-sharing | blic Transpo | El-cycle |
| 15-19 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 20-24 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 25-29 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 30-34 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 35-39 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 40-44 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 45-49 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 50-54 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 55-59 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 60-64 | -0,5 | -0,1 | -0,1 | -0,1 | -0,05 | 0 | -0,15 | 1 |
| 65-69 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 70-74 | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |
| 75+ | -0,05 | -0,1 | -0,6 | -0,1 | -0,05 | 0 | -0,1 | 1 |