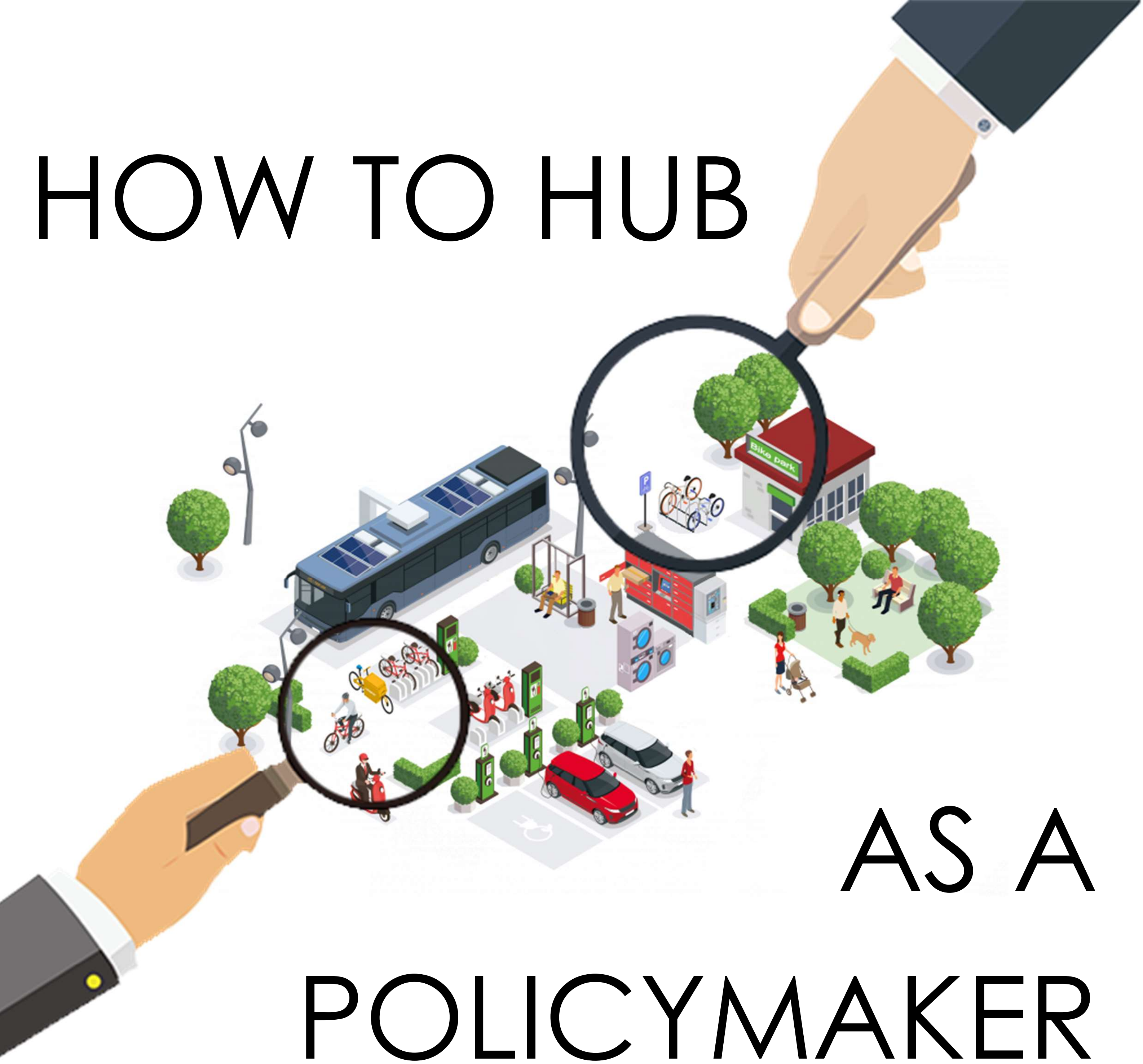
HOW TO HUB AS A POLICYMAKER



Implementing mobility hubs to change car-usage habits: accelerating the green mobility transition

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TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

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This thesis has been carried out according to the rules of the TU/e Code of Scientific Integrity. The information in this thesis is publicity available.

Preface

Over the past ten months, I have had the opportunity to contribute to the sustainable transition of cities. I have learned about the complexity of policymaking and the dynamic relation between citizens and the built environment, which has fascinated me throughout this research. The conversations with professionals and experts, as well as gaining insights from hundreds of respondents, was a very valuable aspect in this process. I am thereby proud to have worked on a topic that is important for a sustainable future and has academic value. Being able to contribute to more sustainable environments motivates me and will be a main driver during the next steps of my professional career.

Therefore, I am excited to present this thesis, which focusses on stimulating sustainable travel behaviour by the implementation of mobility hubs. This thesis marks the final chapter of my double Master's programs at Eindhoven University of Technology in 1) Construction Management and Engineering, and 2) Architecture, Building and Planning, focussing on the Urban Systems and Real Estate track.

I want to express my gratitude to my supervisors Astrid Kemperman, Qi Han and Robert van Dongen for their guidance and feedback during the research, which helped to keep a critical and open view during the project. Secondly, I would like to thank AT Osborne for providing me with the opportunity to link my academic work to practice. I especially would like to express my gratitude to Anna Bootsma and Kees van Son for their guidance and meaningful discussions during the past year. Besides, I would like to thank the mobility team and sustainable living environment team of AT Osborne as well. Welcoming me in their teams and involving me in every aspect, from strategy meetings to team activities, made graduating very enjoyable. Lastly, I would like to thank SmartwayZ.NL for sharing the questionnaire with their travellers' panel.

Finally, I want to thank my family and friends for supporting me throughout these special times.

Enjoy reading my work!

Rachelle Weerts
Eindhoven, June 2024

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Summary

Cities are responsible for a significant share of global emissions and citizens experience the growing consequences of global warming, such as urban heat waves, drought, and the risk of flooding. Moving towards more sustainable mobility, particularly through the reduction of private car usage, is essential for creating sustainable, healthy, and resilient cities. Multimodality is a highly anticipated means to benefit from more sustainable mobility modes and, thereby, reducing private car usage. Multimodality is commonly facilitated through mobility hubs. The implementation of mobility hubs does, however, not automatically result in significant changes in travel behaviour. Travel behaviour is influenced by multiple factors, including travel habits, making behavioural change challenging. Because of its repetitiveness, travel behaviour is especially sensitive to habit forming, making effective interventions even more difficult. Municipalities often struggle to make effective decisions for implementing mobility hubs aimed at reducing private car usage. A deeper understanding on how to change travel behaviour and travel habits towards a reduction of private car usage to favour mobility hub usage is important for the sustainable transition of cities.

The effective implementation of mobility hubs to change private car-based travel habits is understudied. While existing literature on mobility hubs is extensive, it lacks a structured and widely supported definition of mobility hubs and specific mobility hub types. A comprehensive understanding of factors and attributes contributing to the effectiveness of mobility hub implementations to change private car owners' travel behaviour is necessary for informed decision-making and for aligning insights across mobility hub research. This includes insights on flanking policies that policymakers can apply to alter travel behaviour and their related effects. Based on the above, the main research question is:

How can municipalities best implement mobility hubs to effectively change private car-based travel habits?

To answer the main research question, the following sub-questions are answered in this research:

1. What is the definition of mobility hubs and what are their typologies and characteristics?
2. Which behavioural models and municipal interventions exist for stimulating habit change focused on travel behaviour?
3. What is the relationship between habit strength and the attitude towards municipal policies intended to change the habit?
4. How can mobility hubs be made more interesting for citizens regarding functionality and location to stimulate habit change?
5. Which flanking policies should municipalities use for effective implementation of mobility hubs to change car-using habits and which not?
6. Which role should municipalities adopt when implementing hubs and flanking policies?

The methodology of the research consists of different phases. In the exploration phase, a literature study and expert interviews are performed answering sub-questions 1, 2, and 6. The literature study constructs comprehensive definitions of mobility hubs and hub types, addresses the theoretical background of behavioural models and lists flanking policies that municipalities can use to change travel behaviour. The expert interviews provide practical insights from a wide range of mobility hub experts which complement the insights from literature. Furthermore, the literature study and interviews provide detailed input for the execution phase.

In the execution phase, a questionnaire with a stated choice experiment (SCE) is distributed and analysed. The results are tested and applied to a case study to show the practical implications. The SCE tests actual choice behaviour and is designed based on a comprehensive set of mobility hub attributes, *including mobility modes available, additional amenities present, environment characteristics, and travel time and travel costs compared to the usual mode of transport*. The results of the SCE are analysed with the multinomial logit (MNL) model and the latent class model (LCM). The choice sets are completed for three trip purposes; 1) work and educational travels, 2) family and friends visits, and 3) day trips. In the questionnaire, information on other attributes is collected and analysed to gain more insights into how to alter private car-related travel behaviour. A case study is performed to present the practical implications of this research on three mobility hubs in Eindhoven.

The results of the literature review include a comprehensive definition of mobility hubs with necessary and optional features, and definitions of the two mobility hub types that target private car usage, namely neighbourhood and district hubs. A list of push and pull measures is formulated to provide an overview of possible flanking policies, and detailed input from the literature study is used in the questionnaire and SCE design. Several experts from different backgrounds were interviewed and this resulted in interesting additional insights, complementing the literature study.

The results of the SCE are based on 534 respondents, of which 457 completed the entire questionnaire. The analysis resulted in detailed insights into the utilities and preferences of mobility hub attributes and levels of the respondents. The respondents are divided over three quite evenly distributed classes with specific characteristics in the LCM which resulted in a higher model fit than the MNL model (Figure S1).

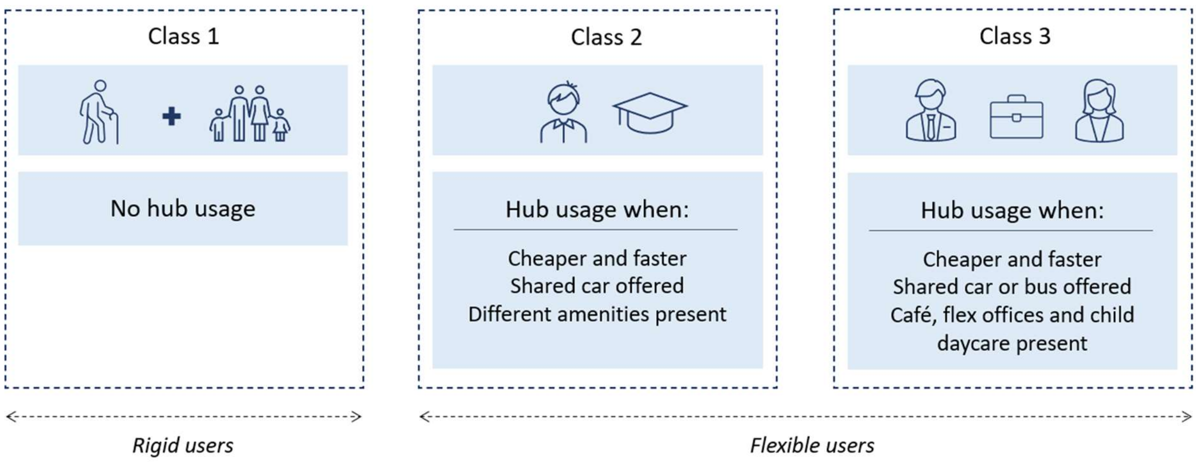


Figure S 1: Overview classes considering mobility hub usage.

Class 1 is characterized by respondents that are reluctant to change their usual travel mode and are unlikely to use any form of mobility hubs. This class is characterized by families with children and higher age groups. Class 2 is characterized by respondents who are still quite reluctant to change their usual travel mode, however, the private car owners in this class can easily be attracted to mobility hubs. Overall, the attributes with the highest effect on attracting this class to hubs are travel costs, except for work and education trips, travel time, and available shared mobility modes. The class is characterized by young people (< 30 years old) and individuals living in non-family households, such as students. These individuals generally live in urbanized locations. Class 3 is characterized by respondents that are most willing to use mobility hubs, however, car owners are more rigid to use their usual mode of transport. They show quite some similarities with class 2 preferences, with travel costs, travel time and availability of travel modes as important indicators. The class is characterized as young urban professionals, aged 30-39, who generally live in highly urbanized locations.

The questionnaire also provides insights into habit strength and the effects of flanking policies. There is no significantly large relation discovered between habit strength and policy support. The analysis of flanking policies gave insight into the relation between policy support and potential behavioural change of several push and pull measures. Push measures, especially with monetary consequences, can potentially change behaviour most but receive the highest policy resistance, while pull measures are more supported but show low potential behavioural change.

All these insights combined create a broad understanding of the effective implementation of mobility hubs and the consequences of flanking policies to change private car usage travel habits. The implications are presented in a case study of three mobility hubs in Eindhoven, for which some design changes and flanking policies are advised to increase the likeliness of successful use of mobility hubs by private car owners and users.

All in all, this research contributes to literature by providing a comprehensive overview of the factors and attributes related to the effective implementation of mobility hubs for changing private car-related travel habits. A deeper understanding of travel habits and flanking policies is realized, and actual behaviour of respondents is modelled and analysed to better understand the effects of mobility hub attributes and levels for different societal groups and trip purposes. This allows better-targeted decision-making by municipalities.

The research also has some limitations and recommendations for future research. One of the main limitations is that the data sample is not representative for the Dutch population. Therefore, results should be interpreted with caution. Furthermore, the effect of flanking policies has not been tested in the SCE but with self-stated ranking methods, which limits the accuracy of the results as a deep understanding of the preferences has to be assumed. Another limitation is that the formulation of classes is based solely on respondents' mobility hub attribute utility and preferences, and not on other attributes like socio-demographics which would allow for better decision-making. Future research is recommended to take this into account and consider the effects of travel habits on mobility hub implementations too. All in all, this research showed the importance of considering habits in decision-making and provided practical insights which can be used when designing and implementing mobility hubs.

Samenvatting

Steden zijn verantwoordelijk voor een aanzienlijk deel van de wereldwijde uitstoot en burgers ervaren de toenemende gevolgen van de opwarming van de aarde, zoals hittegolven, droogte en een toenemend risico op overstromingen. Een transitie naar duurzamere mobiliteit, met name door het verminderen van privé autogebruik, is noodzakelijk voor het creëren van duurzame, gezonde en veerkrachtige steden. Multimodaliteit heeft de potentie om het gebruik van privéauto’s te verminderen door verschillende duurzame vervoersmiddelen te combineren en ze daarmee haalbaarder te maken. Multimodaliteit wordt gefaciliteerd op mobiliteitshubs. De implementatie van enkel fysieke mobiliteitshubs leidt echter niet direct tot significante veranderingen in reisgedrag. Reisgedrag wordt beïnvloed door meerdere factoren, waaronder reisgewoontes, waardoor gedragsverandering een uitdaging is. Reisgedrag is daarbij extra gevoelig voor gewoontevorming vanwege de herhalingen van het gedrag, waardoor effectieve interventies nog moeilijker worden. Gemeenten hebben vaak moeite om effectieve beslissingen te nemen bij het implementeren van mobiliteitshubs die gericht zijn op het verminderen van privéautogebruik. Een beter inzicht in hoe reisgedrag en reisgewoontes kunnen worden veranderd naar minder privéautogebruik en meer gebruik van mobiliteitshubs, is belangrijk voor de duurzame transitie van steden.

De effectieve implementatie van mobiliteitshubs om reisgewoontes van privéautogebruikers te veranderen is onvoldoende onderzocht. Hoewel de literatuur over mobiliteitshubs uitgebreid is, ontbreekt het aan een gestructureerde en breed gedragen definitie van mobiliteitshubs. Een beter inzicht in factoren en attributen die bijdragen aan de effectiviteit van mobiliteitshubs om het reisgedrag van privéautobezitters te veranderen is noodzakelijk voor weloverwogen besluitvorming. Dit omvat ook inzichten over flankerend beleid die beleidsmakers kunnen toepassen om reisgedrag te veranderen. Op basis van bovenstaande is de volgende hoofdonderzoeksvraag geformuleerd:

Hoe kunnen gemeenten mobiliteitshubs het beste implementeren om privéauto-gerelateerde reisgewoontes effectief te veranderen?

Om de hoofdonderzoeksvraag te beantwoorden worden in dit onderzoek de volgende deelvragen beantwoord:

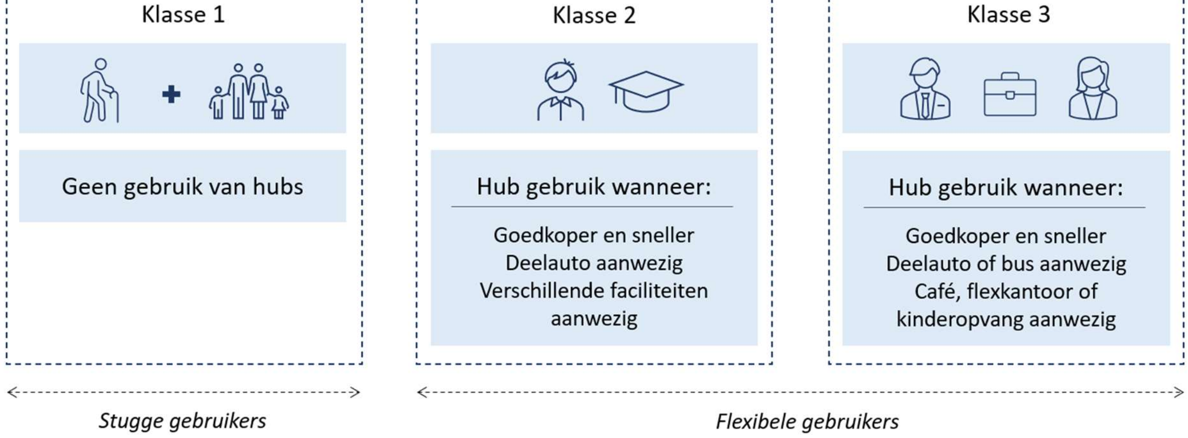
1. Wat is de definitie van mobiliteitshubs en wat zijn hun typologieën en kenmerken?
2. Welke gedragsmodellen en gemeentelijke interventies bestaan er voor het stimuleren van gewoonteverandering gerelateerd aan reisgedrag?
3. Wat is de relatie tussen de sterkte van gewoontes en de houding ten opzichte van gemeentelijk beleid dat bedoeld is om deze gewoontes te veranderen?
4. Hoe kunnen mobiliteitshubs interessanter worden gemaakt voor burgers op het gebied van functionaliteit en locatie om gewoonteverandering te stimuleren?
5. Welk flankerend beleid kunnen gemeenten gebruiken voor een effectieve implementatie van mobiliteitshubs om het gebruik van auto's te veranderen en welke niet?
6. Welke rol kunnen gemeenten aannemen bij de implementatie van hubs en flankerend beleid?

De methodologie van het onderzoek bestaat uit verschillende fasen. In de verkenningsfase worden een literatuurstudie en expertinterviews uitgevoerd om antwoord te geven op de deelvragen 1, 2 en 6. De literatuurstudie construeert uitgebreide definities van mobiliteitshubs en verschillende hub types, gaat in op de theoretische achtergrond van gedragsmodellen en geeft een overzicht van flankerend beleid dat gemeenten kunnen gebruiken om reisgedrag te veranderen. De expertinterviews bieden praktische inzichten op het gebied van mobiliteitshubs die de inzichten uit de literatuur aanvullen. Verder leveren de literatuurstudie en interviews gedetailleerde input voor de uitvoeringsfase.

In de uitvoeringsfase wordt een vragenlijst met een keuze experiment (SCE) verspreid en geanalyseerd. De resultaten worden getoetst met een casestudie om de praktische implicaties van de resultaten aan te tonen. De SCE modelleert keuzegedrag en is ontworpen op basis van kenmerken van mobiliteit hubs, waaronder beschikbare mobiliteits-vormen, aanwezige voorzieningen, omgevingskenmerken, en reistijd en reiskosten ten opzichte van het gewoonlijke vervoersmiddel. De resultaten van de SCE worden geanalyseerd met het multinomiale logit (MNL) model en het latent class model (LCM). De keuzesets worden ingevuld voor drie reisdoeleinden: 1) werk- en educatieve reizen, 2) familie- en vriendenbezoeken en 3) dagtochten. In de vragenlijst wordt ook informatie over andere kenmerken verzameld en geanalyseerd om meer inzicht te krijgen in hoe het reisgedrag van privéautogebruikers kan worden veranderd. Aan de hand van een praktijkvoorbeeld worden de implicaties van dit onderzoek op drie mobiliteitshubs in Eindhoven gepresenteerd.

De resultaten van het literatuuronderzoek zijn een uitgebreide definitie van mobiliteitshubs met de noodzakelijke en optionele functies, en definities van de twee typen mobiliteitshubs die gericht zijn op het verminderen van privé autogebruik, namelijk buurt- en wijkhubs. Daarnaast wordt er een lijst met push- en pull-maatregelen geformuleerd om een overzicht te geven van mogelijke flankerende beleidsmaatregelen. Gedetailleerde input uit de literatuurstudie wordt gebruikt in de vragenlijst en het SCE-ontwerp. Verder zijn er experts met verschillende achtergronden geïnterviewd en dit heeft geresulteerd in interessante inzichten, complementerend aan de literatuurstudie.

De resultaten van de SCE zijn gebaseerd op 534 respondenten, van wie er 457 de volledige vragenlijst hebben ingevuld. De analyse geeft een gedetailleerd inzicht in de voorkeuren van respondenten van mobiliteitshubs' attributen. De respondenten zijn verdeeld over drie vrij gelijkmatig verdeelde klassen met specifieke kenmerken in het LCM, wat resulteerde in een hoge model-fit; hoger dan het MNL-model (Figuur S2).



Figuur S 2: Klassen die mobiliteit hub gebruik overwegen.

Klasse 1 bevat respondenten die zeer terughoudend zijn om hun gebruikelijke manier van reizen te veranderen en geen gebruik maken van vervoersmiddelen aangeboden op hubs. Deze klasse wordt gekenmerkt door gezinnen met kinderen en hogere leeftijdsgroepen. Klasse 2 bevat respondenten die ook vrij terughoudend zijn om hun gebruikelijke manier van reizen te veranderen, met uitzondering van privéautobezitters. Juist deze groep kan overtuigd worden tot minder autogebruik. Reiskosten, behalve voor werk- en onderwijsreizen, reistijd en beschikbare mobiliteitsvormen spelen hierin een belangrijke rol. De klasse wordt gekenmerkt door jongeren (< 30 jaar oud) en personen die in niet-gezinshuishoudens wonen, zoals studenten, wonend in stedelijke gebieden. Klasse 3 bevat respondenten die het meest bereid zijn om mobiliteitshubs te gebruiken, met uitzondering van privéautobezitters. Respondenten in klasse 3 vertonen veel overeenkomsten met de voorkeuren van klasse 2, waarbij reiskosten, reistijd en beschikbaarheid van verschillende mobiliteitsvormen belangrijke indicatoren zijn. De klasse wordt gekenmerkt door ‘young urban professionals’ in de leeftijd van 30 tot 39 jaar, wonend in sterk stedelijke gebieden.

De vragenlijst geeft verder inzicht in de sterkte van autogewoontes en de effecten van flankerend beleid. Er is geen significant groot verband ontdekt tussen de sterkte van autogewoontes en beleidsondersteuning. De analyse van flankerend beleid gaf inzicht in de steun voor beleidsmaatregelen en verwachte gedragsverandering van verschillende push- en pull-maatregelen. Push-maatregelen, vooral met financiële gevolgen, kunnen gedrag het meest veranderen, maar roepen ook de hoogste weerstand op. Pull-maatregelen daarentegen worden meer ondersteund maar hebben een laag potentieel voor gedragsverandering.

De inzichten bieden een breed begrip van de effectieve implementatie van mobiliteitshubs en het effect van aanvullend beleid op het reisgedrag van privéautogebruikers. De implicaties worden gepresenteerd in een casestudie van drie mobiliteitshubs in Eindhoven, waarvoor enkele ontwerpwijzigingen en flankerend beleid worden geadviseerd om de kans op succesvol gebruik van de hubs te vergroten.

Al met al levert dit onderzoek een belangrijke bijdrage aan de literatuur door inzicht te geven in factoren die de implementatie van mobiliteitshubs beïnvloeden en reisgewoontes rond privéautogebruik veranderen. Het modelleert en analyseert reisgewoonten, factoren die invloed hebben op gedrag met betrekking tot mobiliteitshubs, en beleidseffecten, wat gemeenten helpt gerichtere beslissingen te nemen.

Het onderzoek heeft ook enkele limitaties en aanbevelingen voor toekomstig onderzoek. Eén van de belangrijkste limitaties is dat de steekproef niet representatief is voor de Nederlandse bevolking. Daarom moeten de resultaten met zorg worden geïnterpreteerd. Bovendien is het effect van flankerend beleid niet getest in de SCE, maar met zelfverklaarde beoordelingsscores, wat de nauwkeurigheid van de resultaten beperkt. Verder onderzoek naar de effecten van reisgewoonten op implementaties van mobiliteitshubs wordt aanbevolen, aangezien dit onderzoek het belang van het meenemen van reisgewoonten bij het veranderen van reisgedrag heeft aangetoond. Daarbij wordt toekomstig onderzoek aanbevolen om het werkelijke effect, in plaats van het verwachte effect, van flankerend beleid op autoreisgedrag te toetsen om betere besluitvorming mogelijk te maken.

Abstract

Cities are responsible for a significant share of global emissions and citizens experience the growing consequences of global warming. Moving towards more sustainable mobility, particularly through the reduction of private car usage, is essential for creating sustainable, healthy and resilient cities. Multimodality is a highly anticipated means to reduce private car usage as it combines the benefits of more sustainable mobility modes. Multimodality is commonly facilitated through mobility hubs. The implementation of mobility hubs does, however, not automatically result in significant changes in travel behaviour, largely due to travel habits. Municipalities, and thereby policymakers, are struggling with how to effectively implement mobility hubs to change private car-based travel habits in order to stimulate the mobility transition. The aim of this research is to give insights into how mobility hubs, and flanking policies, can best be implemented to stimulate mobility behaviour to be less car-oriented. The research uses a mix of research methods. A literature study is used to describe the theoretical background, expert interviews are conducted to connect the study to practical insights and challenges, and a questionnaire with a stated choice experiment (SCE) is used to test travel mode choice behaviour. In the SCE, individuals are asked to indicate whether they would consider travelling by one of two hub alternatives or stick to their usual mode of transport for different trip purposes. The hub attributes considered are available mobility modes, presence of additional amenities, environment characteristics, and travel costs and travel time compared to the usual mode of transport. Next to the SCE, the questionnaire focusses on current mobility behaviour, and the support and effect of flanking mobility policies. Based on the results, three different groups could be identified based on their choice behaviour. One group consists of rigid usual transport mode users, defined by families with children and individuals over the age of 65 years. The other two groups would consider travelling by mobility hubs. These groups are generally younger, and live in non-family households, alone or together with a partner. The SCE results are tested against a case study of three recently implemented mobility hubs in Eindhoven to show the practical implications of the results. This research adds to literature as well as practice, by allowing better targeted mobility policy decision-making by municipalities.

Keywords: Mobility transition, mobility hubs, travel habits, stated choice experiment, behaviour change

List of Abbreviations

AIC	Akaike Information Criterion
ABC theories	Attitude-Behaviour-Context theory
BIC	Bayesian Information Criterion
COM-B model	Capacity-Opportunity-Motivation lead to Behaviour
DSP	Dominant Social Paradigm
LCM	Latent Class Model
ML model	Mixed Logit model
MNL model	Multinomial Logit model
NEP	New Ecological Paradigm
SCE	Stated Choice Experiment
SRHI	Self-Report Habit Index
RFM	Response Frequency Measure
TOD	Transit Oriented Development
YUP	Young Urban Professional

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1. Introduction

This chapter describes the background of this research and defines the research problem. In Section 1.2., the research questions are stated, after which the research approach is described in Section 1.3. Lastly, a reading guide for this document is provided in Section 1.4.

1.1. Background

Cities contribute significantly to worldwide greenhouse gas emissions and at the same time are highly affected by the consequences of climate change. Cities consume 60-80% of the world's energy and 70-80% of the world's greenhouse gases can be related back to cities (Heller, 2022; Short & Farmer, 2021, Sodiq et al., 2019). The negative effects of climate change are directly felt by citizens in the form of urban heat waves, drought and the risk of flooding (Short & Farmer, 2021). With growing recognition of these effects, cities are increasingly taking responsibility to reduce their impact on global warming and are adapting to changing climate. Citizens play an important role in this transition as they experience the negative effects in daily life and co-determine successful implementation of changes through their choices and behaviour (Bibri & Krogstie, 2020; CDP, 2021; Dodman et al., 2022). CDP (2022), the world's largest institute on carbon disclosure, states that cities taking people-centred climate actions experience more benefits and are taking 50% more climate actions than average cities.

The mobility sector is the most significant contributor to a median household's carbon footprint (Dubois et al., 2019). Cities are confronted with mobility and transport related problems, such as air pollution, noise, congestion, occupation of public spaces, traffic accidents and waste. The fossil fuels used for mobility are contributing to climate change far beyond city limits (Foltýnová et al., 2020). Sustainable mobility can address these problems, as it focusses on human needs, social justice, and environmental sustainability (Foltýnová et al., 2020; Holden et al., 2020). To move towards sustainable mobility, proactive behaviour of individuals is essential, mainly in the form of changes in travel behaviour.

An important part of transitioning towards sustainable mobility is cities stimulating and enabling the reduction of private car use of citizens. The private car is the main transportation mode in the Netherlands and at the same time the largest share of inhabitant's emissions. Of all distance travelled by inhabitants in the Netherlands, 70.3% is travelled by car (CBS, 2021). Private cars are a large source of emissions, occupy a lot of space in cities, and add to noise pollution, heat stress, and related health problems (Foltýnová et al., 2020). To move to sustainable mobility, citizens will need to increasingly switch towards active mobility modes, public transport, electric vehicles and shared mobility (Bamwesigye & Hlavackova, 2019; Diao, 2019; Gallo & Marinelli, 2019). The concept of multimodality supports the above transition towards more sustainable transport modes.

Multimodality refers to a transportation system that combines multiple mobility modes to facilitate efficient movement (Holotová et al., 2023). Active mobility, public transport and shared mobility each have different advantages and disadvantages related to flexibility, comfort, sustainable impact and health. Multimodality combines these transport modes and has the potential to offer the benefits of all modes while avoiding their weaknesses to accomplish sustainable mobility. As stated by Alessandretti et al. (2022, p.2040), "the potential of multimodal mobility lies in 1) creating an interplay between different modes that is more effective than a single mode alone, and 2) in a direct or indirect reduction of unsustainable transport modes”. By linking different transportation modes multimodality can provide an efficient and feasible alternative to private cars, which can contribute to a reduction in private car usage (Holotová et al., 2023). The place where people change their mobility mode is an important consideration in multimodality as each mode of transport has its own underlying infrastructure and operational schedule (Alessandretti et al., 2022). Attractive and well-accessible places are needed where different mobility modes come together and, hence, make it easier to switch between different modes. These places are referred to as mobility hubs. In literature, not one clear definition of mobility hubs exists, however, the core characteristics of mobility hubs coincide and are the provision of multimodal transfers, interaction with surroundings, supportive infrastructure and social services, and often physical and digital integration to facilitate multimodal transfers (Rongen et al., 2022; UITP, 2023).

Mobility hubs can be the solution to several challenges cities face such as the large private car usage by citizens and communities demanding a higher quality of life, less-constrained mobility, and equitable access to opportunities and resources (Rongen et al., 2022; UITP, 2023). According to UITP (2023), mobility hubs add value to the mobility transition on three aspects: 1) they increase awareness of new transport services and multimodal, low-carbon lifestyles, 2) they enhance the connectivity of public transport and new (active) mobility services and 3) they improve community facilities and liveability. By these three aspects, mobility hubs can eventually foster sustainable and low-carbon mobility by showing attractive alternatives over private cars and reducing the need to travel by adding community facilities (UITP, 2023). So, mobility hubs can support a people-centred, integrated, and synchronized approach to adopt more sustainable mobility behaviours by offering a place where public transport, active mobility modes and public services are integrated making mobility hubs evident in the mobility transition (UITP, 2023). However, multimodality is still limited in the Netherlands (4% to 5% of all trips) showing that a large scale shift from private car use towards multimodal transport needed to limit climate change effects did not happen yet (Rongen et al., 2022).

Many studies address reasons for individuals to remain using their cars mainly focussed on rational decision-making. These reasons include longer travel times, unclear regulations, lack of safety measures, loss of autonomy, and affinity with and complexity of alternative travel modes. (Burghard & Dütschke, 2019; Wallsten et al., 2021). While these aspects are already thoroughly studied in literature, there is another factor playing a large role in people’s modal choices which has only received limited attention so far in mobility research: habits. As stated by Verplanken and Whitmarsh (2021), even though people have positive attitudes, favourable beliefs, and a motivation to act, this frequently does not lead to actual behaviour.

Habits can be defined as “memory-based propensities to respond automatically to specific cues, which are acquired by repetition of cue-specific behaviours in stable contexts” (Verplanken & Whitmarsh, 2021, p.42). Because of habits, travel behaviour can follow an irrational path, without conscious decisional involvement (Rahman & Sciara, 2022). Travel behaviour, in this regard, has an important characteristic: it is repetitive (Ramos et al., 2020). The repetitiveness of travel behaviour leads to strong travel habits. Consequently, research shows that individuals with strong habits show a decreasing interest in alternative travel modes. They stick with their initial travel choice, even if better alternatives are available (Haustein & Kroesen, 2022; Ramos et al., 2020; Verplanken & Whitmarsh, 2021). As identified by several studies, further research is needed to identify under which circumstances travel habits are formed and which techniques and solutions are optimal to change old travel habits into new sustainable travel habits (Rahman & Sciara, 2022; Ramos et al., 2020; Verplanken & Whitmarsh, 2021).

The stimulation of forming sustainable travel habits can have great benefits for municipalities, since the features of habits (frequent, automatic, and resistant to change) make them desirable for obtaining sustainable behaviour. When the creation of sustainable habits is incorporated into policies, habits can lead to more durable, low-carbon, and climate-resilient behaviours resulting in policy efficacy (Verplanken & Whitmarsh, 2021). Building more sustainable travel habits is, therefore, important and mobility hubs are a potential means to building these habits. Mobility hubs, in that case, need to be implemented successfully, ensuring they are used to their full potential. However, because of habits, the realization of physical mobility hubs without implementing additional stimuli to use the hub, will not lead to people switching from private car use to more sustainable modes at a larger scale. Flanking policies are needed to stimulate people to rethink their mobility choices and switch from private car use to mobility modes available at mobility hubs (Rongen et al., 2022; Rongen et al., 2023).

Policy making, especially in democratic countries like the Netherlands, requires careful considerations on the response of citizens towards policies. Policies can be popular, and quickly adopted by individuals, but policies can also be considered unacceptable, minimizing the desired effect of the policy and losing credibility as a policymaker. Even when policies are accepted they are not necessarily actively supported and implemented. In this light, Ogunkunbi and Meszoros (2023) show that policymakers should consider trade-offs between environmental effectiveness and political feasibility, which is the policy acceptance and support of individuals. Examining the willingness to support a policy is crucial especially in the context of climate change mitigation measures as these measures often require behavioural changes; individuals need to be willing to promote and facilitate the policy interventions (Ogunkunbi & Meszoros, 2023). In terms of sustainable mobility, the question arises if people that support certain policies are also more likely to change their habit and adopt more pro-environmental behaviour. This insight could be useful for policymakers to be better able to change habits. The effect of policy acceptance and support on changinge habits is, however, understudied.

1.2. Problem statement and research questions

Cities face the enormous challenge to reduce its impact on climate change. Citizens can play a key role in realizing the shift towards sustainable cities through their behaviour. Mobility is a large component of citizens' direct effect on climate change, especially through private car usage. Moving away from the private car and using more sustainable travel modes, such as public transport and active mobility modes, is needed to reduce the negative effect of mobility on climate change in cities. Habits related to private car use, however, contribute largely to citizens not changing their mobility behaviour, even when other mobility choices are rationally better. Multimodality is a promising means to move towards more sustainable mobility in cities since it combines the advantages of different transportation modes while overcoming the disadvantages. Mobility hubs facilitate multimodality in cities by creating attractive and well-connected places where citizens can easily switch to other mobility modes. It is, however, unknown which role mobility hubs can play in changing private car usage habits and, thereby, building more sustainable travel habits, and which role municipalities play in changing car travel behaviour by realizing hubs. To address the comprehensive impact of mobility hubs on private car-using habits, it is important to not only look at the direct attractiveness of mobility hubs but also at flanking policies that can make mobility hub usage more effective. This results in the following main research question:

How can municipalities best implement mobility hubs to effectively change private car-based travel habits?

This research question can be answered by addressing the following sub-questions:

1. What is the definition of mobility hubs and what are their typologies and characteristics?
2. Which behavioural models and municipal interventions exist for stimulating habit change focused on travel behaviour?
3. What is the relationship between habit strength and the attitude towards municipal policies intended to change the habit?
4. How can mobility hubs be made more interesting for citizens regarding functionality and location to stimulate habit change?
5. Which flanking policies should municipalities use for effective implementation of mobility hubs to change car-using habits and which not?
6. Which role should municipalities adopt when implementing hubs and flanking policies?

1.3. Research approach

The research approach is divided into three phases and designed to answer all research questions. An overview of the research approach is given in Figure 1.

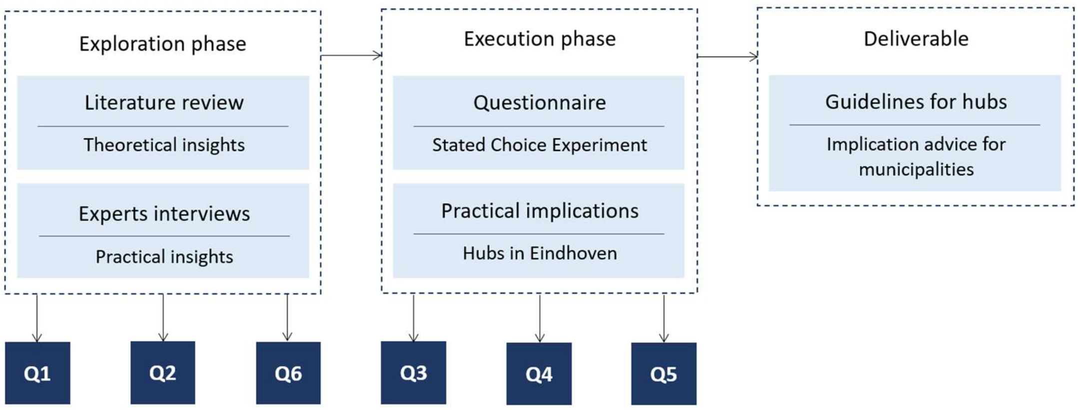

Figure 1: Overview research approach.

The research will start with an exploration phase, consisting of a literature study and expert interviews. First, the literature study is conducted. In order to conduct a comprehensive study, a literature review is needed to form a theoretical background on different concepts and their relationships. Thereby, literature is not always consistent in the definition of mobility hubs and related contexts, and this study intends to combine different descriptions into comprehensive definitions that will be used as a base in this research. Altogether, the literature study will focus on habits, behaviour change approaches, (flanking) mobility policies and mobility hubs. The second component of the exploration phase are expert interviews. The interviews will take place with experts in the mobility (hub) field and are included to receive practical insights on problems and implementations that complement the insights from theoretical background. A diverse group of experts is interviewed in order to gain a comprehensive understanding of mobility practices, including policymakers, knowledge institutes and market parties. The interviews are semi-structured to ensure that all necessary questions receive structured answers while allowing freedom to gain other interesting insights (Van Aken & Berends, 2018). The exploration phase provides answers to sub-questions 1, 2 and 6. Thereby, the exploration phase helps defining relevant variables for the questionnaire in the execution phase.

After the exploration phase, the execution phase takes place. In the execution phase, data on the mobility behaviour of individuals is gathered and analysed using a questionnaire to answer research questions 3, 4 and 5. The questionnaire consists of three parts. The first part focuses on background information, such as daily transportation mode usage, individuals' attitude towards environmental issues, and socio-demographic characteristics. The second part focuses on the attitude towards municipal flanking policies and car habit strength. The third part consists of a stated choice experiment (SCE). Through this experiment, individuals' mobility choice behaviour is tested. Individuals are asked to indicate how they would travel: by modes offered at a hub or their usual mode of transport. In the SCE, hub characteristics, consisting of functional- and location characteristics, are considered. To show the practical implications of this research, the results are plotted against newly implemented mobility hubs in Eindhoven.

After the exploration and execution phase, the research delivers an advice with guidelines on how to effectively implement mobility hubs as a measure to stimulate the switch from private car usage towards more sustainable modes by individuals, in line with the main research question: How can municipalities best implement mobility hubs to effectively change private car-based travel habits?

1.4. Reading guide

This chapter provided a brief introduction into the research topic and described the main outlines of the thesis. In Chapter 2, the literature study is described, followed by the experts' interviews, including more detailed methodology on the interview set-up, in Chapter 3. Chapter 4 describes the questionnaire with the SCE, including the methodology of the SCE, the data collection method and the results of the SCE. As these chapters are quite extensive, each of these three chapters (2, 3, and 4), are supplemented with a conclusion which gives a comprehensive understanding of the most important findings of that specific chapter. Chapter 5 provides the planning implications, showing how the results of the research can be implemented in practice by plotting them against three newly realized mobility hubs in Eindhoven. In Chapter 6, the discussion of the complete research is provided answering the research questions. Lastly, Chapter 7 gives the conclusion and recommendations for further research.

2. Literature study

To provide a complete theoretical background for the research and to formulate definitions for concepts addressed in this thesis, a literature study is conducted. The literature study includes the following topics: 1) behavioural change theories, 2) habit theory, 3) mobility hubs and their typologies, and 4) flanking mobility policies. Using Google Scholar with a focus on publications from 2017 onwards, relevant scientific articles are found. Relevant articles are selected based on their title and abstract. In case a model or theory is established before 2017, the original source is used. Besides, the bibliography of frequently cited sources are scanned to include a broader selection of articles. This chapter describes first the relevant literature regarding general behavioural change theories and habits as a basis for this research in Sections 2.1. and 2.2. Secondly, the concept of mobility hubs is elaborated in more detail and a definition and relevant typologies are defined in Section 2.3. Lastly, relevant flanking mobility policies are discussed in Section 2.4. Section 2.5. summarizes the key findings.

2.1. Rational behaviour change theories and approaches

Mobility is largely determined by the decisions made by citizens on how to travel. To realize the shift to sustainable cities, citizens need to switch from private car usage towards more sustainable mobility modes (Bamwesigye & Hlavackova, 2019; Gallo & Marinelli, 2019). In other words, citizens need to change their mobility behaviour in order to realize the necessary mobility shift. In literature, several behaviour change models, which can be used as a basis for behaviour change approaches, are described. In this section, the most relevant ones will be discussed more elaborately.

2.1.1. Psychological theories

Literature on behaviour can be roughly divided into two categories: theories focused on conscious behaviour and theories focused on unconscious behaviour. Theories focused on conscious behaviour state that people make reasoned, logical choices. Within conscious behaviour theory, there are three well-established theories/models that are relevant for environmental behaviour: (1) theory of planned behaviour, (2) norm activation model, and (3) value-belief-norm theory of environmentalism (Rahman & Sciara, 2022; Steg & De Groot, 2018; Whitmarsh et al., 2021).

The theory of planned behaviour states that people make reasoned decisions based on their attitude, subjective norms and perceived behaviour control, which influences the intention to perform a certain behaviour (Figure 2) (Rahman & Sciara, 2022; Steg & De Groot, 2018; Whitmarsh et al., 2021). Intention is therefore the main predictor of behaviour. In terms of mobility mode choices, attitude can for example be based on the favourable or unfavourable attitudes towards biking, subjective norms can be based on pro-environmental sustainability beliefs, and perceived behaviour control can be based on the perceived ease or difficulty of finding good biking lanes (Rahman & Sciara, 2022). Perceived behaviour control is, therefore, not about the actual situation, but about how individuals interpretate or feel about the possibilities.

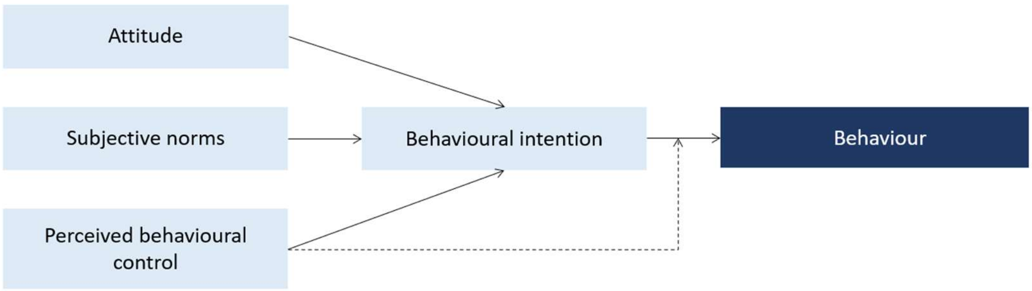

Figure 2: Theory of planned behaviour (Rahman & Sciara, 2022).

The norm activation model states that pro-environmental behaviour follows from the activation of personal norms. These personal norms reflect feelings of moral obligation to perform (or refrain) from specific behaviour. Personal norms are activated by four key elements: (1) problem awareness, (2) ascription of responsibility, (3) outcome efficacy (which shows the identification of behaviour to reduce environmental problems), and (4) self-efficacy (which relates to the recognition of people's own ability to alleviate environmental threats) (Rahman & Sciara, 2022; Steg & De Groot, 2018). These four elements can be referred to as situational factors, as the strength of these elements is different in each situation; the elements are not stable over time (Steg & De Groot, 2018). To give an example, personal norms (which lead to behaviour) can be activated when someone is aware that driving a private fossil fuelled car has a negative influence on air quality, and that person feels personally responsible for this problem and does not blame others. Besides, this person beliefs that switching from personal car use towards biking adds to solving the problem and this person has the physical option to switch towards a bike. If these personal norms are in this way activated, it is, according to the norm activation model, likely that this person will switch towards riding a bike.

The value-belief-norm theory of environmentalism is an extension of the norm activation model and states that situational factors, such as problem awareness, depend on someone's personal values (e.g. general goals which function as guiding principles in someone's life) and specifically ecological worldviews (beliefs on relationships between humans and the environment) (Figure 3) (Steg & De Groot, 2018). The value-belief-norm theory is thus developed specifically with pro-environmental behaviour in mind and is best-known for its prediction of political or low-impact pro-environmental actions (Whitmarsh et al., 2021).

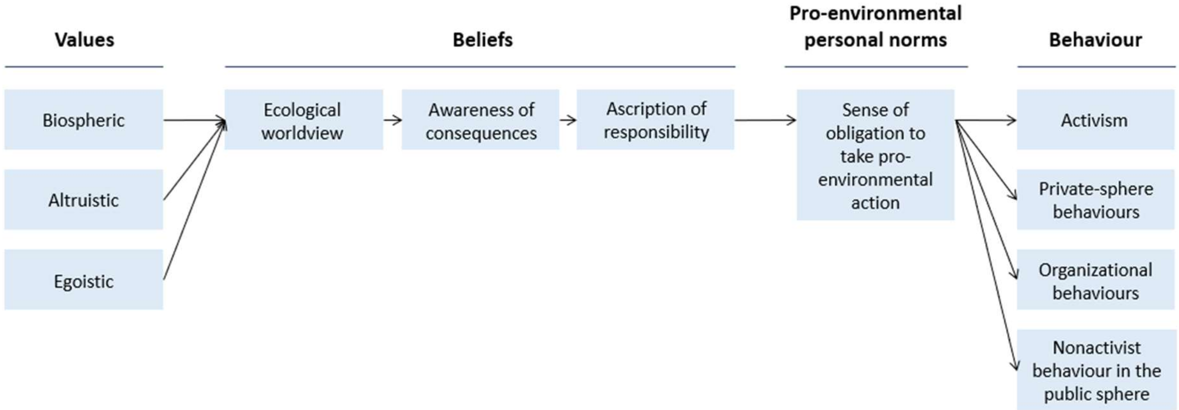

Figure 3: Value-belief-norm theory of Environmentalism adopted from Steg and De Groot (2018).

Even though these models highlight some of the main drivers and barriers towards more pro-environmental behaviour (such as attitudes and personal norms), the models have some limitations that hinder significant progress towards ultimate sustainable behaviour (Whitmarsh et al., 2021). The most significant limitations are:

- The models are based on a small number of common theories which limit their effectiveness in understanding behaviour- and informing interventions.
- The models are too distinctive. Structural factors, such as income and location, outweigh psychological factors in predicting carbon-emitting behaviours and are hardly taking into consideration.
- The models are too linear and assume that people act alone. It is assumed that behaviour is the end point of a causal chain of attitudinal psychological factors, while this is often not the case. In real life cases, people often do not act in isolation from others and their environment can influence their behaviour.
- Lastly, these models assume a rational, conscious decision-making process. They state that people have a motivation to act, and, therefore, will act. However, most of our behaviour is habitual, which is shown by the fact that favourable beliefs, a motivation to act and positive attitudes often do not lead to the expected behaviour. These theories based on conscious behaviour describe new or infrequent behaviour well, but provide a poor account in habitual behaviour (Verplanken & Whitmarsh, 2021).

Mobility behaviour is often habitual (Rahman & Sciara, 2022), and therefore, psychological models are not the best models to describe behaviour change in this content. In Section 2.2., habits are discussed more elaborately.

2.1.2. Behaviour change theories

In behaviour change literature, three relevant theories/models are described: 1) transtheoretical model, 2) ABC theory, and 3) COM-B model including the behaviour change wheels. These models overcome the shortcomings of the psychological theories. The transtheoretical model is a more dynamic model and the COM-B and ABC models take, next to psychological factors, also contextual factors into account, making these models more comprehensive in describing behavioural changes (Prochaska, 2008; Rahman & Sciara, 2022; Social Change UK, 2019; Stern, 2000; Whitmarsh et al., 2021).

The transtheoretical model is a dynamic theory of behaviour change as it describes the stages people move through when establishing new behaviours. Behaviour change is described as a process that unfolds over time through a series of stages. These stages include precontemplation, contemplation, preparation, action, maintenance and termination (Prochaska, 2008; Whitmarsh et al., 2021). The precontemplation, contemplation and preparation stages are characterized by an intention to take action, but not actively making changes yet. In the action stage, people make specific modifications to their behaviour within the next six months. In the maintenance stage, people are working to prevent relapse into the old (habitual) behaviour. The termination stage is characterized by people having zero temptation to return to their former behaviour and 100% self-efficacy, representing an establishment of the desired behaviour (Prochaska, 2008).

The ABC (Attitude-Behaviour-Context) theory describes that behaviour is a function of the individual and its environment, or in other words, behaviour is a product of the interaction between attitude and context (Rahman & Sciara, 2022; Stern, 2000). This means that behaviour depends on the relative strength of one's attitudes and one's surrounding context (both social and physical). This theory also states that some contexts can strongly favour certain behaviours (e.g. biking in terms of mobility) by requiring, facilitating, or rewarding those behaviours (Rahman & Sciara, 2022). To give an example, in a car-dominant neighbourhood with poor bicycle lanes, residents' positive attitudes towards biking might not be reflected by their travel behaviour, as they probably drive their car because the neighbourhood (context) does not offer the right biking infrastructure and, therefore, does not trigger/facilitate biking behaviour. However, if the neighbourhood is restructured with better and safer biking conditions, residents with positive attitudes towards biking will now be more likely to ride their bikes instead of using their cars.

The COM-B model states that there are three components belonging to any behaviour (B): capability (C), opportunity (O), and motivation (M). This means that in order to perform certain behaviour, one must feel they are both psychologically and physically able to execute the behaviour (C), have the social and physical opportunity to execute the behaviour (O), and want (or need) to carry out the behaviour more than other competing behaviours (M) (Social Change UK, 2019). It should be stated that opportunity here represents the actual social or physical opportunity to execute behaviour, and not the perceived opportunity as described by the theory of planned behaviour. The components of the model interact, which means that interventions should target one or more of the components in order to facilitate effective behaviour change (Figure 4). These interacting components also show that by changing behaviour the determinants of behaviour are influenced and changed as well, which brings the opportunity for long-term behaviour change. From Figure 4, it can also be concluded that by influencing capability and opportunity, motivation can be altered, leading to behaviour change. If this change is powerful enough, it will impact the other determinants as well, bring the possibility that the new behaviour is preferred over other competing behaviours leading to an reinforcement of long-term behaviour change.

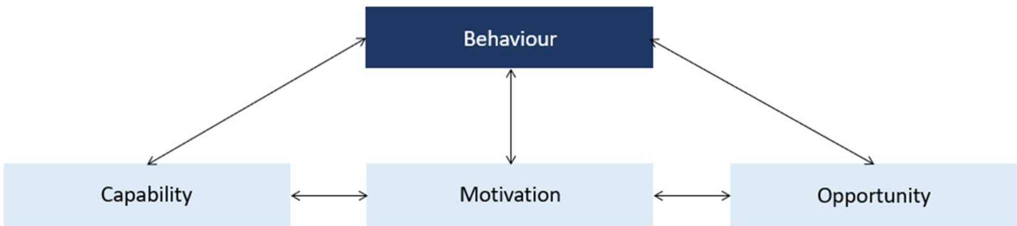

Figure 4: COM-B model of behaviour change adopted from Social Change UK (2019).

The three components of the COM-B model are each determined by two sub-components, which can be described as (Social Change UK, 2019):

- Two components for capability: psychological capability (our knowledge /psychological strength, skills or stamina) and physical capability (our physical strength, skill or stamina).

- Two components for opportunity: physical opportunity (opportunities provided by the environment, such as time, location and resources) and social opportunity (opportunities as a result of social factors, such as cultural norms and social cues).
- Two components for motivation: reflective motivation (reflective processes such as making plans and evaluating past events) and automatic motivation (automatic processes such as our desires, impulses and inhibitions).

In order to use the COM-B model in practical cases, the components of the model are used as a basis for the behaviour change wheel. This tool can be used to set up behaviour change interventions and in that way encourage behaviour change. The wheel consists of seven policy categories and nine intervention functions, which can be used as input for the set-up of behaviour change interventions (Figure 5). The guidelines of the behaviour change wheel can be used to realize change in the main areas of the COM-B model (Social Change UK, 2019).

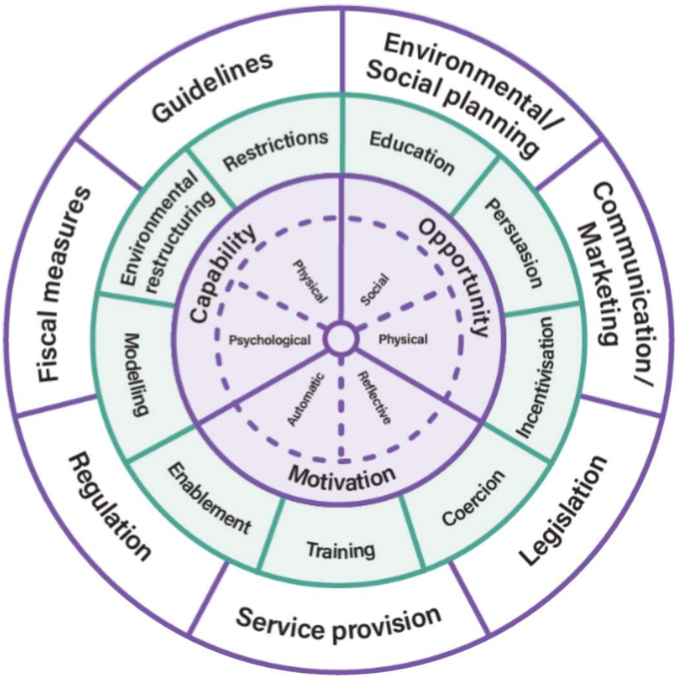

Figure 5: The behaviour change wheel (Social Change UK, 2019).

The models in this section show that behaviour is influenced by more than just psychological attributes. Also the context and actual opportunity to act a certain way determine behaviour. The COM-B model and behaviour change wheel give a practical guideline for setting up behavioural change interventions. However, even when psychological attributes and context is positive towards desired behaviour, this does often not lead to actual behaviour (Verplanken & Whitmarsh, 2021). Habits play an important role in this gap. In the next section (Section 2.2.), habit theory will be explained in more detail.

2.2. Unconscious behaviour: habits

The built environment influences travel behaviour through travel attitudes and habits (Rahman & Sciara, 2022) (Figure 6). As also described in Section 2.1., attitudes are part of reasoned behaviour, leading to logical travel choices. However, despite positive attitudes, favourable beliefs and a motivation to act, this often does not lead to actual travel behaviour (Verplanken & Whitmarsh, 2021). Habits play a role in this. Behaviour then follows an unreasoned path, without conscious decisional involvement (Rahman & Sciara, 2022).

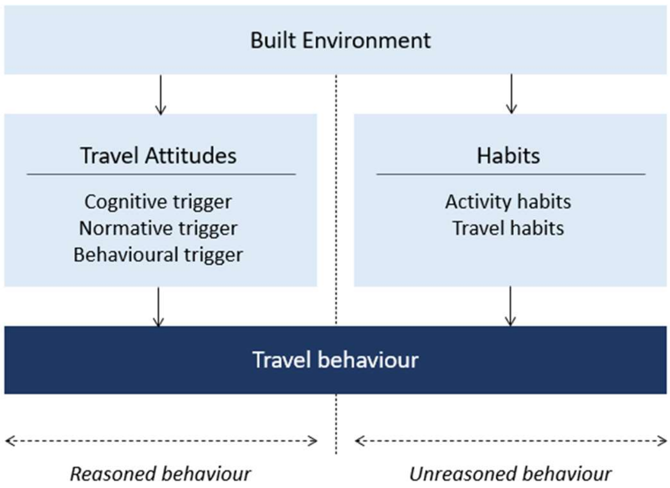

Figure 6: Influence built environment on travel behaviour (Rahman & Sciara, 2022).

Usually, the initial travel mode decision in a new situation is made through rational decisions based on internal factors. Repeatedly choosing that travel mode in a stable environment can generate automatic travel behaviour: a travel habit (Rahman & Sciara, 2022) (Figure 7). It is important to note that habits are not the same as past behaviour; repeating behaviour may lead to the formation of habits (these are memory traces), which then may lead to habitual responses when people are confronted with circumstances or contexts in which the habits were formed (Verplanken & Whitmarsh, 2021). Habits can thus be defined as "memory-based propensities to respond automatically to specific cues, which are acquired by repetition of cue-specific behaviours in stable contexts" (Verplanken & Whitmarsh, 2021, p.42). Travel behaviour, in this regard, has an important characteristic: it is repetitive, especially regarding commuting behaviour, and therefore often shows strong habitual components (Ramos et al., 2020; Verplanken & Whitmarsh, 2021). Haustein and Kroesen (2022) found in their research that people who always choose the same particular travel mode were more likely to keep choosing that travel mode over time, forming a pattern. These people can be classified as habitual travellers. On the other hand, multimodal travellers (travellers who use a combination of travel modes) can be defined as "deliberate-choice" travellers, as they choose the mode that best fits the given circumstances. Multimodal travellers are more likely to change travel patterns when new circumstances arise, as they do not possess strong travel habits (Haustein & Kroesen, 2022, p.3). This trend is also confirmed in other research, which state that individuals with strong travel habits show a decreasing interest in alternative travel modes and, therefore, stick with their initial travel choice, even if better alternatives are available (Ramos et al., 2020; Verplanken & Orbell, 2019; Verplanken & Whitmarsh, 2021).

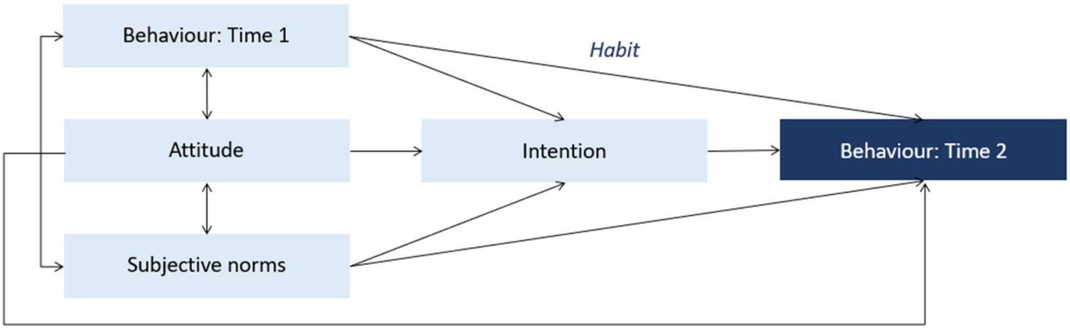

Figure 7: The formation of habits (Rahman and Sciara, 2022).

Habits consists of features which make them stick and difficult to break and/or change. They occur frequently and automatically (without awareness and conscious intent), are difficult not to do, and are resistant to change due to tunnel vision and inertia. Besides, most habits are mentally efficient, and therefore require less energy, making it, for instance, possible to multitask (Verplanken & Orbell, 2019; Verplanken & Whitmarsh, 2021). This results in a moderated interest in new information and sticking with the habitual travel choice. However, habits are controlled by the context in which they occur, the stability of that context is the prime condition for the continuing of habits (Carden & Wood, 2018; Verplanken & Orbell, 2019; Verplanken & Whitmarsh, 2021). If context stability is taken away, this brings opportunities for habit change. Currently, habits are a key driver of human behaviours that contribute to climate change through routine carbon-emitting activities, such as driving fuel-driven private cars. Habits can, therefore, be a barrier to effective interventions mitigating this unsustainable behaviour. On the other hand, the features of habits, such as stickiness, make habits desirable when they are linked to sustainable behaviour. Considering habits in intervention designs can lead to more durable, low-carbon and climate resilient behaviours (Verplanken & Whitmarsh, 2021).

An overview of the key aspects of habits (automatic behaviour) in comparison to conscious decision-making is given in Table 1, as adapted from Steg and De Groot (2018).

Table 1: Overview conscious versus automatic decision-making adopted from Steg and De Groot (2018).

	Conscious decision-making	Automatic decision-making
Level of mental resources needed	High	Low
Parallel processing	Not possible	Possible
Flexibility	High	Low
Sensitivity of change	High	Low
Efficiency	Low	High
Controllability	High	Low
Awareness	High	Low
Attention needed	High	Low
Decisional involvement	High	Low
Speed	Low	High
Accuracy	High	High if situation is the same and low if situation changed

2.2.1. Changing habits

In general, habit changing methods can be classified according to two perspectives: the micro level and the macro level. The micro level focuses on cue-response contingencies that form habits, while the macro level focuses on disrupting the habit performance context (Verplanken & Orbell, 2019). In Table 2, an overview of the strategies that are generally known on each level are described.

Table 2: Overview strategies for changing habits.

Micro level	
Strategy	**Definition**
Implementation intentions	Specific plans that describe where, when, and how to act. These plans are especially applicable when forming habits, as they formulate the exact cues and responses that, by sufficient repetition, may turn into habits. The plans bridge the intention-behaviour gap and consists of an if-then structure (Linder et al., 2021; Verplanken & Whitmarsh, 2021).
Self-monitoring and cue identification	Contextual cues, such as going to work, automatically activate behaviour responses, such as taking the car, which can then be identified as a habit. Self-monitoring and self-consciousness can give insights in when a habit is activated. Tracking this can help in breaking or changing unwanted habits (Linder et al., 2021).
Cognitive strategies	Cognitive strategies focus on the way information is interpretated and processed. Cognitive strategies that are used in habit change are reminders (in environmental contexts) that trigger a certain behaviour (Linder et al., 2021).
Incentives	Incentives, often financial, can be used to stimulate a certain behaviour by rewarding this behaviour or discourage a certain behaviour by making this (financially) unattractive. Incentives are often used by policymakers (Verplanken & Whitmarsh, 2021).
Macro level	
Strategy	**Definition**
Habit discontinuity theory	People consider behaviour-relevant information more thoroughly when context changes (environments where habits take place), creating an opportunity for habit change as environmental cues change. The context in which behaviour takes places can be both physical and social environments. Often context changes converge with life-changing events (such as residential relocation and childbirth), which require adaptation (Haustein & Kroesen, 2022; Linder et al., 2021; Verplanken & Orbell, 2019; Verplanken & Whitmarsh, 2021). To give an example, if individuals move from high urbanized areas to rural areas, where public transport is not available, they are likely to travel more by a private car.
Legislation	Authorities can make it (physically) impossible to execute certain behaviour by legislation (Verplanken & Whitmarsh, 2021). For example, legislation can forbid fuel driven cars to enter city centres (zero-emission zones).
Nudges and cues	Nudges are small and seemingly irrelevant changes in choice contexts that exploit behavioural automatisms (habits) to programme behaviour (Dewies et al., 2022). Cues are environmental stimuli that you can see, hear, smell or feel. They act on unconscious mental processes to provoke certain behaviour (Rijksoverheid, 2023). To give an example, placing footstep stickers on a stair which is located next to an elevator, will trigger individuals to use the stair faster than the elevator.

In this research the focus is on existing environments without the occurrence of life-changing events as municipalities cannot plan on these events to happen. Therefore, the habit discontinuity theory based on life-changing events, is not considered directly. However, it is possible to change the decision-making context of travellers by legislation and environmental reengineering interventions (Carden & Wood, 2018). In this way, habit discontinuity theory can still be used as a habit changing strategy indirectly.

The strategies in Table 2 give a good insight in possible tactics to change habits. However, there are some aspects that need to be considered when dealing with habits as described by Verplanken and Orbell (2019):

- Breaking (or changing) habits and replacing the old habits with new habits does not mean old habits are gone. Habits are memory-based propensities, which means that the memory trace of the old habit may still be intact and only gradually decay. Old habits can therefore be easily triggered when specific cues reappear.
- Habits may be part of larger routines and social practices, and therefore, be linked to other behaviour.
- The behaviour considered is often complex and consists of multiple phases and components. Each of these elements can be habitual. It is therefore important to determine the critical element which needs to be changed or turned into a habit.
- Lastly, habits may be hard to break or change, however, their very features (lack of awareness, difficulty to avoid a habit, tunnel vision and stickiness) make them ideal for long-term pro-environmental behaviour (such as biking). It can, therefore, be interesting to stimulate the forming of sustainable habits, as this will result in automatic sustainable behaviour.

2.2.2. Measuring habit strength

There are three ways to measure habit strength as described by Steg and De Groot (2018): (1) the response frequency measure (RFM), (2) The self-report habit index (SRHI), and (3) the compound measure of habit.

The response frequency measure (RFM) assumes that people need to use existing scripts for making decisions when they are provided with insufficient information and feel time pressure (Steg & De Groot, 2018). The RFM was originally developed to measure travel mode habits. The method uses five to fifteen imaginary travel goals, which are represented to participants. Only the goal of the trip is described and participants are asked to name the first travel mode they would choose for each goal as quickly as possible. Habit strength in that way corresponds to the frequency of a certain travel mode’s appearance across the different goals. The result, the habit strength, reflects general habits as the method generalizes over different travel goals and is not specific for one destination or goal (Steg & De Groot, 2018). So, to give an example, the habit strength measured with RFM can reflect an overall private car driving habit, but cannot reflect commuting trip related habits only.

The Self-Report Habit Index (SRHI) is a well-established measure to measure habit strength (Verplanken & Orbell, 2019). The SRHI consists of twelve items, which are self-reports of a certain behaviour based on repetition and automaticity. These twelve items include aspects which occur in habit behaviour, such as the experience of repetition, lack of awareness and conscious intent, lack of control, mental efficiency and a sense of self-identity (Steg & De

Groot, 2018; Verplanken & Orbell, 2019). The items are scored on Likert response scales. As stated by Verplanken and Orbell (2019), the measure is generic and easy to use, and highly suitable for questionnaires. Besides, the SRHI acknowledges that habit strength might vary independently from behavioural frequency (Steg & De Groot, 2018). This is relevant as habits can occur on different frequently levels. To give an example, always driving with your family car to a Christmas market can be a habit too, even if it only occurs once or twice a year. The SRHI has standardized items which can be used in questionnaires. These items are scored through Likert response scales (Steg & De Groot, 2018; Verplanken & Orbell, 2019). The standardized items respond to the question "Behaviour [X] is something…":

1. I do frequently
2. I do automatically
3. I do without having to consciously remember
4. That makes me feel weird if I do not do it
5. I do without thinking
6. That would require effort not to do
7. That belongs to my (daily, weekly, monthly) routine
8. I start doing before I realize I am doing it
9. I would find hard not to do
10. I have no need to think about doing
11. That is typically me
12. I have been doing for a long time

After checking the internal reliability and correlation of the scale, the averages of the items are added into an overall habit strength score (Verplanken & Orbell, 2019).

Lastly, the compound measure of habit is a measure that combines two main components of forming habits: frequency and context stability. Frequency is measured by how often a certain behaviour is performed given a certain time period. Context stability is measured by asking participants how much the context in which they performed a particular behaviour differed each time they performed the behaviour. These two measures are then averaged. The final habit strength score is computed by multiplying frequency with stability, resulting in the highest scores for frequent behaviour in stable contexts and the lowest scores for circumstantial behaviour in unstable contexts (Steg & De Groot, 2018). The compound measure is, however, hard to implement in studies as both past behaviour and relevant context stability aspects need to be reported and no standardized measures of situational stability exist (Steg & De Groot, 2018).

The SRHI is most suitable for questionnaires without a time constraint. The SRHI is also generic and easy to use and understand. Besides, the measure takes into account that habit strength might vary independently from behaviour frequency. The RFM is also suitable for surveys, however, as the measure functions under time pressure, it can lead to inconsistent data by blank responses. Besides, the measure generalizes the responses into a general habit and, therefore, the measure cannot be used for trip specific questionnaires. Lastly, the compound measure of habit takes into account frequency and context stability, which are important habit aspects, but is hard to implement in studies as it requires a lot of (hard to receive) data (Steg & De Groot, 2018; Verplanken & Orbell, 2019).

2.3. Mobility hubs

Mobility hubs have become increasingly popular within international research and policies, including in the Netherlands, as they are labelled as a tool that can accelerate the green mobility transition (Roukouni et al., 2023). In literature on mobility hubs, different definitions exist. Besides, due to the location of hubs and their function, their typology and characteristics differ. This section gives an overview of the definitions, typologies and characteristics of mobility hubs and compiles the definitions that will be used in this thesis.

2.3.1. Mobility hubs: definition

There are two models to which the fundamentals of mobility hubs can be linked. The first model is developed by Bertolini (1999) and is referred to as the place-node model (Figure 8). This model is based on the principle that transportation nodes are always connected to their urban and social surroundings. As stated by Bertolini (1999, p.201), “an accessible area is one where many, different people can come, but also one where many, different people can do many different things: it is an accessible node, but also an accessible place”. In Figure 8, the y-axis corresponds to the accessibility of the node (the more people can get there, the more interaction is possible) and the x-axis corresponds to the intensity and diversity of activities there (the more activities are present, the more interaction is taking place) (Bertolini, 1999). The goal is to equally balance these two aspects. When node and place are in balance, the most optimal mobility effects are realized. From this model, the most important take-away in relation to mobility hubs is that the offer of different mobility modes (multimodality) and the offer of additional facilities should complement each other.

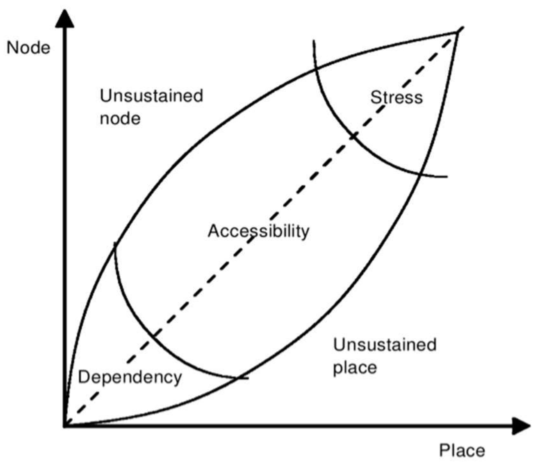

Figure 8: Place-node model (Bertolini, 1999).

Vereniging Deltametropool (2013) translated the place-node model into the butterfly model (Figure 9). This model, therefore, also shows the relationship between place and node, but adds additional characteristics to determine the node and place values. The butterfly model consists of six characteristics: 1) the position in the public transport network, 2) the position in the road network, 3) the position in the slow traffic network (including bicycle facilities), 4) mixing (= ratio of inhabitants and employees per ha), 5) intensity (= density residents, employees, and visitors), and 6) proximity to other facilities (Figure 9). The latter indicates the extent to which the node (station) itself is a high interest point (centre) in its surroundings. The left wing represents the node value and the right wing represents the place value. The butterfly only functions well if both wings are proportionally balanced. In any case, the position of the public transport network and the intensity, both in the middle of the wings, should be balanced with each other. The better the position in the public transport network, the greater the intensity around the node, and vice versa (Vereniging Deltametropool, 2013). The model also shows that the offer of mobility modes and the social functions are related to each other, even complement each other, and should be balanced.

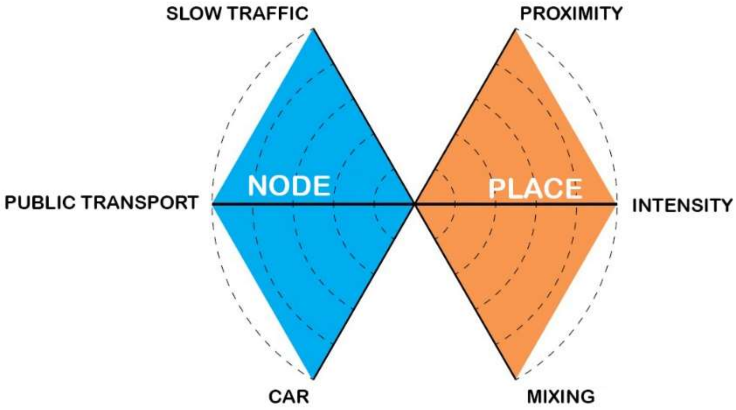

Figure 9: Butterfly model (Vereniging Deltametropool, 2013).

So, both models, the place-node model and the butterfly model, show the necessity to balance the variety of offered mobility modes with additional functions and amenities. This is important to consider when designing mobility hubs.

In literature, several definitions of mobility hubs exist. In Appendix A Table A1, an overview of the most relevant definitions is given. The different definitions in literature have similarities. As also stated by Rongen et al. (2022), specific elaborations of the hubs concept can differ, but the core characteristics are the provision of multimodal transfers and their interaction with surrounding functions based on their locations. Table 3 gives an overview which aspects are considered by the several authors mentioned in Appendix A Table A1. From this, a comprehensive definition of mobility hubs can be created for this research:

A mobility hub can be defined as a strategically located <u>physical node</u> that services as a focal point for transportation services, emphasizing <u>multimodality</u> and <u>shared mobility modes</u>. These hubs are designed to facilitate <u>seamless transitions</u> between different modes of transportation, providing users with convenient access to various transportation options. In additional to the core features, mobility hubs often incorporate supplementary <u>amenities</u> and an <u>integrated digital system</u> to enhance user experience and efficiency.

In the mobility hub definition, the concept of shared mobility is mentioned. In this research, shared mobility is defined, in line with the definition of Machado et al. (2018, p.2), as "short-term access to shared vehicles according to the user's needs and convenience, instead of requiring vehicle ownership". This concerns micro-mobility, such as (cargo) bikes and scooters, but also cars and small busses.

Table 3: Mobility hub aspects considered by several authors.

Author	Physical node	Multimodality	Seamless transfers	Shared mobility modes	Additional amenities on hubs	Integrated system (e.g. apps)	Additional infrastructure
Rongen et al. (2022)	X			X		X	
UITP (2023)	X	X		X		X	X
Province of Noord-Holland (2023)	X	X			X		
Miramontes et al. (2017)	X	X		X		X	
Blad et al. (2022)	X	X	X	X	X		
CoMoUK (2019)	X	X			X		
Bueno (2021)	X	X	X	X			X
Witte et al. (2021)	X	X		X	X		
CROW (2022)	X	X	X		X		
Meulenpas et al. (2021)	X		X	X	X		
Natuur en Milieu (2020)	X		X		X		

2.3.2. Mobility hubs: typologies

Mobility hubs can differ in function, scale and mobility modes offered based on their locations, influencing their reach and accessibility. In this section, the different typologies described in literature will be discussed, aiming to derive typologies that will be referred to in this research.

In literature, there is no consensus on how to define mobility hub typologies. Because of this, literature covers a broad variety of mobility hub typologies, and it is not uncommon for one mobility hub type to be defined very differently among different studies.

A recent literature study by Roukouni et al. (2023) includes a framework to define mobility hub types and is intended as a basis for the development of European mobility hubs. Each mobility hub type can be defined using five dimensions: 1) urban context, 2) transportation function, 3) mobility spatial scale, 4) shared mobility services offered, and 5) proximity to public transport. The urban context dimension is unique for each mobility hub type, and therefore determines the name. Thereby, the urban context is good determinant of travel behaviour. The other four dimensions describe the functionalities of the hub. Naming hubs by their urban context is an effective way of naming mobility hub types because of the association with travel behaviour.

Weustenenk and Mingardo (2023) also studied the properties of different mobility hubs to be able to describe relations and group the mobility hubs into types. The dimensions on which mobility hubs can be grouped into types are: 1) level of amenities, 2) variety of transport modes, 3) geographical location, and 4) operational scale. These four dimensions provide a typology that better fits the description of mobility hubs in literature and make it possible to group the various mobility hubs from literature in types.

In the study of Weustenenk and Mingardo (2023), level of amenities and the variety of transport modes are ordered as low, medium, or high. For the variety of transport modes, a low level means there are only small shared mobility modes available (bikes, cargo bikes, scooters and cars), a medium level means there is, next to small shared mobility modes, a single connection with public transport, and a high level means that a lot of different mobility modes come together, ranging from small shared modes to metro's and trains. The geographical location is described according to the hub location in relation to cities. The operation scale can be described on three levels: 1) local scale, 2) (inter)regional scale, and 3) national scale (Weustenenk & Mingardo, 2023).

Using the geographic location and operational scale dimensions of Weustenenk and Mingardo (2023), literature on mobility hubs has been analysed and reduced to come to an overview of mobility hubs in line with the scope of this research, which is given in Appendix A *Table* A2. In addition to these dimensions the necessity of using a car to reach the hub is added as information in the geographic location dimension. Hubs that need to be reached with a car are excluded, as the research goal is to analyse hubs that might replace private car use. The national scale is excluded as well since these hubs represent central train stations, which are fixed large scale locations in city centres and therefore cannot be easily implemented at a walking distance from individuals' homes. Lastly, private hubs are excluded as these are not openly accessible and are typically realized in large housing projects.

The hubs that are included this research are therefore **neighbourhood hubs** (buurt hubs in Dutch) and **district hubs** (wijk hubs in Dutch). In line with Roukouni et al. (2023), the urban context is used to name these mobility hub types. Combing the information from the sources described in Appendix A Table A2, the following definitions for neighbourhood hubs and district hubs can be formulated:

Neighbourhood hub: *The neighbourhood hub is a small-scale hub in residential areas that aims to replace the private car. The hub offers shared electric micro mobility, such as shared bicycles, shared cargo bicycles, and shared scooters. These options can be complemented by shared electric cars. The neighbourhood often has no additional facilities. However, small-scale facilities, which can be self-operated, can be added (such as a parcel locker). The hub is recognizable and has an information board. It is possible to illuminate the hub by smart lighting, but this is no requirement.*

District hub: *The district hub is a large-scale hub at a strategic location in residential areas with the aim of replacing the private car. A district hub offers shared electric micro mobility, such as shared bicycles, shared cargo bicycles, and shared scooters. These modes can be complemented with a shared electric car and/or a bus connection. The district hub always has small-scale self-serving facilities present, such as a parcel locker, and offers a covered waiting location. Larger-scale facilities can be added as well, such as flex-work places, a café, a supermarket, or child daycare. The hub is recognizable, has an information board, and is illuminated in the dark by smart lighting.*

Both mobility hubs are usually reached by foot or by bicycle. Therefore, the target group for these hubs are inhabitants, as for this target group access to the hub within walking or cycling distance is important (Province of Noord-Holland, 2023). Residents can be defined as "travellers who start their journey from their place of residence" (Province of Noord-Holland, 2023, p.10).

2.4. Flanking mobility policies

Mobility hubs can be used by municipalities as a tool to stimulate the green mobility transition. However, due to habits, realizing physical hubs without implementing additional stimuli to use the hub, will not lead to people switching from private car use to hubs, on a larger scale. Flanking policies are needed to stimulate this switch (Rongen et al., 2022; Rongen et al., 2023). In this section, relevant flanking policies are discussed.

2.4.1. Push versus pull policies

There are several mobility policies that can be used to reduce private car usage. These policies can generally be classified as push or pull policies. Push measures can be defined as measures that push travellers to other modes of transport by discouraging private car use (e.g. road pricing). Pull measures can be defined as measures that pull travellers to other modes of transport by, for example, making walking, biking, and public transport more attractive (e.g. high service frequencies) (Gallo & Marinelli, 2022; Kuss & Nicholas, 2022; Melkonyan et al., 2022). A single measure can either create a push effect, a pull effect, or both. In recent literature, a combination of push and pull strategies are recommended as, in this way, the two measure types can complement each other (Diao, 2019; Foltýnová et al., 2020; Hoerler et al., 2023; Kuss & Nicholas, 2022; Melkonyan et al., 2022). Pull measures are generally more accepted, as they require no large behaviour change, however, these are usually less effective. Push measures are generally more effective than pull measures, but experience more resistance as a larger behaviour change is required (Foltýnová et al., 2020; Hoerler et al., 2023; Melkonyan et al., 2022). In Appendix B, Table B1, an overview of push and pull measures related to mobility is given. These are general mobility measures, not specifically focussed on policies that are suitable to implement next to mobility hubs. Flanking policies that are suitable complementing mobility hubs are understudied in literature. Only Rongen et al. (2023) state that flanking policies (such as strict parking regimes or tariff integration) extending beyond the scope of mobility hubs are needed to increase the effectiveness and efficiency, and thereby successfulness, of hubs.

In literature, it is argued that measures decreasing car use must be implemented in parallel with measures stimulating walking, cycling, or the use of public transport to change the modal share to less car-dependency (Gallo & Marinelli, 2020). Singapore is generally seen as a perfect example of sustainable travel behaviour stimulation through policies, which shows that a combination of push and pull measures has the largest impact. Implemented policies are, among others, 1) improving transit provision, 2) implementing transit-oriented developments (TOD), which lead to higher densities and diverse land uses, and 3) implementing hard push measures, such as additional registration fees when buying private cars and congestion charging also apply in Singapore (Diao, 2019). Combining push and pull measures led to a decreased car use in Singapore.

2.4.2. Policy support

Policy making, especially in democratic countries like the Netherlands, requires careful considerations on the response of citizens towards policies. As stated before, policies can be categorized as push or pull measures. Pull measures are generally more accepted due to a small behavioural change component while push measures experience more resistance due to a larger required behaviour change (Foltýnová et al., 2020; Hoerler et al., 2023;

Melkonyan et al., 2022). Policies can be popular, and quickly adopted, however, policies can also be considered unacceptable, minimizing the desired effect of the policy and losing credibility as a policymaker. This is important to consider before implementing new policies.

Foltýnová et al. (2020) researched the acceptance and effectiveness of push and pull measures in relation to mobility behaviour. They discovered that people broadly support pull measures, even though push measures are more important determinants in limiting individual car use than pull measures. To overcome this, push and pull measures are combined. Foltýnová et al. (2020) found that this combination showed the most effective change in mobility behaviour as people would support measurements more.

It can be stated that policies are generally more accepted when a small behavioural change component is present (Foltýnová et al., 2020; Hoerler et al., 2023; Melkonyan et al., 2022). As push measures require a larger behaviour change, they are harder to implement due to a lack of public support. Public support may increase if policies do not threaten individual freedom of choice and quality of life, citizens believe in policies, or are involved in the decision-making process (Macea et al., 2023; Melkonyan et al., 2022). Policies are also more accepted if they are believed to be fair and when people trust the good intentions of the government implementing the policies (Melkonyan et al., 2022). So, in regard of travel behaviour, this means that policies should target the instrumental costs and benefits, qualities and attractiveness of urban transportation (Melkonyan et al., 2022).

Ogunkunbi and Meszaros (2023) researched the willingness to support policies amongst citizens in Budapest. Understanding the factors that drive willingness to support, such as attitude to policies, perceived costs and benefits, personal values, and behavioural dispositions, is crucial in effectively communicating the benefits of climate change mitigation policies and activating public support for their implementation. Ogunkunbi and Meszaros (2023) show that policymakers should consider these trade-offs. In their research they distinguish policy acceptance and policy support. Acceptability is defined as "a construct reflecting individual's positive or negative attitudes toward a particular policy before its implementation" (Ogunkunbi & Meszaros, 2023, p.2). Support, however, spans both before and after the policy's implementation and requires additional behaviour change components. Policy acceptance does not necessarily lead to policy support, as individuals need to be willing to promote and facilitate the policy interventions which requires behaviour change. In this light, Ogunkunbi and Meszaros (2023) found that engaging stakeholders and citizens in the decision-making process is essential to ensure the acceptance and implementation of policies. By involving stakeholders and citizens, preferences for certain policy attributes can be expressed. This relates back to the benefits of a people-centric approach discussed in the introduction.

So, to effectively implement policies, it is important to considered individuals' values and concerns, next to implementing a combination of push and pull measures. Public participation can play a role in this. It is important to ensure that individuals are willing to accept a policy, but it may be even more important to elicit individuals to support policies, as this will intrinsically motivate individuals to advocate the desired behaviour.

2.5. Conclusion literature study

The literature study focussed on the following topics: behaviour change models and theories, including the theory of habits, mobility hubs, and mobility (flanking) policies. Based on the findings of the literature study, sub-questions 1 and 2 can already be (partly) answered. Besides, the literature study creates a solid theoretical basis for the other research methods to be conducted.

Answering the theoretical part of sub-question 2, several rational behavioural change theories are discussed, such as the COM-B model for behaviour change. However, positive attitudes, favourable beliefs and a motivation to act, are often not enough to lead to actual (travel) behaviour. Habits play a key role in this. When habits are in place, behaviour follows an unreasoned path, without conscious decisional involvement. Habits, for a large part, explain rigid travel behaviour. Travel behaviour, especially commuting behaviour, can largely be explained by habits, as it is repetitive. Habits are hard to break, however, the very features of habits, such as difficulty to avoid and stickiness, make them ideal for long-term desired travel behaviour. Therefore, it can be interesting to stimulate the forming of sustainable habits, as this will result in automatic sustainable behaviour. Sustainable travel habits can, among other things, be stimulated by incentives, legislation, or environmental cues.

In order for individuals to start executing desired travel behaviour, in this case switching from private car usage towards multimodality, the desired travel behaviour needs to be possible. Multimodality can be offered at hubs, and hubs can be implemented by municipalities to offer alternatives to the private car. In this research, literature is combined to come to a mobility hub definition, answering sub-question 1. Hubs are defined as:

A strategically located <u>physical node</u> that services as a focal point for transportation services, emphasizing <u>multimodality</u> and <u>shared mobility modes</u>. These hubs are designed to facilitate <u>seamless transitions</u> between different modes of transportation, providing users with convenient access to various transportation options. In additional to the core features, mobility hubs often incorporate supplementary <u>amenities</u> and an <u>integrated digital system</u> to enhance user experience and efficiency.

In this research, the focus is on neighbourhood- and district hub, as these hub typologies specifically can replace private cars. The following typology has been adopted based on the literature study for a **neighbourhood hub**:

The neighbourhood hub is a small-scale hub in residential areas that aims to replace the private car. The hub offers shared electric micro mobility, such as shared bicycles, shared cargo bicycles, and shared scooters. These options can be complemented by shared electric cars. The neighbourhood often has no additional facilities. However, small-scale facilities, which can be self-operated, can be added (such as a parcel locker). The hub is recognizable and has an information board. It is possible to illuminate the hub by smart lighting, but this is no requirement.

The following typology has been adopted based on the literature study for a **district hub**:

The district hub is a large-scale hub at a strategic location in residential areas with the aim of replacing the private car. A district hub offers shared electric micro mobility, such as shared bicycles, shared cargo bicycles, and shared scooters. These modes can be complemented with a shared electric car and/or a bus connection. The district hub always has small-scale self-serving facilities present, such as a parcel locker, and offers a covered waiting location. Larger-scale facilities can be added as well, such as flex-work places, a café, a supermarket, or child daycare. The hub is recognizable, has an information board, and is illuminated in the dark by smart lighting.

Providing the opportunity to switch towards other mobility modes over the private car is the first step towards more sustainable travel behaviour of individuals, however, due to habits, realizing physical mobility hubs without implementing additional stimuli to use the hub, will not lead to individuals switching from private car use to multimodality on a larger scale. Flanking policies are needed to stimulate people to rethink their mobility choices.

Answering the theoretical part of sub-question 2, flanking policies can, generally, be categorized into measures with push effects, pull effects or a combination of both. A combination of push and pull strategies are desired, as in this way, the two measure effects can complement each other. Pull measures are generally more accepted, as they require no large behavioural sacrifice, however, these are usually less effective. Push measures are generally more effective than pull measures, but more resistance is experienced when implementing these, as a larger behaviour change is required. Which push and pull measures are most desired and effective will be further researched by analysing the results of the questionnaire described in Chapter 4. Not only the effectiveness of measures is important, but also the support of individuals for the measurements has a large role, especially in democratic countries such as the Netherlands. To effectively implement policies, it is, therefore, important to consider individuals’ values and beliefs as well. Public participation can play a key role in this. It is important to ensure that individuals will accept a policy, and may even support a policy as this will intrinsically motivate individuals to advocate the desired behaviour.

The literature study gave insights into the theoretical knowledge regarding relevant topics for this research. As an extension of the literature study, experts interviews will be conducted bringing practical knowledge. The results of the conducted experts interviews will be discussed in Chapter 3. Based on the gained theoretical and practical knowledge, the questionnaire, including the SCE, will be created in Chapter 4.

3. Interviews on mobility trends

As part of the exploration phase of this research, interviews with experts are conducted next to the literature study. Interviews can give insights into practical views and problems next to the theoretical background found in literature. The expert interviews conducted give insights into the current practices regarding mobility policies, mobility hubs, flanking policies and the role of municipalities within these practices. Besides, the interviews help defining the exact mobility issues municipalities face and the struggles they experience when implementing private car discouraging interventions. In total, eight expert interviews were conducted with municipalities, provinces, a knowledge institution, and a market party.

3.1. Interviews set-up

The interviews are conducted following a semi-structured interview form. This form provides the opportunity to discuss the same questions in each interview, making it easier to compare the interviews, but also provides the freedom to have an open conversation, collecting additional relevant information (Van Aken & Berends, 2018). The eight interviews were conducted between the 27th of November 2023 and the 19th of December 2023. Table 4 gives an overview of the organizations that were interviewed. These organizations are interviewed as they have in-depth knowledge regarding mobility behaviour, mobility trends, and flanking policies. The interviewed parties are chosen based on their operation level and mobility scale. The municipalities range from smaller scaled cities, such as Helmond, to larger scaled cities, such as Rotterdam. They also vary in their scale and level of new mobility concept implementations. To give an example, Helmond is still developing their specific plan to implement hubs while Rotterdam already implemented over 100 hubs offering micro-mobility. As cities differ, it is important to find both city specific challenges and matching challenges. Provinces are interviewed while they are indirectly (financially) responsible for the mobility interventions cities can implement. CROW is interviewed as they are a knowledge institution that works a lot in the field of mobility hubs, and therefore already has extensive practical knowledge, as well as an understanding of the challenges faced by different parties. Lastly, Q-park is interviewed as Q-park can outline the view on hubs from the market. Besides, Q-park can highlight the importance of market players (mobility providers) and the financial business case for realizing mobility hubs.

Table 4: Overview interviewed organizations.

Organization	Interview date	Interview form
Municipality of Eindhoven	27-11-2023	Physically, Eindhoven
Municipality of Helmond	06-12-2023	Physically, Helmond
SmartwayZ.NL (province of Noord-Brabant and province of Limburg)	07-12-2023	Physically, ‘s-Hertogenbosch
Province of Noord-Holland	07-12-2023	Online, Microsoft Teams
Municipality of Rotterdam	11-12-2023	Physically, Rotterdam
Q-park	14-12-2023	Physically, Eindhoven
CROW	19-12-2023	Online, Microsoft Teams
Municipality of Amersfoort	19-12-2023	Online, Microsoft Teams

The interviews consist of four parts: 1) an introduction also including an explanation of the research and interview structure, and asking permission for recording the interview, 2) questions about the current situation, making it possible to define problems, 3) questions about the vision and expectation of future mobility (trends), and 4) more in-depth questions about mobility hubs and flanking mobility policies. By asking about the current mobility situation and problems, it is possible to outline the current practical challenges. Next, the future mobility vision is asked while there are several different parties involved, and the view on future mobility influences the development of mobility. Besides, it is interesting to test whether there are, for example, large differences between small-scaled municipalities and large-scaled municipalities. More in-depth questions are asked regarding mobility hubs and flanking policies. The input collected on these topics will be used and tested in the SCE and questionnaire. Lastly, the view on mobility hubs and the role municipalities (would like to) adopt when designing and implementing hubs helps identifying the different ways to realize hubs. The complete interview set-up including the prepared questions are given in Appendix C. The questions are created by an iterative process, receiving feedback from advisors. The results of the interviews are discussed in Sections 3.2. to 3.4. Section 3.5. gives the conclusion and key take-aways from the interviews.

3.2. Current situation – problem definition

Interviewees were asked about their views on current mobility trends, the role of the private car and sustainable mobility modes, and the problems they may face caused by cars. All parties stated that the private car has currently an excessive role in transportation networks. The municipalities and provinces also state that they are working on plans to stimulate more sustainable modes of transport and discourage private car usage. To give an example, the College of Aldermen of the municipality of Eindhoven decided on three pillars to focus on: 1) investing more in walking and biking, 2) investing more in behaviour change, and 3) investing in high-quality public transport. These pillars are also mentioned by other interviewees.

The switch to more sustainable mobility is mainly driven by the problems municipalities and provinces face due to extensive private car usage by inhabitants. Table 5 gives an overview of the problems that were mentioned by the interviewees.

The problems interviewees mentioned can roughly be categorized into three main challenges: 1) liveability challenge, 2) sustainability challenge, and 3) spatial distribution challenge. It can be noted that all interviewees mentioned the increased need for residential dwellings. This increased need relates to other challenges. If more dwellings are realized, the parking pressure in cities increases and congestion occurs more often. By municipalities, the increased need for space is labelled as the biggest challenge they are facing and the driver to invest in more sustainable modes of transport and mobility hubs. They see mobility hubs as a way to “create space”. If citizens switch from private car usage towards other modes, in the form of multimodality, and get rid of their cars, space can be freed up. Less parking spaces are needed and the road capacity can be decreased. This all leads to free space which can be transformed into other functions, such as playgrounds and parks.

The spatial distribution challenge also relates to the liveability challenge. Interviewees believe that if cars are used less and the potentially freed space is transformed into other functions, the quality of life will increase as this will result in, for example, less noise pollution, higher air quality, and healthier lifestyles. As stated by the municipality of Eindhoven: “about 55% of the city’s area is dedicated to mobility, this needs to change”.

Table 5: Overview identified problems by interviewees.

Problem	Eindhoven	Helmond	Amersfoort	Rotterdam	Noord-Holland	Smart-wayZ.NL	CROW	Q-park
Liveability challenge								
Noise pollution		x	x	x		x		
Health		x			x	x		
Air quality		x	x	x	x	x		x
Lack greenery	x				x	x		
Sustainability challenge								
Pollution		x	x	x	x	x	x	x
Decreasing biodiversity						x		
Heat stress						x		x
Climate adaptation	x			x	x	x	x	x
Green energy	x							
Spatial distribution challenge								
Increased housing need	x	x	x	x	x	x	x	x
Parking pressure	x			x			x	
Population growth	x			x				
Congestion		x			x		x	

Climate change and sustainability is also an aspect that is mentioned by all the interviewees. However, for most interviewees this is not mentioned as the biggest challenge. Therefore, this is not the main driver to change mobility behaviour, which is interesting. Most interviewees label the increased need for housing and the expected population growth, which results in spatial distribution problems, as the main driver to stimulate mobility behaviour change. So, as the municipality of Eindhoven articulated: “the battle for space is the largest trigger of this whole story, next to climate change and sustainability”.

Travel motives that mainly contribute to the problems mentioned are primarily 1) commuting behaviour, 2) inner-city movements, such as grocery shopping, and 3) leisure activities, such as day trips. Commuting behaviour is by all interviewees labelled as the largest contributor. As stated by the municipality of Eindhoven, “35% of the 60% of citizens that drive their car to work in the city centre of Eindhoven live within 7.5 kilometres from their work, which is a distance that most people should be able to bike”.

Municipalities also face problems that are specific to their municipality. For example, Eindhoven has a diverse population, consisting of many different cultures. They are struggling to reach all these different kinds of people.

All parties face one main problem: excessive car usage by inhabitants. They are all finding ways to change this behaviour. CROW posted an interesting point of view: “is the freedom of movement a fundamental right, or in other words, is it apparent that we own a car?”.

Overall it can be stated that car usage behaviour needs to change in order to minimize the problems society is facing.

3.3. Future vision – challenges to get there

The province of Noord-Holland and the municipalities were asked about their future mobility vision and the challenges they will face to get there. Each party has their own vision and challenges, but similarities can be found.

All parties indicate a smaller role for the private car in the future. The private car needs to be discouraged, in order to create space, and more sustainable modes of transport should become the norm. For cities, it should be less obvious that the city centre can be reached by cars. Mobility hubs are indicated as a key instrument to offer an alternative to the private car. However, a well-connected network of hubs is needed to offer a fully-fledged alternative. This network of hubs consists of different “levels of hubs”; from micro hubs to large city hubs. The municipality of Rotterdam adds to this the concept of Mobility as a Service (MaaS), which is something they consider important for the future. The municipality of Amersfoort indicate that district hubs, which are part of the network of hubs in the city of the future, should be large enough to house at least 2/3rd of the cars which are now parked on the streets in the neighbourhoods. Freed up parking space can be transformed into other functions, such as greenery.

Next to hubs, the municipalities of Helmond and Eindhoven add that the public transport network needs to be upgraded in the future. A well-connected public transport network, with high-quality public transport connections, needs to be created. The municipality of Eindhoven wants to implement zero-emission zones and states that shared cars should become the norm in the city centre. Besides, the city wants restructure the city according to the “5-minute city” concept, in which all essential facilities are within a 5-minute walking distance from home.

Lastly, the municipality of Amersfoort adds that behaviour change is also an important aspect of their vision. The goal is to make citizens more actively consider their mobility behaviour: which alternatives are available to the private car? The municipality wants to stimulate this behaviour change by implementing push and pull measures.

Implementing the future visions poses challenges. All municipalities state that changing the behaviour of citizens is the main challenge. As stated by the municipality of Helmond: “people find it hard to change, due to habits. There is a resistance factor and people are not intrinsic motivated to change. On the one hand, the municipality is responsible for stimulating behaviour change as a facilitator. On the other hand, people have to change themselves. But how do we tempt them to change behaviour?”. The municipality of Rotterdam adds to this that is it hard to tempt rigid car users, as the car is a convenient transport mode and using, for example, shared mobility has its hurdles. People need to know how the system works and where they can find shared vehicles. So, in other words, the alternatives to the car need to be convenient and easy to use. The municipality of Eindhoven states that “to show people that mobility hubs can work ,we need to create an example that is of a large scale and can operate for a sufficient time period. We need to prove to the people that it can work. However, creating such an example, which is financially feasible, is a challenge". In line with this, both the municipality of Eindhoven and Helmond indicate that they struggle in finding the right role for the municipality. A lot of different stakeholders are involved: how do you cope with this? What is the municipality's role and how are market parties involved?

The municipalities of Eindhoven, Helmond and Rotterdam also face physical challenges. The cities are currently car-oriented and the physical structure of the cities need to change in order to exclude cars in the city centres. The municipality of Rotterdam also indicates that it is a challenge to implement the new vision city wide in a way that it will work for all citizens. In deprived neighbourhoods, (social) safety is an additional challenge: "citizens living in deprived neighbourhoods indicate that they would not let their children, especially daughters, travel alone with public transport, afraid something would happen".

3.4. Mobility hubs and flanking policies

In Chapter 2 Section 2.3., the definition of mobility hubs based on literature is defined. As there is not one well-established definition of mobility hubs, interviewees are asked about their understanding of hubs as well. Some interviewees indicate that it is difficult that not one clear definition of hubs, and their typologies, exist. It would be helpful if a national manual would be established. Table 6 shows which hub aspects are considered by the interviewees. To compare the interviewees' definitions to the definitions described in literature, the same aspects are considered as in Table 3. It is relevant to note that Table 6 gives an overview of the aspects mentioned during the interviews. It is, therefore, possible that organizations also consider other aspects as relevant for the general definition of hubs. For this research, only the aspects mentioned during the interviews are considered. The interviewees indicate that the overall goal of hubs is to offer and alternative and eventually substitute the private car. Municipalities add to this that they want to counteract the nuisance of free-floating vehicles by locating them at a designated location.

Table 6: Overview hub characteristics mentioned by interviewees.

Organization	Physical node	Multi-modality	Seamless transfers	Shared mobility modes	Additional amenities on hubs	Integrated system	Additional infra-structure	Parking of private car
Municipality of Helmond	x	x		x	x			
Municipality of Eindhoven	x	x		x	±			x
Municipality of Amersfoort	x	x		x	x			x
Municipality of Rotterdam	x	x		x	x			x
Province of Noord-Holland	x	x		x	±			
SmartwayZ.NL	x	x	x	x				
CROW	x	x	x		±			
Q-park	x	x		x	x	x	x	x

In Table 6, it is shown that all interviewed parties define hubs as a physical node where multimodal transfers are possible. Most parties also indicate that shared vehicles need to be present and that additional amenities can be present. The municipality of Eindhoven, the province of Noord-Holland, and CROW have a different view on additional facilities for hubs located in cities: instead of realizing additional amenities at the hub, the hub needs to be strategically located at places where already daily visited facilities are present, so-called "points of interest". This is therefore indicated with a ± sign in Table 6. In addition to literature, half of the interviewees consider car parking facilities as a part of hubs, making it possible to remove street parking spaces. Q-park adds to this that car charging facilities need to be present and that all services offered at the hub should be well integrated through a mobile application.

Not only the general definition of hubs differ among the interviewees, also the understanding and naming of the typologies of hubs differ. For example, the municipality of Helmond maintains four hub types: micro hub, district hub, regional hub, and highway hub. The municipality of Rotterdam maintains five hub types: neighbourhood hubs, district hubs, city hubs, region hubs, and private hubs. Not only have municipalities different names for different hub typologies, also the attributes of the hub types with the same name differ. To give an example, the municipality of Helmond defines a district hub as a small-scaled hub, which does not necessarily has a public transport connection, and where individuals can pick up and leave shared mobility modes such as bicycles and cars. However, the municipality of Amersfoort defines a district hub as a large-scaled hub with many car and van parking facilities including amenities such as flex offices or cafés. The goal of the hub is to accommodate 2/3rd of the currently street parked cars. This shows that large differences exist in the understanding of hubs and their typologies between different stakeholders. To avoid misunderstandings, it is therefore important to clearly define what a mobility hub is and which typologies exist.

All interviewees indicate that, amenities, flanking policies, location attributes, behaviour change approaches add to the successful implementation of hubs. Especially flanking policies and behaviour change approaches are indicated as a necessity while most individuals do not change behaviour without being triggered.

Regarding amenities and location attributes, interviewees state that small-scaled hubs should be located within a walking distance of 300 meters from home. Next, hubs need to be pleasant places to be and need to feel safe. Interviewees mention different amenities and attributes that can be added to a hub, such as a café, flex offices, good bicycle parking facilities, sufficient lighting or a toilet. However, as stated by SmartwayZ.NL: "it is hard to indicate what would work, it depends on the people who will visit the hub and what their wishes and needs are. The exact factors which will trigger behaviour need to be researched. Regarding the feeling of safety, it needs to be tested whether good lighting, the amount of greenery, or the presence of other people at the hub would increase this feeling of safety". Rotterdam states in line with the statement of SmartwayZ.NL, that the implementation of hubs is an iterative process, and feedback received from stakeholders needs to be implemented when a new "round of hubs" will be realized. Interviewees also mention that hubs should be more convenient that the private car, so, travelling by hubs should be faster and easier. For example, shared vehicles should be available at all times.

Next to the physical hub, behaviour change approaches and flanking policies play a role in the success of hubs. First of all, some interviewees state that information campaigns are important. Individuals need to know that an alternative to private cars is available. However, only making use of campaigns does not lead to desired behaviour. As stated by SmartwayZ.NL: "you first have to consider what the desired behaviour is? And how does current behaviour emerge? Individuals need to be triggered before they have the travel goal in mind, which is a large challenge due to habits. One thing is for sure, current (car travel) behaviour needs to become less efficient and the desired behaviour should become easier. Flanking policies can play a role in this". Different kind of flanking policies, such as parking policies or financial cues, are mentioned by interviewees, however, they all state that a combination of push and pull measures is desired. CROW states that, first, a good alternative needs to be available. Then flanking policies can be implemented. When implementing these flanking policies, start with pull measures (carrot), creating support for the alternative. When a solid basis is present, then start implementing push measures (stick). This will lead to less opposition of the change by individuals.

CROW agrees to the aspects for successful hub implementation mentioned before. However, CROW adds one more aspect which they consider as the most important one: participation. The process towards hub realization is important. It is important how you approach future users of hubs. Hubs should be indicated as a solution to a problem individuals can actually "feel", such as health. For most individuals concepts such as "climate change" are vague and they do not directly feel the consequences. When indicating that, for example, active mobility helps to get healthier, individuals have an idea of the result: it becomes tangible.

All in all, hubs need to at the right location with the right functions, and flanking policies need to be applied. It is important to consider future users of hubs, what their wishes and travel behaviour are, and how the message needs to be conveyed. All interviewees indicate that to realize a large scale transition, a comprehensive network of hubs should be realized.

Table 7: Hub target groups and target motives as indicated by interviewees.

Organization	Target group and/or target motive
Municipality of Helmond	Commuters, tourists, and new inhabitants.
Municipality of Eindhoven	Young urban professionals, students, and citizens with a second car. Young families with a car are not relevant. Tackling commuting behaviour and leisure trips is most promising.
Municipality of Amersfoort	Inhabitants, especially those owning a second car, and tourists.
Municipality of Rotterdam	Roughly three groups: students and young urban professionals, families with children without cars, and individuals experiencing life-changing events. City edge hubs are, however, targeting tourists.
Province of Noord-Holland	Commuting and recreational behaviour. So, target commuters, tourists and people over 65 years old.
SmartwayZ.NL	No clear target group, however, individuals experiencing life-changing events can be approached.
CROW	Commuters, business visitors and tourists.
Q-park	Young individuals living in cities.

Table 7 gives an overview of the travel motives and target groups for which hubs could be interesting as mentioned by the interviewees. Commuting- and recreational behaviour are indicated as target travel motives. Additionally, students and young individuals are mentioned as target groups. Also, individuals who are experiencing life-changing events, and therefore reconsider their travel behaviour, should be targeted. Lastly, CROW and

SmartwayZ.NL believe that hubs should not be designed for certain target groups, as these groups are broad and consist of various types of people.

Lastly, the municipalities, CROW and SmartwayZ.NL are asked about their view on the role of municipalities when implementing hubs. Most parties are still discovering which role fits municipalities best, as there are several factors that need to be balanced. For municipalities especially financial feasibility seems to play a role in determining their attitude and involvement. As stated by the municipality of Amersfoort, “there is a balance between being able to make decisions and taking the lead for hub implementation, and having a business case that is feasible”. Even though most are still struggling with finding the right role, all state that there should be at least some involvement of the municipalities. The municipality of Helmond and SmartwayZ.NL stated that the municipality should have an initiating or facilitating role, for example, realizing public space and arranging the right permits, while market parties should have an exploitation role, with offering shared vehicles. CROW adds to this that municipalities should exploit market parties more. Most municipalities are struggling to create a feasible business case, and market parties can play a role in this. However, the municipality of Eindhoven states that exploiting shared vehicles through market parties is also the biggest risk, as these parties always search for the best business case, which may be in another city if shared mobility is more popular there. Lastly, it can be stated that the municipality of Rotterdam is a forerunner of implementing hubs, as they already implemented 100 neighbourhood hubs (small-scaled hubs with micro-mobility). This can also be linked back to the role they take. The municipality of Rotterdam has a large role; they, among other things, create policies, allocate strategic hub locations based on dashboard data, and communicate biweekly with shared mobility providers. Besides, they are also active on a national scale to create a comprehensive framework for the implementation of hubs.

All in all, most municipalities are still discovering the best role for the municipality when implementing hubs. The best balance between initiating (initiating hub implementation by market parties), facilitating (creating the right boundaries for hub implementations by market parties) and realising (realising hubs themselves) still needs to be found. However, it can be stated that this is correlated with the feasibility of the business case.

3.5. Conclusion expert interviews

The conducted interviews give an insight into the current mobility practice in the Netherlands. Besides, the answers collected in the interviews also help answering sub-questions 1, 2, and 6.

Interviewees indicate different sets of problems and challenges caused by driving private cars, such as the impact on climate change, congestion and the impact on health issues. However, the spatial distribution challenge, related to the need for increased housing, is mentioned as the largest challenge and the main driver for implementing mobility hubs. If more dwellings are being realized in cities, this results in more citizens, however, there is no space to park a car for each additional individual. Therefore, new mobility ideas, such as mobility hubs, can be the solution as not every needs to own a car. Besides, freed up space in cities by getting rid of parking spaces can be used for other functions, such as greenery. The spatial distribution challenge also links back to problems related to climate change and congestion. To give an example, if more space in cities is available, and cars are managed better, congestion problems will also be reduced. Interviewees indicate commuting behaviour as the largest contributor to the mentioned problems.

In ten years' time, all interviewees expect a smaller role for the private car and a larger role for sustainable mobility solutions, such as multimodality offered at hubs. However, to implement future visions, some challenges need to be overcome. The largest challenge indicated is to change individuals' travel behaviour, especially due to habits. Interviewees are struggling with how individuals can best be reached, how you cope with different kind of stakeholders, and how to convince rigid car users.

As stated before, interviewees indicate that mobility hubs can be a solution for some problems municipalities (and provinces) are facing. However, a comprehensive all-adopted definition of mobility hubs, and the typologies that exist, is also lacking in practice. Interviewees mention the key aspects of hubs which were also described in literature, and therefore, the mobility hub definition stated in Section 2.5. is valid for this research. Additionally, some interviewees add that parking facilities could also be an aspect of hubs, but this mainly considers larger hubs. Therefore, this aspect is not directly considered in the hub definition in this thesis. This answer, sub-question 1. It can be stated that most interviewees express the need for a comprehensive definition of mobility hubs, and the possible typologies, on a national scale. In that way, stakeholders can easier communicate about hubs and all stakeholders know what, for example, a neighbourhood hub is.

All interviewees indicate that amenities, flanking policies, location attributes, and behaviour change approaches add to the successfulness of a hub. Especially flanking policies and behaviour change approaches are a necessity. CROW added to these aspects, the participation process. It is important to consider who your target group is, what are their wishes, and how changes are communicated to them. It becomes also clear that, regarding amenities, all interviewees have different ideas of which function will trigger the desired behaviour change. Therefore, it can be stated that there is no best practice yet, and that the effect of the design of hubs needs to be additionally researched. Lastly, answering sub-question 2, interviewees mention different flanking policies which could be implemented to stimulate or discourage certain travel behaviour. However, it can be stated that all interviewees think that a combination of push and pull measures will yield the most desired effect.

Lastly, answering sub-question 6, it can be stated that most municipalities are still discovering the best role to take for implementing hubs. Municipalities are struggling to find the best balance between being an initiator (only initiate hub implementation by market parties), facilitator (create the right boundaries for hub implementation by market parties), or realizer (realize hubs themselves). The role municipalities want to take is also highly related to the feasibility of the business case. In that sense, it can be interesting for municipalities to work together more with market parties, so that the financial burdens do not have to be borne by municipalities alone, which makes it possible to create financially feasible business cases.

Overall, it can be stated that the expert interviews give useful practical insights about the challenges and struggles of organizations which work on daily basis on the mobility transition, of which the implementation of mobility hubs is an aspect. Figure 10 gives an overview of the most important collected input for this research. As the interviewed organizations do not have examples from best practices to stimulate the mobility transition, this research adds practical value. Especially for municipalities this research adds value, as it provides more direction and clarification on how municipalities can stimulate the mobility transition.

Figure 10: Overview most important findings expert interviews in a word web format.

4. Stated choice experiment – measuring behaviour

In this chapter the third research method, the stated choice experiment (SCE) is described. The SCE is part of a larger questionnaire. The chapter starts with the methodology of the SCE and the set-up of the questionnaire in Section 4.1. Section 4.2. describes the data collection and data cleaning. The results are described in Section 4.3. The results document the descriptive analysis, model analysis and additional classes analysis. Lastly, the most relevant results are summarized in Section 4.4.

4.1. Methodology

In this section, the detailed methodology for the stated choice experiment is described. First, the theory behind modelling choice behaviour is discussed, after which the analysis methods used in this research are explained. After the theoretical background, the conceptual model and the variables considered in the analysis are described. Lastly, the experimental design and the set-up of the questionnaire are explained.

4.1.1. Modelling choice behaviour

Several methods for modelling choice behaviour exist. Figure 11 gives an overview of these methods (Kemperman, 2000). There are two categories of methods which can be used to model choice behaviour: revealed and stated methods. The main difference between revealed and stated methods is the way in which data is collected. Revealed models are based on observations of behaviour, while stated models are based on choices made by respondents in controlled hypothetical situations (Kemperman, 2000). Within the stated model, two categories can be defined as well: stated preference models and stated choice models. In stated choice models, respondents are asked about their hypothetically “actual” behaviour, whereas in stated preference models, respondents are asked to rate or rank their preference of alternatives. There are various ways to measure stated preferences and choices. Three main ways can be distinguished: 1) ranking alternatives, 2) rating alternatives, and 3) choice tasks. A difference is made between compositional and decompositional methods. In compositional methods, respondents evaluate attributes separately (ranking or rating), while in decompositional methods (choice tasks), respondents are presented with choice sets and make selections based on their preferences (Kemperman, 2000). When ranking alternatives, respondents arrange choice alternatives based on the order of preference. However, this method does not give insights in the degree of preference expressed by respondents. When rating alternatives, both the order and the degree of preferences can be expressed. However, for this method, it is assumed that respondents can accurately indicate their preferences, which in real life is often not the case. Stated choice tasks require respondents to make actual choices between multiple (controlled) hypothetical situations, resulting in more realistic choice behaviour. A disadvantage of this method is that a large sample is needed to estimate the model correctly (Kemperman, 2000).

The stated choice method or, in other words, stated choice experiment (SCE) is selected as measurement method in this research as it can model “actual” travel choice behaviour instead of travel mode preferences (indicated in light blue in Figure 11). Revealed choice methods are not relevant for this research, as mobility hubs still need to be applied on a large scale, and the attributes which best contribute to individuals using hubs still need to be researched. The stated choice method is used, instead of the stated preference method, as this method can most accurately measure “actual” behaviour. In the SCE in this study, respondents are presented with sets of hypothetical mobility hub situations of which the levels of the attributes differ and the choice to use their usual mode of transport. Respondents are asked to select the option which best represents their travel behaviour. The SCE can best model behaviour as respondents have to choose the option that best represents their preferences. This is more appropriate than asking respondents if they agree with certain statement and asking if their behaviour would change, as respondents have in that case a higher likelihood to presume a change in behaviour than that they actually would change behaviour. The SCE can measure the impact of each attribute (and its levels) on the decision-making behaviour of the respondents as an orthogonal design is used to create the hypothetical hubs. The SCE design is further elaborated in Section 4.1.4.

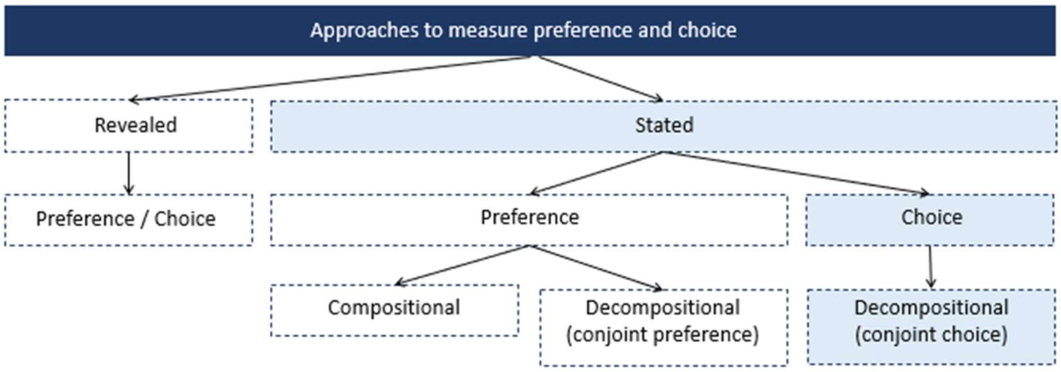

Figure 11: Choice modelling methods as adopted from Kemperman (2000).

Constructing a stated choice model consists of six steps as explained by Kemperman (2000) (Figure 12). Step one, two and four are covered from Section 4.1.3. till Section 4.2.2. and step six will be explained in Section 4.3. As already stated, choice tasks (SCE) are chosen as measurement task in this research, as this best models individuals’ choice behaviour.

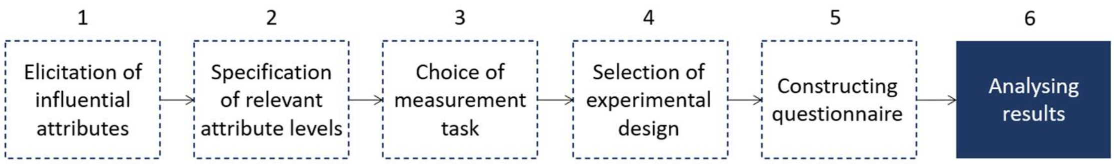

Figure 12: Construction steps stated choice model adopted from Kemperman (2000).

Random utility theory

Stated choice models are based on the random utility theory and, therefore, rely on the assumptions that respondents derive utility from attributes and that each respondent selects the attribute with the highest utility (‘utility-maximizing behaviour’) (Hensher et al., 2015). Utility can be described as the satisfaction respondents derive from the attributes associated with a certain alternative. So, in other words, respondents will choose the alternative that satisfies them the most. The goal of stated choice modelling is to identify the contribution of a certain attribute (and its levels) to the overall level of utility associated with the alternatives in a choice set. This overall utility can be represented by U_{nsj}, in which n represents the respondent (or decision maker), s represents the choice situation, and j represents the choice alternative (Equation 1). So, U_{nsj} represents the utility that respondent n in choice situation s will derive from chosen alternative j (Hensher et al., 2015).

$$U_{nsj} = V_{nsj} + \varepsilon_{nsj} \tag{1}$$

The derived utility consists of two components: the observed structural utility (V_{nsj}) and the random utility (ε_{nsj}) (or error term). The observed structural utility is the utility that can be estimated by the SCE as it is captured in the levels of the attributes of each alternative. However, respondents can also consider other attributes as important, which are not represented in the SCE. This component is unknown and therefore included in the formula as an error term. Equation 2 shows the formula of the observed structural utility component. β_c represents the weight of attribute *c*. So, given a unit change in attribute *c*, utility will change by a value equivalent to β_c. X_{nsjc} represents the score of alternative *j* in choice situation *s* on attribute *c* for respondent *n* (Hensher et al., 2015).

$$V_{nsj} = \sum_{c=1}^{C} \beta_c x_{nsjc} \tag{2}$$

4.1.2. Analysis methods

This section describes the analysis methods that are used in this research. SCE's give insights into preferences of alternatives represented by utilities indicating the strength of these preferences. It needs to be noted that measuring actual utility is not possible, as the collected data only represents observed responses to hypothetical situations. Unobserved preferences therefore need to be assumed (error term). This can be done when analysing the data. Logit models are widely used to model SCE's (Hensher et al., 2015). In this research the multinomial logit (MNL) model and latent class model (LCM) are used. The MNL model can be used to get general insights into the analysis results. The LCM can be used to get more detailed insights into the analysis results. A mixed logit (ML) model can also be used to get detailed results. The ML model assumes that individuals' preferences vary randomly within a population. The model predicts these variations without knowing to which social group someone belongs. So, it predicts a continuous variation in preferences. In this research, the classification of groups is desired as the Dutch population consists of different social groups which exhibit different behaviour, therefore, the ML model is not chosen as analysis method. The LCM predicts discrete groups with similar preferences based on individual's behaviour. Therefore, LCM is chosen as the detailed analysis method. The MNL model, LCM, and model performance methods are explained in more detail next.

Multinomial logit model

The MNL model is a simple logit model and easy to use and understand as it assumes that all covariances between the alternatives' error terms are zero (not correlated) and that all variances are equal (same variance). This means that the error terms are Independently and Identically Distributed (IID) following a Gumbel distribution (Hensher et al., 2015). MNL can be estimated using the formula described in Equation 3 (Hensher et al., 2015; Kemperman, 2000; Train, 2009). In this formula *P(j|A)* describes the probability that alternative *j* is chosen from choice set *A* and V_j is the structural utility of alternative *j* (Kemperman, 2000). As in this research a single dataset is used, the Gumbel scale factor is not stated in the formula.

$$P(j|A) = \frac{\exp(V_j)}{\sum_{j' \in A} \exp(V_j)} \tag{3}$$

MNL is easy to use, however, it is also the most limited model of the logit modelling approaches. The most important limitation is the Independence from Irrelevant Alternatives (IIA) property, which is implied due to the IID property of the model. IIA implies that the structural utility component (V_j) is a function of only the attributes of alternative *j*, not considering the attributes of other alternatives in the choice set. This results in an equal probability of choosing one option over another, independent of the other alternatives' attributes in the choice sets (Kemperman, 2000). Despite this limitation, the MNL model can give good first insights into the attributes influencing travel behaviour and their utilities. The model is therefore used to conduct a first check on the significant attributes and their utilities; for example, right direction of effect (positive or negative).

Latent class model

The LCM is a more advanced analysing technique compared to the MNL model. The LCM assumes that the behaviour of individuals depends on observable attributes and latent heterogeneity (unobserved attributes), and therefore allows for heterogeneity compared to the MNL model. The model groups the sample into heterogenous classes, with common parameters (β_Q) for the members of the group. The groups themselves differ. Therefore, it is possible to create groups which have the same values and share common attributes. This helps to better understand the variation in preferences and behaviours within a population, as it does not assume everyone behaves in the same way, which helps with developing targeted policies. The input that is given to the LCM is the number of groups that is expected. This is determined by running the model several times (trial and error) and selecting the number of groups with the best model performance. The LCM then determines which observation belongs to which group, as a form of unsupervised learning (clustering) (Hensher et al., 2015). However, the probability that an observation belongs to a certain class can be calculated, making it possible to find underlying attributes which indicate belonging to a particular class (e.g. socio-demographic attributes). Equation 4 describes the LCM for discrete choices. The model gives the probability for a choice between J_n alternatives, by individual *n* observed in S_n choice situations (Hensher et al., 2015).

$$F(n,s,j|q) = \frac{\exp(x'_{ns,j}\beta_q)}{\sum_{j-1}^{Jn}\exp(x'_{ns,j}\beta_q)} \tag{4}$$

Model performance

To test whether the model performs well and fits the data, different performance measurements can be used. First of all, the model's goodness-of-fit is commonly used and can be determined using McFadden's Rho-Square (ρ^2). A higher ρ^2 indicates a better fit. The closer the value of ρ^2 to 1, the better the model explains the data. In general, a ρ^2 value between 0.2 and 0.4 is considered as an adequate model-fit (Hensher & Stopher, 2021). Equation 5, shows the formula to calculate ρ^2. The variables in this formula will be explained by Equation 6.

$$\rho^2 = 1.0 - [\frac{LL(\beta)}{LL(0)}] \tag{5}$$

Based on the ρ^2 the adjusted Rho-Square can be calculated. The adjusted Rho-Square is also a goodness-of-fit measurement, which, in addition to ρ^2, considers the number of independent variables. The value for the ρ^2 is often overestimated as it increases if more variables are added to the model (not considering if a certain variable really improves the model). The adjusted Rho-Square can take this into account and determines whether new independent variables improve the goodness-of-fit. Equation 6 describes the adjusted Rho-Square, in which N_{alt} represents the total number of choice alternatives in the SCE and N_{par} represents the number of parameters in the model (Borgers, 2021).

$$\rho^2_{adjusted} = 1.0 - \left[\frac{N_{alt}}{\left(N_{alt} - N_{par}\right)}\right] * [1.0 - \rho^2] \tag{6}$$

The ρ^2 depends on the log-likelihood functions. The maximum log-likelihood function is given in Equation 7 (Train, 2009). This function estimates the parameters of stated choice models by maximizing the log of the likelihood function. Stated choice models are non-linear and therefore require maximum likelihood estimations. In Equation 7, y_{ni} is 1 if person *n* selects alternative *j* and zero if not. P_{nj} represents the probability that person *n* will choose alternative *j* (Train, 2009). *LL(0)* is the log-likelihood function when using the null-model, which means that all alternatives have the same probability of being chosen, as all parameters β are equal to zero (Borgers, 2021).

$$LL(\beta) = \sum_{n=1}^{N} \sum_{j} y_{nj} ln P_{nj} \tag{7}$$

Based on the log-likelihood functions as well, the Likelihood Ratio Statistic (LRS) can be used to check whether one model outperforms another. This LRS can be used for comparing different models with each other (e.g. LCM's with different number of classes). Equation 8 describes the LRS (X^2) formula. The difference of $LL(0)$ and $LL(\beta)$ multiplied by two is compared with the Chi-squared value for *K* degrees of freedom. *K* is the difference in the number of parameters (Borgers, 2021). If the value for LRS is larger than the Chi-squared value, the model is significant.

$$LRS(X^2) = -2\,(LL(0) - LL(\beta)) \tag{8}$$

Next to the LRS, two additional criterion can be used to compare models: the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The AIC and BIC are widely used as quantitative measures of model fit (Fabozzi et al., 2014). Lower values for these criteria indicate a better model fit. The AIC and BIC scores alone are not very informative, but they can be used to compare fits between models. Equations 9 and 10 represent the formulas for the AIC and BIC. In these formulas, *k* represents the number of estimated parameters and *o* represents the number of observations (Fabozzi et al., 2014).

$$AIC = -2LL(\beta) + 2k \tag{9}$$

$$BIC = -2LL(\beta) + \log(o)k \tag{10}$$

Lastly, the Chi-square test is used to check whether the data sample is representative for the Dutch population. The Chi-square test compares the observed cell frequencies (data sample) with the expected cell frequencies (Dutch population statistics). Equation 11 shows the formula for the Chi-square test (X^2), where O is the observed cell frequency and E is the expected cell frequency. If there is a large difference between the observed and expected values, the value for X^2 will be large. If the value for X^2 is larger than the critical Chi-square value, which is determined based on the degrees of freedom (df), the sample is not representative for the Dutch population. Next to sample representativeness, the Chi-square test can also be used to test whether categorial variables are associated with each other (e.g. gender and educational level). In this case, a large significant value for X^2 would indicate that there is a relationship between the categorial variables.

$$X^2 = \sum \frac{(O - E)^2}{E} \tag{11}$$

4.1.3. Conceptual model

Before the SCE can be designed, the variables that will be considered in the research need to be determined (step 1 of construction SCE in Figure 12). Figure 13 shows the conceptual model with the variables that will be included in the research. These variables are included based on the literature study and interviews conducted as described in Chapter 2 and 3, respectively. The socio-demographics and trip purpose variables are not specifically discussed in the literature study and interviews. These variables are added to better understand different groups of travellers and to allow more specific policies to be implemented to target these groups. Additional background information on why these variables are included is provided in this section.

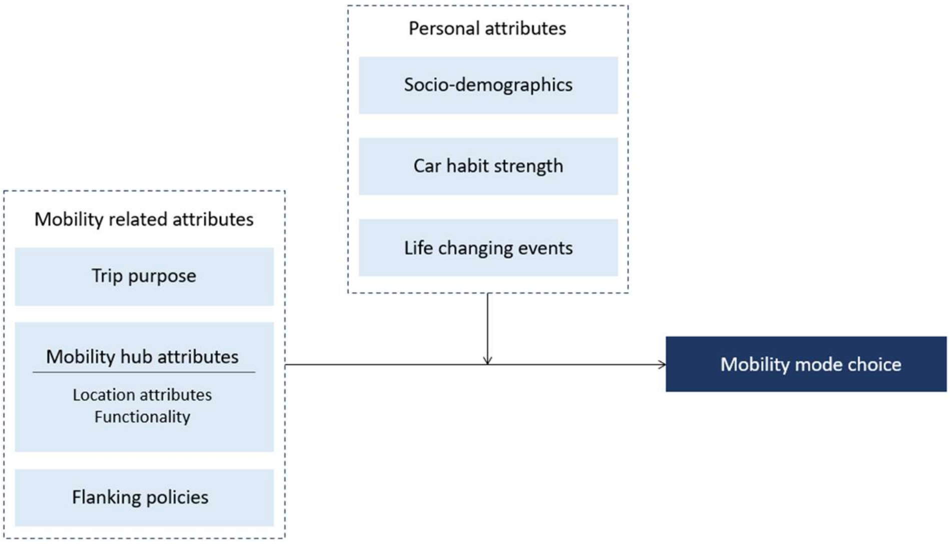

Figure 13: Conceptual model.

The variables influencing mobility mode choice can be classified into two categories: mobility related attributes and personal attributes. Trip purpose, mobility hub attributes and flanking policies are considered as mobility related attributes and socio-demographics, car habit strength, and the occurrence of life-changing events are considered as personal attributes.

Mobility related attributes

First, mobility related attributes are discussed. The aim of the stated choice experiment is to find attributes which influence the choice to travel by more sustainable mobility modes which are offered at mobility hubs. Therefore, direct mobility hub attributes, linked to location and functionality, are considered. This includes the mobility modes offered at a hub, the additional amenities present at a hub, and environment (ambient) attributes, such as greenery. The results from the expert interviewees indicate that travelling by a mobility hub should be more convenient (cheaper and faster) than travelling with own transport modes. Therefore, travel costs and travel time of modes presented at the hub are considered as well. Further assumptions are discussed in Section 4.1.4.

As stated in Chapter 2 Section 2.4., only implementing mobility hubs physically will not influence travel behaviour sufficiently towards using sustainable mobility modes due to car travel habits. Therefore, flanking policies are necessary to further convince individuals to use mobility hubs (Rongen et al., 2022). The need for flanking policies is also confirmed by interviewees who recognize these car travel habits and state that additional stimuli are needed to interrupt habit tunnel visions and introduce citizens to other mobility modes.

Trip purpose is also added to the model as mobility related attribute. As stated by Asgari and Jin (2019), a strong relationship exists between trip purpose and mobility mode choice. They found that certain trip purposes (or destinations) automatically resulted in choosing certain mobility modes. In this component, also habitual behaviour is partly recognized.

Personal attributes

Secondly, personal attributes influence travel mode choice behaviour. As indicated in the literature study, habits are a strong indicator of behaviour. Individuals with a strong car habit strength are less likely to consider and use other modes of transport. Therefore, this attribute is included in the model. Related to this, the occurrence of life-changing events are added as well. As stated by the habit discontinuity theory, individuals are more likely to consider their travel behaviour after the occurrence of life-changing events (Haustein & Kroesen, 2022).

Lastly, socio-demographic attributes are considered in the research as well. O'Driscoll et al. (2024) indicate that socio-demographic aspects (next to other considerations) influence individual travel behaviour. For example, car use generally peaks in middle age, as improvements in income increase car use. In their research, O'Driscoll et al. (2024) considered age, gender, socio-economic group (field of employment) and household composition. All socio-demographic aspects were found significant and influencing transport mode choice. Based on this, age, gender, household composition, yearly income and employment status are added as socio-demographics in this research. Besides, educational level and environmental awareness are added as well, as it is expected that higher educated individuals and more environmental aware individuals are more likely to consider travelling by modes offered at a mobility hub (Sun et al., 2020). Lastly, car ownership is also considered, as individuals owning a car are more likely to use it which relates to car habits explained before.

4.1.4. Choice experiment design

Based on the conceptual model, the SCE can be designed. In the choice experiment, respondents are asked to complete a set of choice tasks consisting of different alternatives, each with different variables. In these choice tasks, respondents are asked to indicate their travel behaviour. In this section, step 2 till 4 of the construction steps for an SCE, as given in Figure 11, are described in more detail.

Relevant attributes and their levels

As stated in Section 4.1.3., five mobility hub attributes are considered in this research: 1) mobility modes available, 2) additional amenities present, 3) environment attributes, 4) travel time, and 5) travel costs. These five attributes are considered in the SCE. The other attributes considered in the conceptual model will be incorporated in other questions in the questionnaire to ensure an understandable and manageable SCE for the respondents. As stated in the literature study (Chapter 2), flanking policies are needed to increase the efficiency of mobility hubs. However, adding flanking policies directly to the SCE as a sixth attribute would increase complexity making it more difficult and uncomprehensive for respondents to fill in the SCE correctly (Hensher et al., 2015). Therefore, flanking policies are tested as a separate question block in the questionnaire, as will be explained in Section 4.1.5.

The five mobility hub attributes are each described by four different levels. These will be combined to create different profiles which will be displayed in the choice tasks. Levels are the options with combinations of characteristics that fit a certain attribute. The levels of the attributes are based on the literature study and interviews (Sections 2.3. and 3.4.). To minimize the respondents needed and ensuring that the SCE is comprehensive for respondents, a balanced number of levels per attributes is chosen. Table 8, describes the attributes and their relevant levels. It can be noted that a difference is made between car owners and non-car owners. This difference is made as the relative travel costs compared to an own transportation mode significantly differs between these groups. Cars are, generally, more expensive than, for example, bicycles, especially for individual travellers (purchase and maintenance costs). Relatively speaking, it is therefore cheaper for car owners to make use of mobility modes offered at hubs, than for non-car owners. This is taken into account by increasing the relative price differences for non-car owners. All other attribute levels are equal between the two groups.

In this research, the focus is on neighbourhood and district hubs, as the aim of these hubs is to replace the private car, and these hubs can be reached without a private car. As stated in the literature study, the mobility modes that can be offered at these hubs are small-scale shared mobility, shared cars, and a bus connection. Besides, neighbourhood hubs can host small-scale self-service facilities, but this is often not the case. District hubs on the other hand are larger and often host larger-scale facilities. The levels for the mobility modes and amenities attributes are based on these findings. The first level for the mobility modes attribute are only the small-scale shared mobility alternatives. This is the minimum level of mobility modes that should be available at a hub as the basic function of a hub is to provide different alternative transportation modes at one spot. The first level for the amenities attribute is a hub without amenities, as it is no requirement for a hub to have additional amenities.

Table 8: Overview attributes and levels considered in SCE.

Car owners		Non-car owners	
Attributes	**Levels**	**Attributes**	**Levels**
Mobility modes available	1) Shared bicycle, shared cargo bicycle and shared scooter	Mobility modes available	1) Shared bicycle, shared cargo bicycle and shared scooter
	2) Shared bicycle, shared cargo bicycle, shared scooter and shared car		2) Shared bicycle, shared cargo bicycle, shared scooter and shared car
	3) Shared bicycle, shared cargo bicycle, shared scooter, shared car and bus connection		3) Shared bicycle, shared cargo bicycle, shared scooter, shared car and bus connection
	4) Shared bicycle, shared cargo bicycle, shared scooter and bus connection		4) Shared bicycle, shared cargo bicycle, shared scooter and bus connection
Additional amenities	1) None	Additional amenities	1) None
	2) Small-scale self-service functions, such as parcel locker, medicine locker and washing machines		2) Small-scale self-service functions, such as parcel locker, medicine locker and washing machines
	3) Medium work-related functions, such as community café, flex co-working spaces, and child daycare		3) Medium work-related functions, such as community café, flex co-working spaces, and child daycare
	4) Medium leisure-related functions, such as bike-repair shop, supermarket and gym		4) Medium leisure-related functions, such as bike-repair shop, supermarket and gym
Environment attributes	1) None	Environment attributes	1) None
	2) Greenery and guarded bike parking		2) Greenery and guarded bike parking
	3) Greenery and smart lightning		3) Greenery and smart lightning
	4) Guarded bike parking and smart lightning		4) Guarded bike parking and smart lightning
Travel time relative to own trans-portation	1) -10%	Travel time relative to own trans-portation	1) -10%
	2) 0%		2) 0%
	3) +10%		3) +10%
	4) +20%		4) +20%
Travel costs relative to own trans-portation	1) -50%	Travel costs relative to own trans-portation	1) -25%
	2) -25%		2) 0%
	3) 0%		3) +25%
	4) +25%		4) +50%

In the interviews, it is stated by the interviewees that the environmental characteristics of the hub also matter; a hub should be a pleasant place to be. Besides, some interviewees indicate that mobility hubs should be perceived as a (social) safe space. The interviewees mention that this can be accomplished by adding green, convenient lighting and maybe even a guarded bike parking. The levels for the environmental characteristics are based on these insights. The first level is the base level, where none of the mentioned characteristics are present, as it is no requirement for a hub to have these characteristics.

Travel time and travel costs are considered relative to own transportation modes to create comprehensible levels for the respondents. It is not intended to precisely describe the differences in travel time and travel costs of modes offered at the hub. Rather these levels are added to create insights on the impact travel time and travel costs might have on choice behaviour. There are two levels added in which travel time increases because when using mobility modes offered at a hub, individuals still have to reach the hub first, leading to additional travel time compared to using a mobility mode available at home. Travel costs are considered in steps of 25% as the costs of using a mobility mode offered at a hub is largely cheaper or more expensive compared to complete costs of ownership of cars or bicycles, especially for individual travellers (considering complete costs of ownership) (Milieu Centraal, n.d.). To account for the difference in costs for car owners and non-car owners, the levels for non-car owners are increased as stated before and shown in Table 8. The costs percentages are based on individual use. Using a car with four persons is automatically cheaper, however, it is hard to account whether individuals make choices based on this and, therefore, individual use is assumed for these cost percentages. A linear relationship is assumed between the travel time and costs levels, as these levels have equally large steps.

Relevant assumptions Stated Choice Experiment

In the SCE, a few assumptions are made as some attributes are already thoroughly researched. First of all, it is assumed that mobility hubs are within 300 meters from the residential and end location of the journey. As stated in literature, and by the interviewees, the maximum distance individuals are willing to walk to a mobility hub is 300 meters (about 5 minutes) (Geurs et al., 2023). Next to this, as also stated by the interviewees, using the modes available at the mobility hub should be easy and convenient. Therefore, it is assumed that all mobility modes offered at the hub are seamlessly integrated through a mobile applications. Besides, all shared mobility modes are always available and the bus stops four times an hour at the hub. Lastly, it is assumed that all shared vehicles offered are completely electric and that travelling by a mobility hub is always more sustainable than travelling with a private motor vehicle. An outside (non-guarded) bike parking is present as well.

Experimental design

The experimental design is created based on the attributes and levels given in Table 9. If all attributes and levels are plotted against each other, this would result in a full factorial design of 1024 possible combinations (without considering interactions effects). In this research interaction effects are considered for the attributes: 1) mobility modes available, 2) additional amenities, and 3) environmental characteristics. Interaction effects can estimate the combined effect of multiple variables on the dependent variable (Hensher et al., 2015). Interactions between these three attributes are considered as it is expected that these may reinforce or weaken each other's effect on mobility mode choice. For example, if a bus connection and a café are both present at a hub, this may result in a higher chance of individuals considering to travel by bus as they can wait for the bus inside the café. Including the interaction effects for the three attributes would result in a 4^8 fractional factorial design. Testing this number of combinations is not desirable as an unrealistically large number of respondents is required to obtain significant results. To reduce the required number of combinations, a fractional factorial design with 64 possible combinations (which considers the desired interaction effects) is chosen. This design is presented in Appendix D Table D1. A fractional factorial is an orthogonal subset of attribute level combinations which takes into account the attribute balance condition, meaning that each level of each attribute is equally represented in the design (Kemperman, 2022). The fractional factorial design is translated into a textual design for both car owners and non-car owners, which is presented in Appendix D Tables D2 and D3. The profiles are randomized using Excel before combining them into choice tasks. This randomization results in choice tasks with more advanced and representative trade-offs between profiles. The profiles that are combined into one choice task are presented in Appendix D Table D4. The 64 profiles result in 32 choice tasks. To prevent boredom, burden of respondents and, therefore, patronized responses, the 32 choice tasks are divided into 4 choice sets with 8 eight choice tasks (Appendix D Table D4) (Kemperman, 2022). Each respondent is presented with a different choice set, which results in collecting sufficient data for the complete SCE (heterogeneous design). To increase the total data collection for the SCE, respondents have the possibility to fill in an additional choice set, which leads to these respondents filling in 16 choice tasks. For each choice task, respondents are asked to indicate their choice for three different travel purpose: 1) work or education, 2) family or friends visit, and 3) day trip. By asking to indicate travel behaviour per trip purpose, the influence of different trip purposes on the usage of hubs can be estimated.

Choice task example

Before filling in the SCE, respondents are provided with an explanation block of the choice task, the attributes and their levels. Besides, respondents are informed of the assumptions made in the study that they need to consider. Respondents are presented with an example question as well, to make sure they understand the experiment. The questionnaire is completely presented in Appendix E. Figure 14 shows an example of the choice tasks respondents are presented with.

You are planning to make the following **three trips** next week:

On a weekday, you will travel to your **workplace or school** (or other educational purposes). During the weekend, you will **visit family or friends** on Saturday and go on a **day trip** on Sunday. You have the option to make your trips through one of the hubs below or use your own mode of transport. How would you travel to your destination?

You indicated that your **usual travel modes** for the following trips are:

Work:

School or other educational purposes:

Visiting family or friends:

Day trip:

If you indicated somewhere 'not applicable', you can assume for this question that you use your car.

	Hub A	Hub B
Mobility modes available	Shared bicycle Shared cargo bicycle Shared scooter Bus connection	Shared bicycle Shared cargo bicycle Shared scooter
Additional functions	Community cafe Flex office Child daycare	-
Travel time compared to own mode of transport	20% slower than own mode of transport.	10% faster than own mode of transport.
Travel costs compared to own mode of transport	As expensive as own mode of transport.	25% more expensive than own mode of transport.
Environment	Greenery and smart lightning.	Greenery and guarded bike parking.

Weekday trip to **work, school** or other educational purposes	Please choose...
Weekend visit to **family or friends**	Please choose... I use hub A I use hub B I use my usual mode of transport
Weekend **day trip**	

Figure 14: Example choice task in questionnaire.

4.1.5. Questionnaire design

This section describes the fifth step of the construction steps to create a stated choice model: the questionnaire design. Based on the conceptual model, the questionnaire to collect the data needed for the research can be designed. Figure 15 gives an overview of the question blocks in the questionnaire. The complete questionnaire is described in Appendix E.

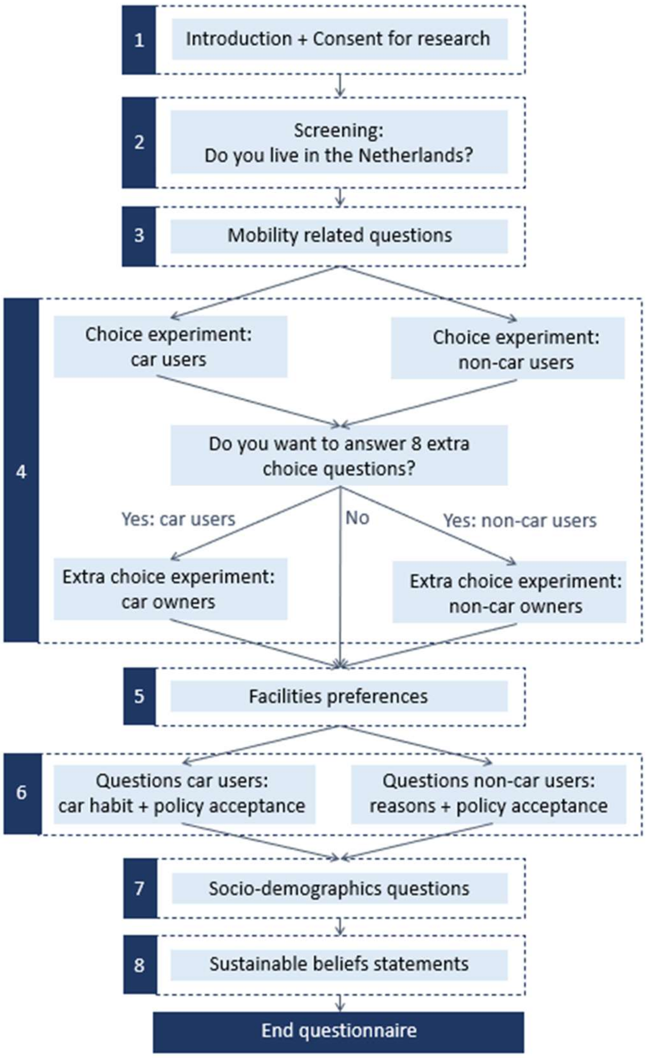

Figure 15: Overview questionnaire structure.

The questionnaire consists of eight blocks. The first two blocks consist of the introduction of the questionnaire, including accepting the terms and conditions for this research, and the screening question. Participants need to live in the Netherlands in order to participate in this research, as the set of participants will be compared to the Dutch population to draw conclusions on the representativeness of the data.

In the third block, mobility-related question are asked. Respondents are asked to indicate which mobility modes are available to them at home and within 7.5 kilometres from their dwelling, which is the average distance people are willing to bike from home (CROW, 2009). Respondents are also asked to indicate their familiarity with mobility hubs and shared mobility modes. Besides, respondents are asked if they hold a public transport card. Respondents are also asked in case a car is available to them, what the energy source is of this car. This could influence the expected behaviour change related to the introduction of zero-emission zones as fuel-driven vehicles are not allowed to enter these zones. The block ends with two questions collecting travel journey information. Respondents are asked to indicate their usual mode of transport for certain travel purposes and whether the destination of these purposes is mainly located within or outside of their municipality. As this research focusses on neighbourhood- and district hubs, and the travel range of these hubs is mostly local, it is expected that individuals that travel to destinations outside their municipality are less likely to make use of mobility hubs.

The fourth block consists of the SCE, which is explained in Section 4.1.4. Respondents either answer eight or sixteen choice tasks depending on whether they agree to fill in an additional choice set. In addition to the SCE, respondents are asked to order the facilities present in the SCE from most to least important for them in block five. This makes it possible to have more nuances between the nine different amenities as the importance of the amenities, and their expected influence on attracting people to the hub, can be estimated in more detail.

In block six, respondents are assigned different questions based on whether they have a car available at home or not (car owners versus non-car owners). Respondents that use a car, will be shown two types of questions: 1) questions related to car habit strength, and 2) questions related to municipal mobility policies acceptance. To measure car habit strength, the Self-Report Habit Index (SRHI), as explained in the literature study (Section 2.2.2.) is used (Steg & De Groot, 2018; Verplanken and Orbell, 2019). The SRHI statements used are presented in Figure 16. For each statement, respondents are asked to indicate on a 7-point Likert scale whether they agree with the statement or not. On this scale, 1 represents total disagreement and 7 represents total agreement with the statement. Car habit strength can be calculated based on the Likert scale scores.

SRHI statements for car habit strength

Using my own car is something….

1. I do frequently
2. I do automatically
3. I do without having to consciously remember
4. That makes me feel weird if I do not do it
5. I do without thinking
6. That would require effort not to do
7. That belongs to my routine
8. I start doing before I realize I am doing it
9. I would find hard not to do
10. I have no need to think about doing
11. That is typically me
12. I have been doing for a long time

Figure 16: SRHI statements used to measure car habit strength (Verplanken & Orbell, 2019).

After the car habit strength statements, respondents are presented with an information block explaining eight municipal mobility policies. The eight policies are based on the flanking policies described in Section 2.4.1. and the interviews conducted with policymakers. The eight policies implemented in the questionnaire are presented in Table 9. These policies are selected based on their comprehensibility. Respondents are asked to indicate for each policy whether they would support it on a 5-point Likert scale as adopted from Ogunkunbi and Meszaros (2023), in which 1 represents largely opposed and 5 represents largely in favour of the measure. Respondents are asked to indicate how much the measure would influence their car travel behaviour on a 5-point Likert scale as well, in which 1 represents much less use of car and 5 represents much more use of car. The self-stated car behaviour change needs to be interpretated with caution as it is not the most accurate method of measuring behaviour, as stated in Section 4.1.1. Additionally, a sixth answer option is offered, which indicates respondents would not use their car anymore.

Table 9: Eight policies considered in questionnaire.

Flanking policy	Explanation
Parking fee increases	Parking fees in cities will be increased. This will make it more expensive to park cars in cities.
Reduction of parking spaces	The number of parking spaces in cities will be reduced to make way for more green spaces. This increases the search time for a parking space.
Introduction zero-emission zones	Zero-emission zones will be introduced in city centres. This allows only vehicles without combustion engines to enter the city centre.
Introduction 30 km/h zones	In cities, the maximum speed on all roads will be 30 kilometres per hour, which increases travel time for car users.
Distribution of shared mobility vouchers	Municipalities distribute vouchers for the use of shared mobility. This allows you to try out shared mobility at a discount or even for free.
Redevelopment of public space (more one-way roads)	In cities, space is being redesigned. This includes more space for cyclists and pedestrians, and more greenery. To make space, roads disappear, and certain roads are designed as one-way roads. Travel time for car users increases because it is more difficult to drive in and out cities.
Introduction pay for use (toll roads)	Pay for use (toll roads) will be introduced in cities. This means that when driving a car into a city centre, a certain fee is charged.
Reduction parking permits	Residents in cities can get a maximum of one parking permit per household. As a result, it is no longer possible to park a second car in front of the door.

In block seven and eight, socio-demographic and sustainable orientation related questions are asked lastly. These questions are added at the end of the questionnaire to increase the overall response rate. As stated before, the socio-demographic characteristics that are asked in the questionnaire are: age, gender, level of education, household composition, yearly income, and employment status. These variables and their corresponding levels are presented in Table 10. The levels of the variables are based on the available data of the Dutch population by CBS and the WoON database of the Rijksoverheid (2021) as this eases comparing the collected data to the Dutch population statistics. Besides, the four digits of the postal code and the occurrence of life-changing events are asked. As stated before, individuals who experienced a life-changing event are more likely to reconsider their travel behaviour (Haustein & Kroesen, 2022). The life-changing events that are added to the answer options based on literature are: 1) new job, 2) child birth, 3) residential relocation, 4) start cohabiting, and 5) stop cohabiting (Rahman, 2023). Besides, obtaining a driver’s license is added to the options as well, as this may result in respondents using cars more often. The postal code helps indicating whether respondents are living in rural or dense areas.

Table 10: Overview socio-demographic variables and their corresponding levels.

Variable	Level
Age	1) Younger than 18 years old
	2) 18 years old to 24 years old
	3) 25 years old to 29 years old
	4) 30 years old to 39 years old
	5) 40 years old to 49 years old
	6) 50 years old to 59 years old
	7) 60 years old to 64 years old
	8) 65 years old and over
Gender	1) Male
	2) Female
	3) Other, or I would rather not say
Level of education	1) Primary education
	2) vocational education (or vmbo, mbo1, havo undergrad, vwo undergrad)
	3) Intermediate vocational education (or havo, atheneum, gymnasium, mbo2, mbo3, mbo4)
	4) Bachelor degree
	5) Master degree or doctor
	6) I would rather not say
	7) Other …
Household composition	1) Single
	2) Single parent
	3) Couple, without children
	4) Couple, with children
	5) Non-family household (including student households)
	6) I would rather not say
	7) Other ….
Employment status	1) Full-time (35 hours or more per week (CBS, 2024a))
	2) Part-time (less than 35 hours per week (CBS, 2024b))
	3) Not working (unemployed or retired)
	4) I would rather not say
	5) Other ….
Yearly household income	1) Less than €20000 (≤0.5x modal income)
	2) €20000 till €40000 (0.5x to 1x modal income)
	3) €40000 till €60000 (1x to 1.5x modal income)
	4) €60000 till €80000 (1.5x to 2x modal income)
	5) More than €80000 (≥2x modal income)
	6) I would rather not say

Lastly, the sustainable orientation related questions are based on the New Ecological Paradigm (NEP) statements, which are scientifically accepted statements to measure sustainable orientation (Anderson, 2012). The NEP consists of fifteen statements. Eight statements reflecting the endorsement of the new paradigm (NEP), indicating environmental awareness, and seven statements reflecting the endorsement of the dominant social paradigm (DSP), indicating conservative thoughts towards environmentally related change. For each statement, respondents are asked to indicate their strength of agreement on a 5-point Likert scale (strongly disagree (1) to strongly agree (5)). The statements are shown in Figure 17. The even numbered items represent endorsement of the DSP if agreed to by a respondent. The odd numbered items represent endorsement of the NEP if agreed to by a respondent (Anderson, 2012).

New Ecological Paradigm (NEP) scale

1. We are approaching the limit of the number of people the Earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will ensure that we do not make the Earth unliveable.
5. Humans are seriously abusing the environment.
6. The Earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities, humans are still subject to the laws of nature.
10. The so-called "ecological" crisis facing humankind has been greatly exaggerated.
11. The Earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue their present course, we will soon experience a major ecological catastrophe.

Figure 17: NEP statements (Anderson, 2012).

4.1.6. Conclusion SCE methodology

This section described the SCE methodology used in this research. It gave an introduction into choice behaviour and choice modelling. SCE is selected as measurement method as this is the best method to hypothetically test "actual" travel choice behaviour. Following the first five steps of constructing a SCE as described by Kemperman (2000) (Figure 12), the SCE and questionnaire are constructed. In the choice tasks of the SCE, participants are shown two mobility hubs in one choice task and they have to indicate whether they would travel by a mobility mode presented at one of the hubs or by their own usual mode of transport, as this makes it possible to identify the hub attributes that influence travel mode choice behaviour. There are several attributes influencing travel mode choice behaviour as indicated in the conceptual model (Figure 13), these are all incorporated in addition to the SCE in the questionnaire.

Next to the design of the SCE and the questionnaire, the MNL and LCM's and their corresponding model-fit indicators were introduced. These models are used as analysis methods to understand and predict travel choice behaviour of individuals. In Section 4.2., the data collection and data preparation will be described next.

4.2. Data collection and preparation

This section describes the data collection and data preparation for analysis. First, the collection of the data is described, after which the cleaning and modifying steps to make the dataset ready for analysis are discussed.

4.2.1. Data collection

For a statistically good analysis, a large sample size is desired. To reach this sample size, the questionnaire was distributed through several channels. The questionnaire is created in an online tool, LimeSurvey, which facilitates easy distribution. The data collection took place between the 15th of February and the 11th of March 2024. First, the questionnaire was distributed through personal networks. It was shared amongst colleagues, interviewed parties, relatives and acquaintances through e-mail, WhatsApp, Facebook, Instagram and LinkedIn. Additionally, the questionnaire was shared in Facebook groups. On the online platforms, the questionnaire was shared by third parties as well. On the 26th of February, the questionnaire was shared with the SmartwayZ.NL's travellers panel. This panel consists of 5000+ members who are interested in mobility related topics. SmartwayZ.NL is a cooperation between several partners, such as the province of Limburg, the province of Noord-Brabant, ministry of infrastructure and waterways, NS, Eindhoven University of Technology, and others. Before distributing the questionnaire amongst members of the travellers panel, the questionnaire was started 311 times and finished 116 times.

In total, the questionnaire was started by 962 respondents and completed by 465 respondents. Most respondents that did not complete the questionnaire, stopped at the beginning of the questionnaire maybe due to a lack of interest or the perceived length of the questionnaire. On average it took respondents 26 minutes to complete the questionnaire.

4.2.2. Data preparation

Before the data analysis can be conducted, the dataset needs to be cleaned. Data cleaning is needed to ensure the dataset is representable and does not include incomplete answers. After cleaning the dataset, the data needs to be recoded and restructured in order to be able to analyse the data in Nlogit.

Data cleaning and modification

The data cleaning steps are described in Table 11.

Table 11: Overview data cleaning steps.

Number of respondents	Data cleaning steps
962	**Start value**
-419	Respondents that did not finish first choice task are excluded from database.
543	
-3	Respondents that finished within 6 minutes are removed, as they also respondent the same answer for multiple question.
540	
-2	Respondents with “false” information are removed.
538	
-4	Respondents that left a comment stating they did not properly fill in the questionnaire are removed.
534	**End value**

As shown in Table 11, all respondents that did not finish the first choice task are excluded from the dataset resulting in 543 respondents remaining. As a next step, respondents that completed the questionnaire within six minutes are removed as this is much faster than the average completion time and are considered impossible for reliable answers. Besides, these respondents filled in the same answers for multiple questions. This group consists of three participants, which leads to 540 respondents. Furthermore, two respondents are removed due to filling in "wrong" information. Respondent 168 stated to not have a car at home, but stated later in the survey that he or she does possess a car. Respondent 37 filled in for every mobility mode that he or she did not know if a certain mode was available to him or her and besides did not finish the questionnaire. Lastly, four more unrepresentative responses were removed as respondents commented to not have responded properly due to the lengthiness of the questionnaire. This results in 534 respondents being in the dataset considered for data analysis, of which 457 respondents completed the questionnaire.

After removing invalid respondents, the dataset is cleaned by modifying and deleting answers where needed. First, all questions that had an "other" answer category are checked. If the answer written in the "other" category matches one of the presented multiple choice answers, this answer is reorganized among one of the presented answers. The modified answers are presented in Appendix F Table F.1. Next, the filled-in characters of the postal codes are removed. Based on the postal codes and CBS data, the degree of urbanization is added to the dataset (CBS, 2022; CBS, 2024c). The habit strength is calculated based on the Likert-scale questions described in Section 4.1.5. and added to the dataset as well. Besides, based on the NEP statements an average NEP score is calculated and added to the dataset (Anderson, 2012). Lastly, all respondents that filled in "I do not know" for each mobility mode that can be available at home for the question "which of the following mobility modes are available to you at home or within 7.5km from your home?", so for example a bicycle, are modified to "no" as it is assumed that respondents that own a certain mobility mode know that they have this available at home.

For six respondents, some answers are deleted. Respondent 142 started filling in a second choice task, but did not finish, which leads to missing values. Therefore, the answers of the second choice task are removed. Respondents 35, 165, 500, 504, and 526 all own a car but, due to incorrect linking in the questionnaire set-up, they filled in both car and non-car related questions. The linking mistake occurred as these respondents filled in "I do not know" for the mobility modes "work lease car" and/or "private lease car" instead of a clear "no" for the question "which of the following mobility modes are available to you at home or within 7.5km from your home". As they all own a car, their answers for the non-car related questions are removed.

Data coding Nlogit

After cleaning the dataset, categorial data needs to be recoded to be able to perform statistical analysis. Categorial data can either be dummy coded or effect-coded; this does not influence the model fit, only the interpretation of the eventual results differs between the two (Hensher et al., 2015). Dummy coding compares the utilities to the base level of an attribute, whereas effect coding compares the utilities to the overall mean. As for this research clear base levels can be defined for the hub attributes used in the SCE (base levels with a zero value), dummy coding is used as a data coding means.

To run the data analysis in Nlogit, the attributes considered in the SCE need to be dummy coded. The socio-demographic aspects need to be dummy coded to run the additional analysis in SPSS, however, these variables will be dummy coded after the descriptive analysis described in Section 4.3.1. Table 12 shows the dummy coded variables. For mobility modes offered, additional amenities and environmental characteristics, the levels with no "additions" are chosen as the base level, making it possible to add value to different functionalities. Day trips are chosen as a base level for the trip purpose as these are travel activities that do not take place on a daily or weekly basis. Trips to work or education, and family or friends, generally happen more often. In this way, these trip purposes can be compared to the day trip purpose.

Table 12: Dummy coded SCE variables.

Attribute	Levels	var1	var2	var3
Trip purpose	Work or education	1	0	
	Family or friends visit	0	1	
	Day trip	0	0	
Mobility modes	Micro-mobility and shared car	1	0	0
	Micro-mobility, shared car and bus connection	0	1	0
	Micro-mobility and bus connection	0	0	1
	Micro-mobility	0	0	0
Amenities	Parcel lockers, medicine lockers, laundry machines	1	0	0
	Café, flex office, child daycare	0	1	0
	Bike-repair shop, supermarket, gym	0	0	1
	No amenities	0	0	0
Environmental attributes	Greenery and guarded bike parking	1	0	0
	Greenery and smart lighting	0	1	0
	Guarded bike parking and smart lighting	0	0	1
	No attributes	0	0	0

The attributes travel time and travel costs (compared to own mode of transportation) do not need to be dummy coded, as the levels of these variables can be transformed into absolute values, which can be considered by Nlogit. For travel costs these values range from -0.5 to +0.5, and for travel time these values range from -0.1 to +0.2. The absolute values make it possible to consider price elasticity and travel time elasticity.

Data structuring Nlogit

To run the analysis in Nlogit, restructuring of the data collected through LimeSurvey is needed. In the data format from LimeSurvey each row in Excel represents one respondent. However, Nlogit requires that each choice possibility respondents have is presented in one row. This means that several rows in Excel represent the choices made by one respondent. Thus, a transformation from a wide to a long data format is required (Hensher et al., 2015). This transformation is performed using Excel. Each respondent is represented by 72 or 144 rows in Excel depending on whether they completed one or two choice sets. Each choice set consists of eight choice tasks with three answer options, which are answered for three trip purposes (8*3*3=72). If respondents answer two choice sets this, therefore, results in 144 rows in Excel (2*72=144). Table 13 shows an example of the format of the restructured dataset. Each row has a unique ID number ('ID'). Each respondent has an unique respondent number, which is the original number the respondent received in LimeSurvey ('Resp'). The

‘EXset’ column indicates whether a respondent filled in an additional set (1 if an additional set if filled in, otherwise 0). This column links to the ‘Nsets’ column, which indicates how many choice sets a respondent answered (either 24 or 48). The ‘CHtask’ column indicates the specific task within the choice sets (either 1 to 24 or 1 to 48). ‘Nalt’ is a constant value and indicates that each choice task consists of three choice alternatives. The ‘profID’ column indicates the choice profile that is shown to the respondent. The columns ‘Tripwork’ and ‘Tripfam’ indicates for which trip purpose the respondent filled in the choice task. Lastly, the ‘choice’ column indicates the choice the respondent made by a 1 in the row of the alternative that was chosen. The column ‘NC’ is added to the data format to measure the utility of travelling by the usual mode of transport alternative.

Table 13: Nlogit data format.

ID	Resp	EXset	Nsets	CHtask	Nalt	profID	Tripwork	Tripfam	choice	NC	…
1	19	0	24	1	3	55	1	0	0	0	…
2	19	0	24	1	3	29	1	0	0	0	…
3	19	0	24	1	3	0	1	0	1	1	…
4	19	0	24	2	3	55	0	1	0	0	…
5	19	0	24	2	3	29	0	1	0	0	…
6	19	0	24	2	3	0	0	1	1	1	…
…	…	…	…	…	…	…	…	…	…	…	…
59254	978	1	48	48	3	40	0	0	1	0	…
59255	978	1	48	48	3	31	0	0	0	0	…
59256	978	1	48	48	3	0	0	0	0	1	…

In the long data format, also the dummy coded attributes and absolute values linked to the choice profiles are added. In this way, the effect of these attributes on the choice to travel by modes offered at a hub can be measured. As stated before, interaction effects are considered as well. The hub attributes for which interaction effects can be taken into account are also dummy coded and added to the long data format (by multiplying the dummy coded values of these attributes). The trip purposes are also added as an interaction effect to the data format. To create these interaction effects, the trip purpose values are multiplied with the main hub effect values, so, for example, the value for ‘Tripwork’ is multiplied with the absolute value for travel costs. For trip purpose, third degree interactions effects turned out to be not significant and are, therefore, not considered in this research.

4.2.3. Conclusion data cleaning

Data is collected through various channels, including the travellers’ panel of SmartwayZ.nl. After cleaning and modifying the data, the data could be analysed. Sufficient data was collected to have a cleaned data sample large enough (534 respondents) to conduct a comprehensive analysis with significant results. The analysis will be conducted using the analysis programs Nlogit and SPSS. The results of the analysis will be described in Section 4.3.

4.3. Results

After cleaning and modifying the data, the dataset can be used for analysis. First, a descriptive analysis is conducted using Excel and SPSS. This analysis gives insights into the data sample and makes it possible to check the dataset for representativeness for the Dutch population. The descriptive analysis consists of the data distribution, socio-demographic characteristics, environmental awareness, mobility statistics and the flanking policies, and will be discussed in Section 4.3.1. After the descriptive analysis, the MNL and LCM are conducted using Nlogit. The socio-demographic variables are linked to the classes of the LCM by SPSS. The results of these models will be discussed in Section 4.3.2.

4.3.1. Descriptive analysis

The descriptive analysis gives insights into the data sample collected in this research and makes it possible to compare the data sample with the Dutch population for relevant attributes, checking its representativeness. First the data distribution will be discussed. Next the socio-demographics and the environmental awareness of the sample will be explained. Fourth, the mobility statistics will be explored and, lastly, the habit strength and occurrence of life-changing events will be discussed as well.

<u>Data distribution</u>

Table 14 shows the distribution of the respondents across the Netherlands. A high response rate is observed in larger cities, such as Eindhoven and 's-Hertogenbosch. Besides, a high response rate is visible in Weert. All respondents are located in the South and the centre of the Netherlands. This was expected as the data was distributed amongst relatives and colleagues living in these areas. The highest response rate is visible in the province of Noord-Brabant, which can be explained by the distribution of the questionnaire through the SmartwayZ.NL travellers' panel. There are no responses from the North of the Netherlands, indicating that the Dutch population is not fully represented in this sample based on location. This is also confirmed by the Chi-square value of 92.70 ($p<0.01$), which indicates that the sample is not representative for the Netherlands as the value is higher than the critical Chi-square value of 19.675 (df=11). This was expected based on the data in Table 14.

Table 14: Distribution respondents across the Netherlands.

Province	Freq.	% Sample	% Dutch pop. (CBS, 2024d)
Limburg	68	15.3	6.3
Noord-Brabant	319	71.8	14.7
Zeeland	3	0.7	2.2
Gelderland	9	2.0	12.0
Utrecht	18	4.1	7.8
Zuid-Holland	18	4.1	21.4
Noord-Holland	9	2.0	16.7
Flevoland	0	-	2.5
Overijssel	0	-	6.6
Drenthe	0	-	2.8
Groningen	0	-	3.3
Friesland	0	-	3.7
Missing values	90	-	-
Chi-square value			**92.7**

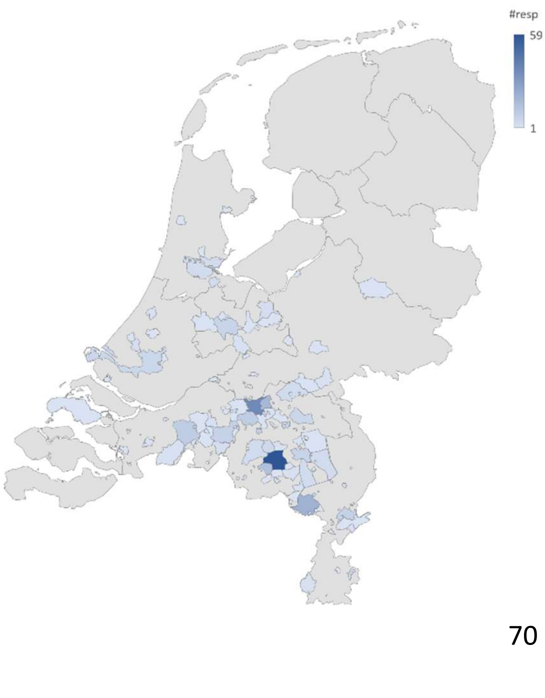

Figure 18 shows the degree of urbanization of the neighbourhoods in which respondents live. From this figure it can be noted that 64.2% of the respondents live in a moderately urban to very highly urban neighbourhood, of which 43.5% of the respondents is living in a highly urban or very highly urban neighbourhood. A very high urban neighbourhood can be defined as an area with 2500 or more addresses per squared kilometre. A non-urban area can be defined as an area with 500 or less addresses per squared kilometre. The other levels are stepwise categorized between these two definitions (CBS, 2024c). Unfortunately, the Dutch statistics on the percentage of respondents living in urbanized areas is not available, therefore, these statistics cannot be compared to Dutch averages.

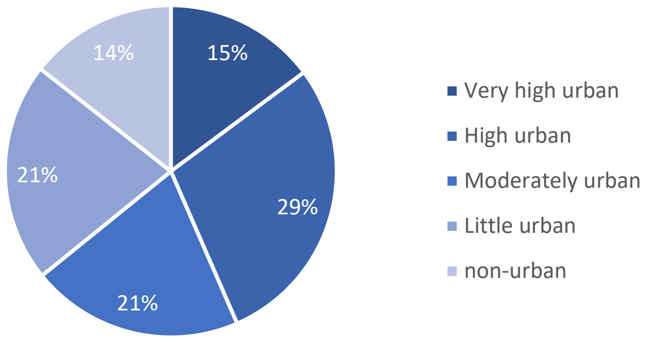

Figure 18: Percentage of data sample living in urban areas.

Socio-demographic characteristics

This section gives insights into the socio-demographic data of the sample. It should be noted that there are 74 missing values in the sample for the socio-demographic characteristics. To check the representativeness of the data sample in accordance with the Dutch population, the collected data is compared with data from the Dutch Bureau of Statistics (CBS). The characteristics also compared are gender, age, educational level, household composition, employment status and yearly income. For the yearly income attribute, no CBS data was available, therefore, data from the WoON dataset (Rijksoverheid, 2021) is used to compare this attribute to the Dutch population. Table 15 gives an overview of these comparisons and the corresponding Chi-square values (X^2).

Table 15: Overview socio-demographic values of data sample (CBS, 2024e; CBS, 2024f; CBS, 2024g; CBS, 2024h; CBS, 2024i; CBS, 2024j; Rijksoverheid, 2021).

Characteristic	Level	Freq.	% Sample	% Dutch pop.	X^2	p-value
Gender	Male	309	67.2	50.3	7.51	0.023
	Female	146	31.7	49.7		
	Other/rather not say	5	1.1	-		
Age	< 18 years	0	-	18.6	28.18	<0.001
	18 – 24 years	40	8.7	9.0		
	25 – 29 years	38	8.3	6.5		
	30 – 39 years	42	9.1	12.8		
	40 – 49 years	78	17.0	11.9		
	50 – 59 years	120	26.1	14.3		
	60 – 64 years	72	15.6	6.6		
	65+ years	70	15.2	20.3		

Table 15 continued.

Characteristic	Level	Freq.	% Sample	% Dutch pop.	X^2	p-value
Education level	Primary education	0	-	7.4	49.68	<0.001
	Vocational	10	2.2	20.2		
	Intermediate vocational	80	17.4	37.9		
	Bachelor	177	38.5	21.4		
	Master	188	40.8	13.1		
	Rather not say	5	1.1	-		
Household composition	Single	86	18.7	18	2.12	0.713
	Single parent	9	2.0	3		
	Couple, with children	157	34.1	26		
	Couple, without children	171	37.2	49		
	Non-family household	26	5.6			
	Other/rather not say	11	2.4	2		
Employment status	Full-time	255	55.4	38	10.18	0.017
	Part-time	137	29.8	35		
	Not working	60	13.1	27		
	Other/rather not say	8	1.7	-		
Yearly income	≤0.5x modal income	22	4.8	33	26.21	<0.001
	0.5x – 1x modal income	44	9.6			
	1x-1.5x modal income	86	18.7	19		
	1.5x – 2x modal income	90	19.6	15		
	2x modal income or more	135	29.4	33		
	I would rather not say	83	18.0	-		

Gender

Males are largely overrepresented in the dataset as about two-third of the respondents are male. Compared to the Dutch population statistics, males are overrepresented in the sample as well. A Chi-square test is used to statistically check if the sample represents the Dutch population. This test results in a Chi-square value (X^2) of 7.51 with 2 degrees of freedom and a p-value of 0.023. This value is larger than the critical value for X^2 (5.991), which indicates that the data sample does not represent the Dutch population based on gender.

Age

In the sample, 50- till 59-year-olds are the largest group in the sample (26.1%). Comparing the data to the Dutch statistics, it can be stated that 40- till 64-years-olds are largely overrepresented (58.7% compared to 32.8% of the Dutch population). This is also confirmed by the Chi-square test, which yields a value for X^2 of 28.18 with 7 degrees of freedom and a p-value of <0.001. This value is larger than the critical value X^2 of 14.067 indicating that the data sample is not representative for the Dutch population based on age.

Education level

Respondents were asked to indicate their highest finished level of education. In the sample, there is a very large overrepresentation of highly education individuals (bachelors and masters), which leads to a underrepresentation of the other education levels. This is also confirmed by a Chi-square value (X^2) of 49.68 with 5 degrees of freedom and a p-value of <0.001. This value is larger than the critical value for X^2 (11.070), indicating that the data sample does not represent the Dutch population based on education level.

Household composition

In the sample, couples are mostly present. There is not one category which is largely over- or underrepresented. Only couples with children are a bit overrepresented compared to the Dutch population, which results in a small underrepresentation of couples without children. The limited differences are confirmed by the Chi-square test. The value for X^2 is 2.12 with 4 degrees of freedom and a p-value of 0.713. As the p-value is higher than 0.05, this indicates that Chi-square test is not significant, indicating that the sample is representative for the Dutch population based on household composition.

Employment status

To get an insight into the weekly occupation of respondents, they were asked about their employment status. More than half of the respondents (55.4%) work full time. This group is overrepresented in the sample compared to the Dutch statistics, which mainly leads to an underrepresentation of the non-working class. This is confirmed by a Chi-square value (X^2) of 10.18 with 3 degrees of freedom with a p-value of 0.017. This value is higher than the critical value for X^2 of 7.815, which indicates that the data sample is not representative for the Dutch population based on employment status.

Yearly income

Lastly, respondents were asked to state their annual household income. In the sample, the lower income groups are largely underrepresented compared to the Dutch population (14.4% versus 33%). It should be noted that a substantial part of the respondents wished to not state their yearly income (18%). Even though the other income levels are quite in line with the Dutch population, the data sample is not representative. This is also confirmed by the Chi-square value (X^2) of 26.21 with 4 degrees of freedom and a p-value of <0.001. This value is larger than the critical value for (X^2) of 9.488, indicating that the data sample is not representative for the Dutch population based on annual income.

Regrouping and coding socio-demographic characteristics

Based on the descriptive statistics, the socio-demographic characteristics can be regrouped and dummy coded for analysis. Table 16 gives an overview of the regrouped and dummy coded characteristics. For the age attribute, the level younger than 18 years old is not considered in the analysis as no respondents fit this category. For the education level attribute, the education levels up to a bachelor’s degree were clustered. Lastly, for the yearly income attribute, the incomes up to a modal household yearly income are clustered together. In this way, these categories have more weight compared to the overrepresented categories. The variables are dummy coded to be able to add them in the Nlogit model and are transformed into numbers for the analysis in SPSS. In SPSS, the data is still labelled as nominal or ordinal data depending on the attribute. The data is transformed into numbers as otherwise the missing values are considered as a category by SPSS, while these should be left out of the analysis.

Table 16: Overview regrouping and recoding socio-demographic attributes.

Attribute	Levels	var1	var2	var3	var4	var5	var6	SPSS
Gender	Male	1	0					1
	Female	0	1					2
	Other/ rather not say	0	0					3
Age	18 – 24 years	1	0	0	0	0	0	1
	25 – 29 years	0	1	0	0	0	0	2
	30 – 39 years	0	0	1	0	0	0	3
	40 – 49 years	0	0	0	1	0	0	4
	50 – 59 years	0	0	0	0	1	0	5
	60 – 64 years	0	0	0	0	0	1	6
	65+ years	0	0	0	0	0	0	7
Education level	Low to medium education	1	0	0				1
	Bachelor	0	1	0				2
	Master	0	0	1				3
	Other/ rather not say	0	0	0				4
Household composition	Single	1	0	0	0			1
	Couple without children	0	1	0	0			2
	Household with children	0	0	1	0			3
	Non-family household	0	0	0	1			4
	Other / rather not say	0	0	0	0			5
Employment status	Full-time	1	0	0				1
	Part-time	0	1	0				2
	Not working	0	0	1				3
	Other / rather not say	0	0	0				4
Yearly income	≤modal income	1	0	0	0			1
	1x-1.5x modal income	0	1	0	0			2
	1.5x – 2x modal income	0	0	1	0			3
	2x modal income or more	0	0	0	1			4
	Rather not say	0	0	0	0			5

Relations between socio-demographic characteristics

To get additional insights and a better understanding of the sample, the socio-demographic characteristics that are expected to be related to each other are analysed in more detail using cross-tabular bivariate analyses in SPSS. The SPSS output is given in Appendix G. The most interesting insights are discussed in this section, of which some are used to better describe the classes of the LCM analysis.

Age relates to household composition, yearly income and education level. Bachelor graduates are mostly present among 18- to 24-year-olds and master graduates are mostly present among 25- to 29-year-olds. Low to medium educated individuals are mostly younger than 24 years or older than 50 years. Regarding yearly household income, individuals younger than 30 years, earn up to an annual modal household income, while older individuals have higher incomes. Lastly, most 40- to 59-year-olds have children living at home and most individuals younger than 24 years live in a non-family household, such as student housing. 25- to 29-year-olds live mostly alone or together with a partner.

Urbanity level relates to age and household composition. Most individuals live in highly urban to very highly urban areas up to the age of 29 years, after which a transition to moderately, little or non-urban areas is visible. Furthermore, most individuals living in non-family households (e.g. student housing) live in highly urbanized areas, while families with children mostly live in moderately urban to rural areas.

Environmental awareness

At the end of the questionnaire, respondents were asked to state their agreement to the fifteen NEP statements. Table 17 gives an overview of the average scores of the statements. From the table it can be concluded that in general the respondents have a higher endorsement of the NEP statements than the DSP statements, indicating environmental awareness. The DSP scores are in the last column transformed to scores in line with the NEP statements. To give an example, if a respondent indicated a 1 for the DSP statement "humans have the right to modify the natural environment to suit their needs" this is transformed to a 5 on the NEP scale (opposite). These transformed NEP scores are used to calculate the average endorsement of the New Ecological Paradigm. This average score is 3.63 (out of 5), indicating endorsement of the NEP and environmental awareness. This means that the sample is generally environmental aware. In SPSS, a factor analysis is ran on these statements, to check whether a certain answer to one of the statements would predict the answer to the other statements. However, this factor analysis turned out to be not significant, indicating that a certain answer to one of the statements does not necessarily lead to the same answer to other statements.

Table 17: Overview average scores of the NEP statements.

#	Paradigm	Statement	Av. score	Transformed to NEP score
1	NEP	We are approaching the limit of the number of people the Earth can support.	3.90	3.90
2	DSP	Humans have the right to modify the natural environment to suit their needs.	2.50	3.50
3	NEP	When human interfere with nature, it often produces disastrous consequences.	3.47	3.47
4	DSP	Human ingenuity will ensure that we do not make the Earth unliveable.	3.16	2.84
5	NEP	Humans are seriously abusing the environment.	3.92	3.92
6	DSP	The Earth has plenty has natural resources if we just learn how to develop them.	3.21	2.79
7	NEP	Plants and animals have as much right as humans to exist.	3.91	3.91
8	DSP	The balance of nature is strong enough to cope with the impacts of modern industrial nations.	1.98	4.02
9	NEP	Despite our abilities, humans are still subject to the laws of nature.	4.12	4.12
10	DSP	The so-called "ecological crisis" facing humankind has been greatly exaggerated.	2.14	3.85
11	NEP	The Earth is like a spaceship with very limited room and resources.	3.44	3.44
12	DSP	Humans were meant to rule over the rest of nature.	1.84	4.16
13	NEP	The balance of nature is very delicate and easily upset.	3.68	3.68
14	DSP	Humans will eventually learn enough about how nature works to be able to control it.	2.78	3.22
15	NEP	If things continue on their present course, we will soon experience a major ecological catastrophe.	3.55	3.55
Average NEP score			**3.75**	
Average DSP score			**2.51**	
Total score all statements in NEP scale				**3.63**

Mobility statistics

This section describes the current mobility behaviour of the respondents. As this research focuses on changing car usage habits towards using more sustainable modes of transport available at mobility hubs, it is interesting to gain insights into current travel behaviour. Next to current travel behaviour patterns, this section also focuses on the current familiarity with shared mobility modes and hubs. Lastly, it gives insights into the current car habit strength.

Availability mobility modes

Respondents were asked to indicate which mobility modes are available to them at home or within 7.5 kilometres from home. Figure 20 gives insights into the mobility modes available to them. From this figure, it can be concluded that most respondents have a bicycle and a car available to them. Besides, most respondents live in an area where public transport is available to them, especially small public transport (bus and tram) are available to most respondents (87.3%). Large public transport (train) is available to 65.0% of the respondents. The fact that public transport is available to most respondents is in line with a large part of the respondents living in urban areas (Figure 18). Lastly, a substantial part of the respondents states that they do not know whether shared mobility modes are available to them (9 to 15%). However, a large part of the respondents live in highly urbanized areas (43.5%). Therefore, it is expected that the percentage of respondents living close to shared vehicles is actually higher. This is confirmed by CROW (2024) which developed a dashboard with the actual locations of shared vehicles. Figure 19 combines the data from the dashboard f CROW (2024) with the residential locations of respondents. This results in already 234 respondents living in areas where shared mobility is available.

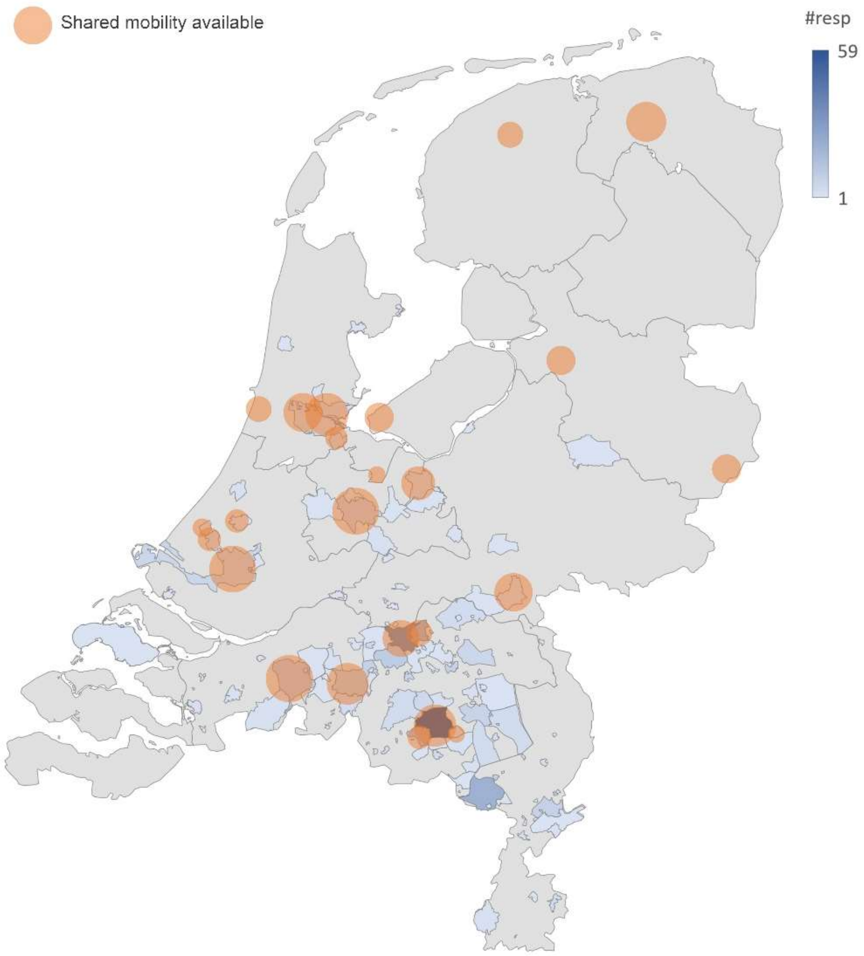

Figure 19: Respondents living in areas where shared mobility is available (CROW, 2024).

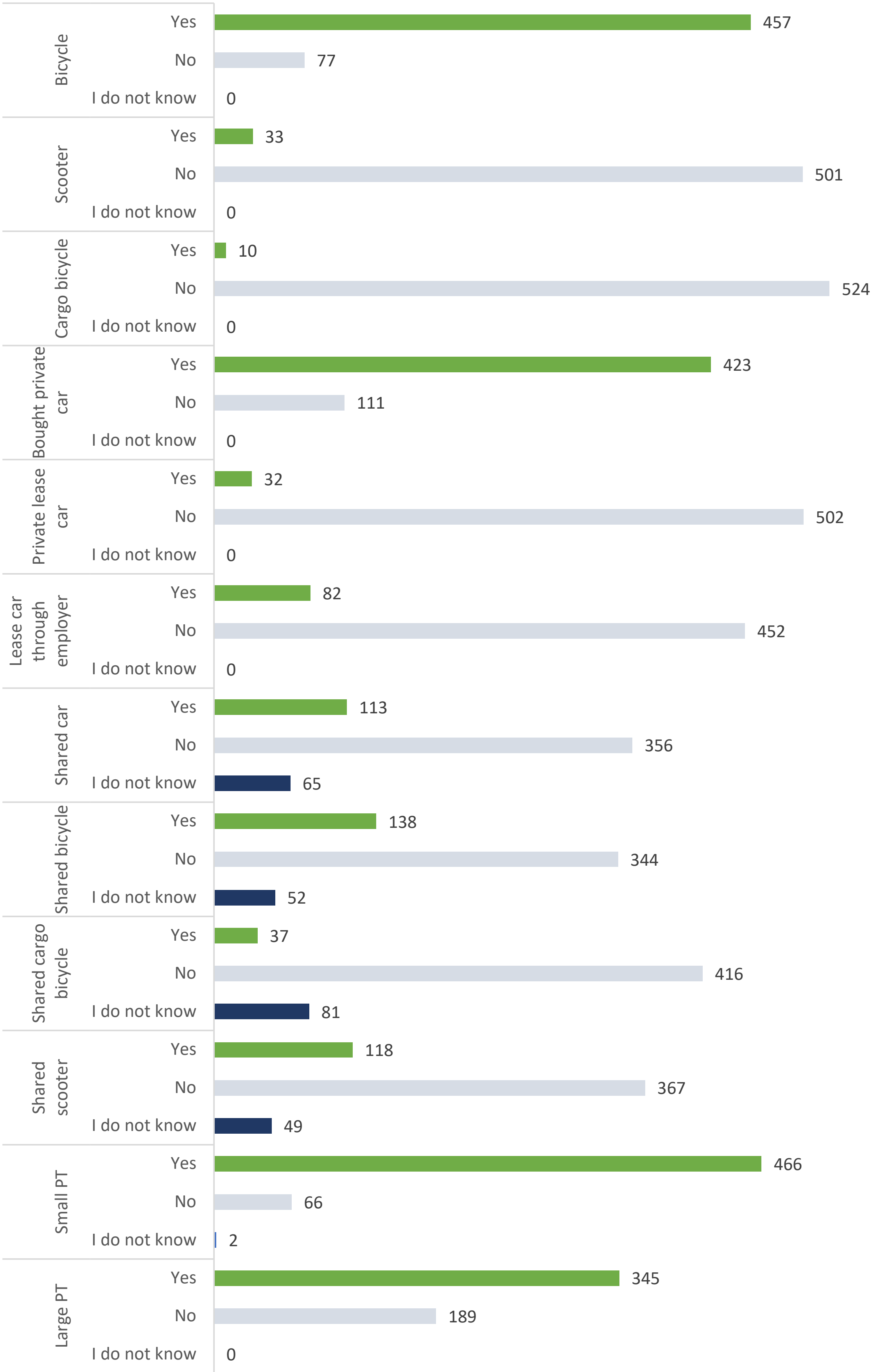

Figure 20: Available mobility modes at home and within 7.5 kilometres from home.

Car ownership

As stated before, a large part of the respondents has a car available at home. Figure 21 shows the car availability per age category compared to the Dutch population (CBS, 2024k). It can be concluded that in the sample, 40- to 65-year-olds on average more often own a car than the Dutch population. On the other hand, 30- to 40-year-olds and 65+-years-olds less often own a car than the Dutch population. However, based on the Chi-square test value (X^2) of 8.224 with a p-value of 0.222, the sample is still representative for the Dutch population considering car ownership as the Chi-square test is not significant.

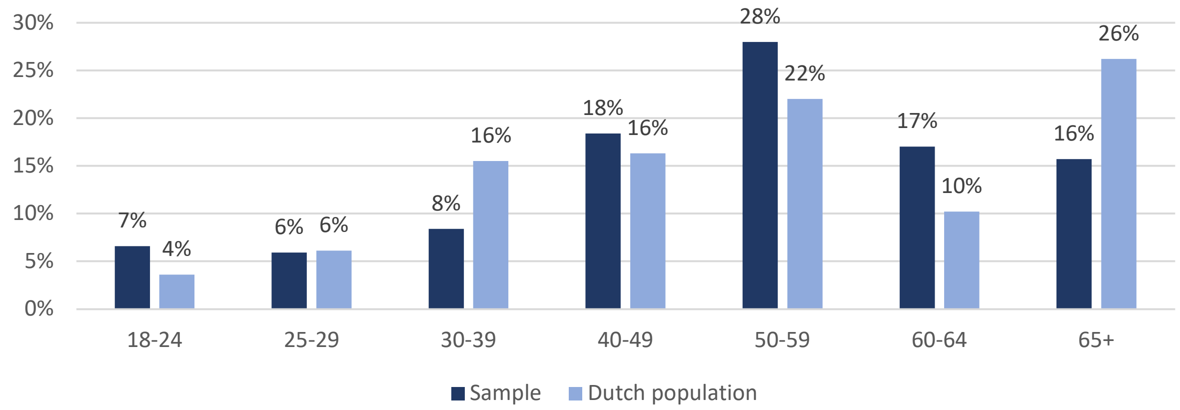

Figure 21: Percentage of cars in the Netherlands by owner's age (CBS, 2024k)

Fifty-seven respondents indicate to not own a car or have a car available to them. The reasons why individuals do not own a car, are giving in Figure 22. The most mentioned reasoned are 1) respondents find cars too expensive or have no need for a car, 2) respondents rather use other mobility modes, and 3) environmental considerations.

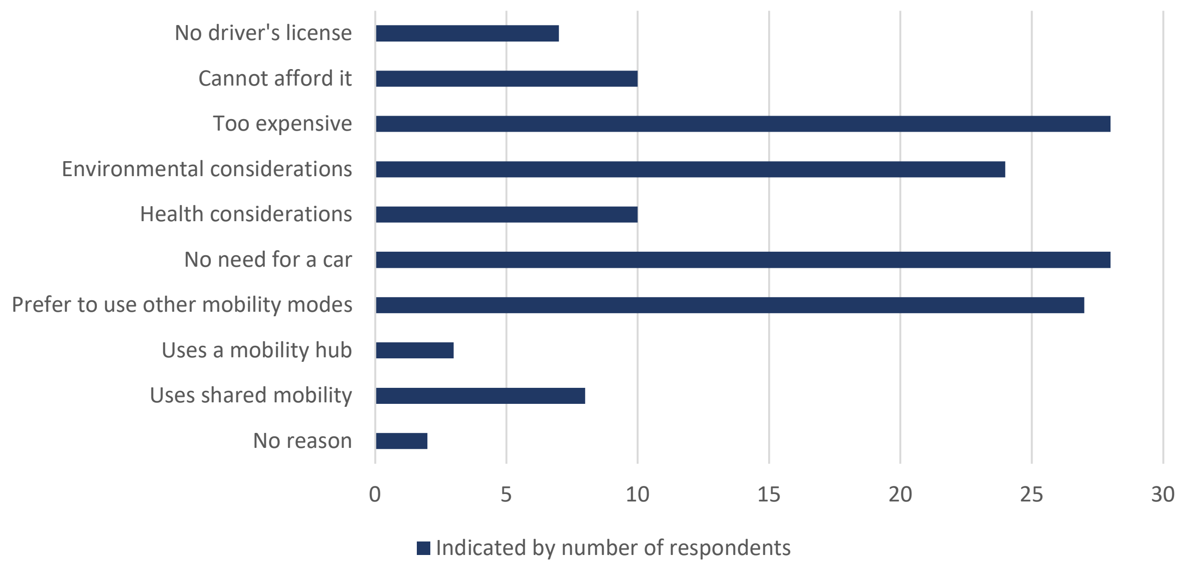

Figure 22: Reasons for not owning a car as indicated by non-car owners.

Energy source cars

Figure 23 indicates the energy sources of the cars that are available to the respondents (owned as well as shared cars). The largest share of cars drives on petrol (59.5%) and about one quarter drives (partly) electric (26.1%), of which 13.4% drives fully electric. In case of a zero-emission zone, only this part of the respondents can enter this zone with their car.

Public transport card ownership

Figure 24 shows the percentage of respondents owning a personal public transport card. More than half of the respondents owns a personal public transport card (63.3%) of which 36.5% owns a card including a subscription such as student discount or a business card, indicating they can using public transport with a discount.

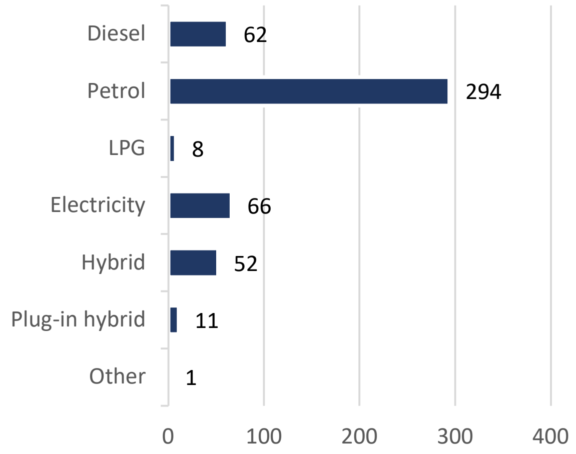

Figure 23: Energy source available cars.

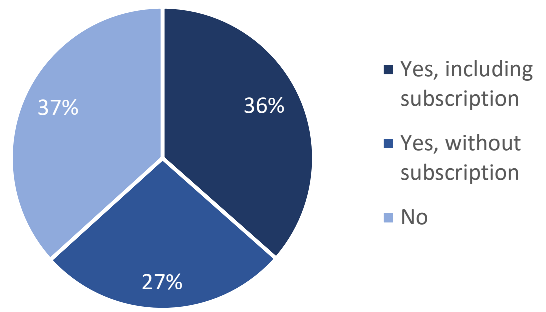

Figure 24: Public transport card ownership.

Mobility behaviour

In the mobility related section of the questionnaire, respondents were asked to indicate their usual travel mode for seven travel purposes: 1) commuting, 2) going to school, 3) groceries or shopping, 4) sport or hobbies, 5) friends or family visits, 6) day trips and 7) personal care. Besides, they were asked to indicate whether the destinations of these travel purposes are mainly located within our outside of their municipality. Figures 25 and 26 give an insight into these statistics. From Figure 25, it can be concluded that the car (bought, leased and borrowed) is largely used for every trip purpose (at least >30%). Next to the car, the bicycle and train are also often used. Lastly, trips close to home, such as doing groceries, are also often completed by walking. Shared vehicles are hardly used, as less than 1% of the respondents indicate to usually use a shared vehicle. A shared car is usually used by one person to go to educational purposes and a shared bicycle is usually used by one person to go to work. Further, as shown in Figure 26, the destination for groceries, sport or hobby, and personal care (e.g. visiting general practitioner) are mostly located with the municipality individuals are living. The destination of the other purposes (work, education, family or friends and day trips) are mainly located outside of the municipality individuals are living. Combining Figures 25 and 26 indicates that for trips outside of the municipality, mostly the car and train are used as transport mode (at least >65%).

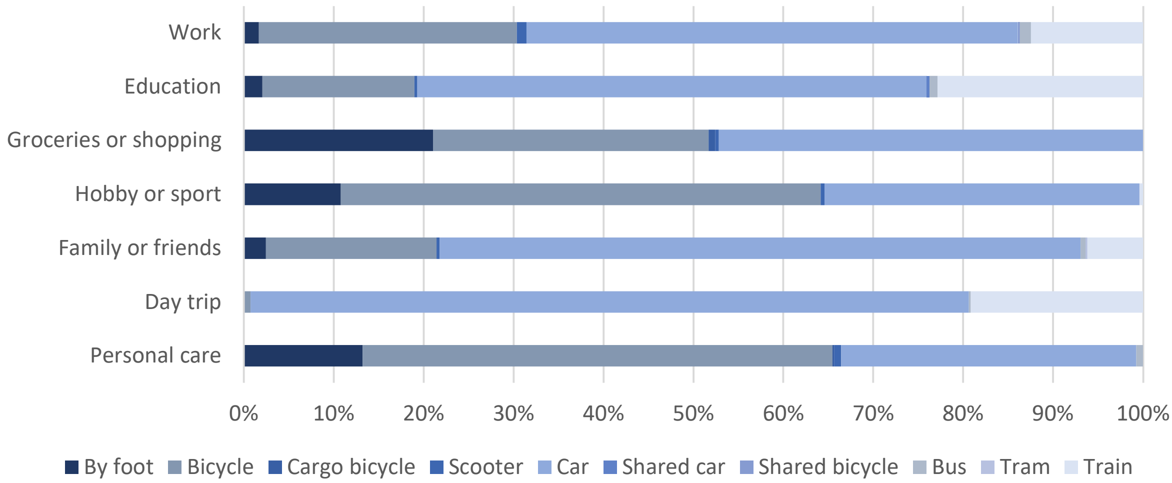

Figure 25: Usual transportation modes to destination of trip purposes.

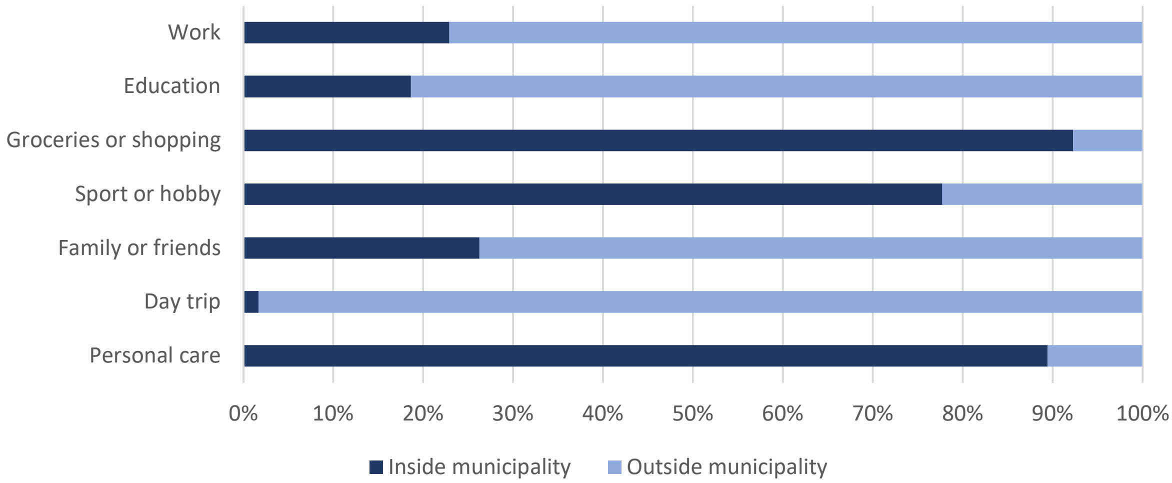

Figure 26: Location of destination of trip purposes.

Familiarity mobility trends

Respondents were asked about their familiarity with shared mobility modes and mobility hubs. Figure 27 shows that almost all respondents (except 7%) are familiar with shared mobility, and 28% of the respondents have used shared mobility before. This is higher than the Dutch national average in 2022 which states that 17% of the Dutch population has used shared mobility before (Ministry of Infrastructure and Water Management, 2022). Figure 28 shows that 42% of the respondents know what a mobility hub is and that 36% of the respondents have heard of the term before. The higher than average shared mobility usage percentage and the high percentage of respondents being familiar with mobility can be explained by the fact that the questionnaire was distributed among members of SmartwayZ.NL' travellers panel. It is expected that the members of this panel are interested in the mobility topic.

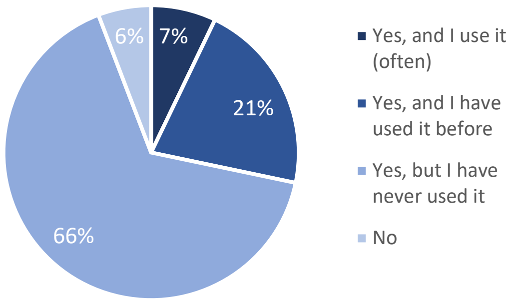

Figure 27: Familiarity with shared mobility.

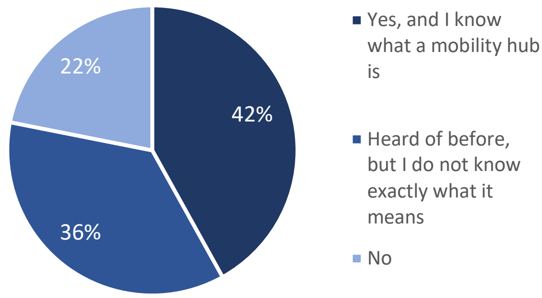

Figure 28: Familiarity with mobility hubs.

Occurrence life-changing events versus car habits

In the questionnaire, respondents were asked about the occurrence of life-changing events in their lives during the past year, as this can influence the strength and forming of habits. The life-changing events considered in this research are: 1) started a new job, 2) child birth, 3) residential relocation, 4) obtained a driver’s license, 5) started cohabiting and 6) stopped cohabiting. 86 respondents indicated to have experienced one or more of these life-changing events in the past year. This is about 18.7% of the respondents. Starting a new job and residential relocation are the events that happened most often as illustrated in Figure 29.

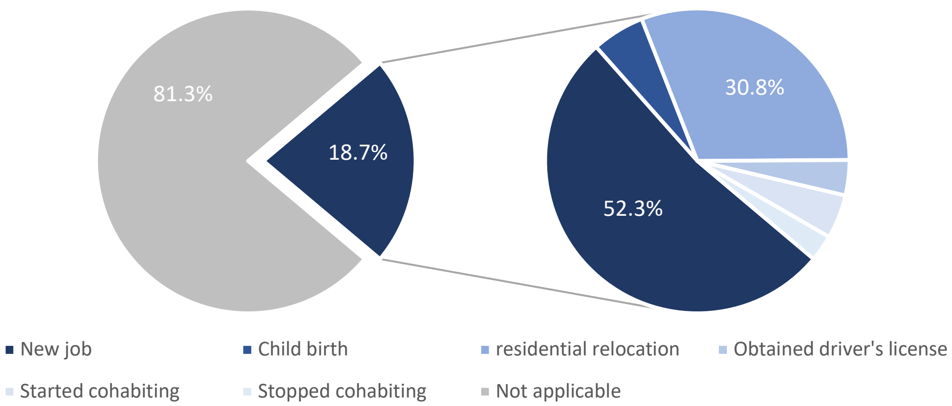

Figure 29: Occurrence life-changing events in the past year.

To find the effect of car habits on mobility choice behaviour, respondents are also asked about their car habits. As explained before in Section 2.2.2., the Self-Report Habit Index (SRHI) is used as the measurement method for finding the car usage habit strength. Figure 29 gives the final results of this measurement. Figure 30 indicates that the car usage habit strength is not significantly lower if life-changing events occur in the past year, it even suggest otherwise as the group which experience life-changing events scores percentage-wise higher than the group that did not experience life-changing events. These results are not in line with literature, as literature states that the habits of individuals that experience life-changing events get interrupted making them reconsider their mobility behaviour (Haustein & Kroesen, 2022).

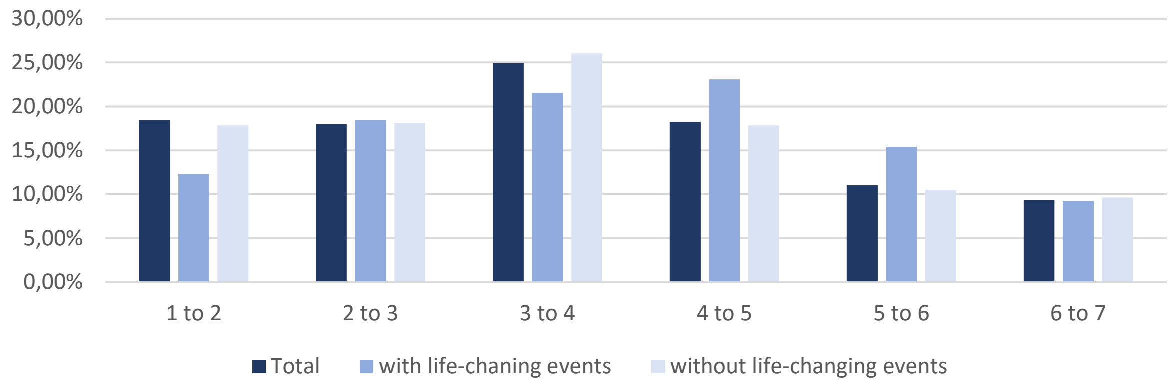

Figure 30: Car habit strength versus the percentual number of respondents.

<u>*Flanking policies*</u>

In the survey, respondents were asked to indicate their support for eight different flanking mobility policies. Besides, respondents who own a car were asked to state how their car usage behaviour would change if these measures were implemented. Figure 31 describes the general support of the flanking policies. From this table, it can be concluded that, in general, individuals are most opposed to policies related to parking. This includes less parking spaces and higher parking fees. The introduction of pay for use (toll roads) is the third most opposed policy. Therefore, it can be concluded that an increasement of monetary costs for individuals could lead to more resistance. This is in line with literature, as these policies can be categorized as push measures, which receive usually more resistance (Foltýnová et al., 2020; Hoerler et al., 2023; Melkonyan et al., 2022). On the other hand, the introduction of 30 km/h zones is mostly supported by individuals. The distribution of shared mobility vouchers and the introduction of zero-emission zones are supported as well. The acceptance and support of these measures can be related to the smaller direct impact on car usage behaviour of these measures. With the introduction of 30 km/h zones, individuals can still use their car and lowered speed may even lead to more safety. Handing out shared mobility vouchers is a pull measure, which are generally more accepted as stated in literature (Foltýnová et al., 2020; Hoerler et al., 2023; Melkonyan et al., 2022). A factor analysis is used to test whether support of or resistant to a certain policy would predict the view on other policies. However, this factor analysis turned out to be not significant.

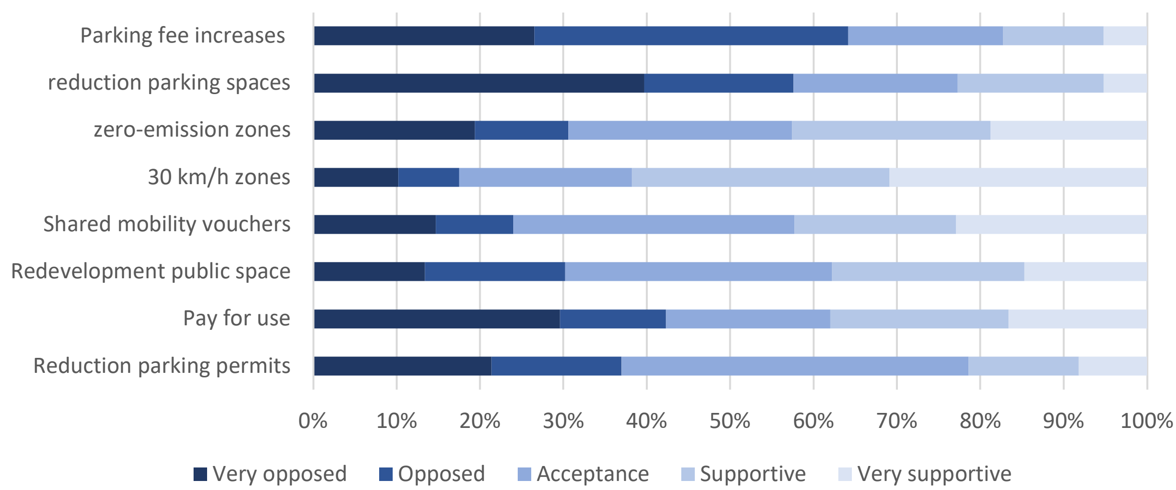

Figure 31: Policy support within sample.

It is interesting to test whether there is a difference between the policy support of car owners and non-car owners. Figure 32, shows these differences. From this figure, it becomes optically clear that for all flanking policies, non-car owners are less opposed and more supportive than car owners. The only policy for which the differences are small, is pay for use (toll). This is also the policy non-car owners are most opposed to compared to the other flanking policies. These optical findings are also confirmed by an independent samples t-test (Tables H1 and H2 Appendix H). This test indicates a significant difference in policy support between car- and non-car owners except for the pay for use measurement, which has a p-value of 0.209 indicating no significant difference between the two groups. It was expected that non-car owners would be more supportive as their behaviour is less impacted.

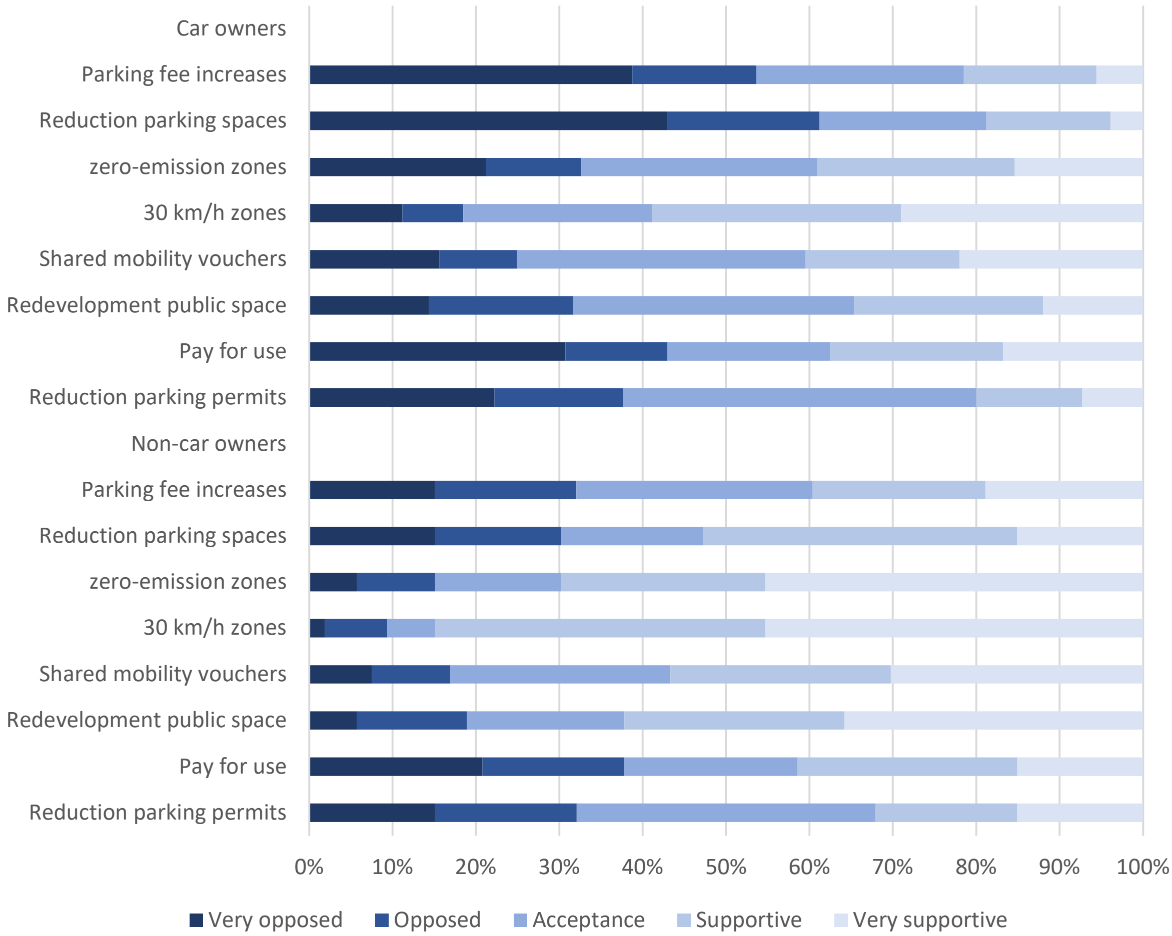

Figure 32: Policy support of car owners versus non-car owners.

Figure 33 shows the self-stated behaviour change of car owners, so how individuals assess their car behaviour change. From this figure, it can be concluded that individuals mainly believe their behaviour would not change or slightly change towards using their car less often. The policy which has the highest potential for behaviour change towards less car usage, based on self-reporting, is implementing pay for use (toll). This is in line with literature, Measures where costs are increased have a push effect and push effects are identified as being most effective in changing behaviour (Foltýnová et al., 2020; Hoerler et al., 2023; Melkonyan et al., 2022). The measurement which has the least potential for behaviour change towards less car usage, is implementing 30 km/h zones. Implementing 30 km/h zones is, on the other hand, the measurement which is supported most by car-owners.

This is also in line with literature, which shows that policies which require a small behaviour change, are supported most by individuals (Foltýnová et al., 2020; Hoerler et al., 2023; Melkonyan et al., 2022). Surprisingly, only approximately 30% of the respondents indicate that they would use their car less, or not at all, when zero-emission zones are implemented. As a large part of the respondents live in urban areas, and approximately 70% of the respondents drives fuel-driven cars (Figures 18 and 23) it is expected that this percentage would actually be higher in practice.

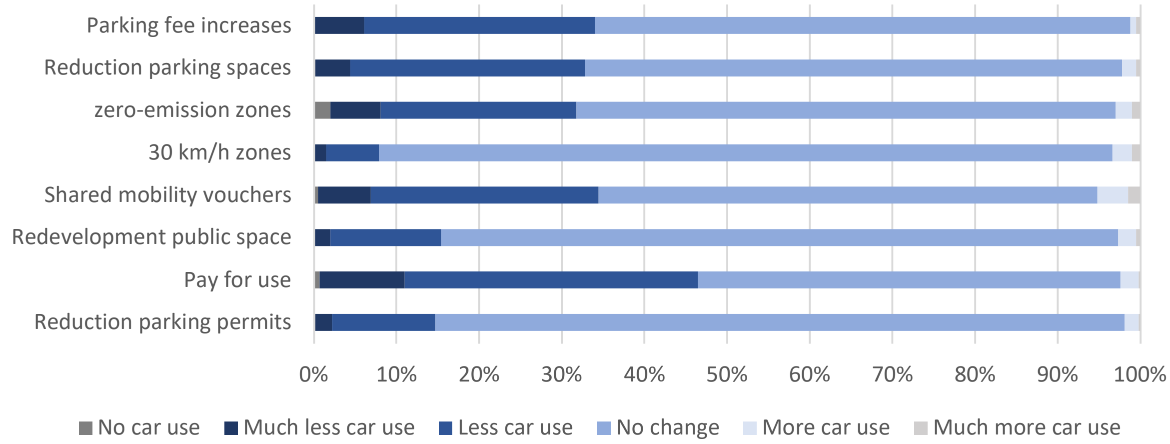

Figure 33: Self-stated behaviour change car owners versus flanking policies.

Habit strength versus policy support

Based on the literature study and experts interviews, it is expected that car-owners with a high car habit strength are more opposed towards policies that have a higher likelihood to change their car usage. To test this, a Pearson correlation test is used to check the relation between habit strength and policy support. Table 18 shows that there is a relationship between habit strength and policy support for most flanking policies, only implementing zero-emission zones is not significant. The significant values are rather small, which indicates a weak relationship (closer to 0 indicates a weak relationship and closer to 1 indicates a strong relationship). All significant values are negative, indicating that a low value for the habit strength would result in a high value for supporting the policy, which was also expected. However, as the relationships are rather weak, it cannot be stated if the effects of habit strength on policy support have practical implementations.

Table 18: Habit strength car-users versus policy support car-owners.

	Habit strength	
Policy	Pearson correlation	Sig.
Parking fee increases	-0.202	<0.001
Reduction parking spaces	-0.233	<0.001
Zero-emission zones	-0.096	0.053
30 km/h zones	-0.214	<0.001
Shared mobility vouchers	-0.156	0.002
Redevelopment of public space	-0.155	0.002
Pay for use	-0.199	0.016
Reduction parking permits	-0.121	0.015

4.3.2. Model results

This section describes the results of the MNL model and the LCM, without and with class membership. The MNL model and LCM are ran using Nlogit as a statistical software package. The class membership statistics are added using SPSS.

Multinomial Logit Model

Table 19 provides the MNL model output. All main effects are described in this table. Only the significant interaction effects are shown in the table. The complete Nlogit output can be found in Appendix I.

Table 19: Results multinomial logit model.

Main effects			
Attribute	Level	β	Sig.
Usual mode of transport		2.02927	***
Car owners' usual mode of transport		0.75672	***
Mobility modes available	Micro-mobility (base)	-	-
	Micro-mobility and shared car	1.50143	***
	Micro-mobility, shared car and bus connection	1.39793	***
	Micro-mobility and bus connection	1.05708	***
Additional amenities	No amenities present (base)	-	-
	Parcel lockers, medicine lockers and laundry machines	0.10149	n.s.
	Café, flex office and child daycare	- 0.44004	***
	Bike-repair shop, supermarket and gym	0.32756	**
Environment characteristics	No environment characteristics present (base)	-	-
	Greenery and guarded bike parking	-0.32735	**
	Greenery and smart lighting	0.76685	***
	Guarded bike parking and smart lighting	0.41194	***
Travel time relative to own mode of transport		-1.79718	***
	-10%	0.17918	
	0%	0.00000	
	+10%	-0.17918	
	+20%	-0.35944	
Travel costs relative to own mode of transport		-2.89813	***
	-50%	1.44907	
	-25%	0.72453	
	0%	0.00000	
	+25%	-0.72453	
	+50%	-1.44907	
Significant interaction effects			
Level 1	Level 2	β	Sig.
Micro-mobility and shared car	Parcel lockers, medicine lockers and laundry machines	-0.45816	***
Micro-mobility and shared car	Café, flex office and child daycare	0.58664	***
Micro-mobility and shared car	Bike-repair shop, supermarket and gym	-1.17816	***
Micro-mobility and shared car	Greenery and smart lighting	-1.04476	***
Micro-mobility and shared car	Guarded bike parking and smart lighting	-0.88721	***
Micro-mobility, shared car and bus connection	Café, flex office and child daycare	0.52753	***
Micro-mobility, shared car and bus connection	Bike-repair shop, supermarket and gym	-0.33043	**
Micro-mobility, shared car and bus connection	Greenery and guarded bike parking	-0.75168	***

Significant interaction effects			
Level 1	Level 2	β	Sig.
Micro-mobility, shared car and bus connection	Guarded bike parking and smart lighting	-0.30996	***
Micro-mobility and bus con.	Café, flex office and child daycare	0.66974	***
Micro-mobility and bus con.	Greenery and guarded bike parking	-0.39264	***
Micro-mobility and bus con.	Greenery and smart lighting	-0.72093	***
Micro-mobility and bus con.	Guarded bike parking and smart lighting	-0.85300	***
Greenery and guarded bike parking	Parcel lockers, medicine lockers and laundry machines	0.41964	***
Greenery and guarded bike parking	Bike-repair shop, supermarket and gym	0.40913	***
Greenery and smart lighting	Bike-repair shop, supermarket and gym	-0.62460	***
Significant trip purpose (interaction) effects			
Trip purpose	Attribute / level	β	Sig.
Work or education	Micro-mobility and shared car	-0.35505	***
Work or education	Micro-mobility, shared car and bus connection	-0.41706	***
Work or education	Micro-mobility and bus connection	-0.26642	**
Work or education	Travel time compared to own mode of transport	-1.35069	***
	-10%	0.13507	
	0%	0.00000	
	+10%	-0.13507	
	+20%	-0.27014	
Work or education	Travel costs compared to own mode of transport	0.66539	***
	-50%	-0.33267	
	-25%	-0.16635	
	0%	0.00000	
	+25%	0.16635	
	+50%	0.33267	
Family or friends visit	Micro-mobility and shared car	-0.24334	**
Family or friends visit	Micro-mobility, shared car and bus connection	-0.33401	***
Family or friends visit	Micro-mobility and bus connection	-0.33111	***
Model fit statistics			
LL (β)		-14405.06	
LL (0)		-21699.79	
ρ^2		0.336	
Likelihood ratio test (LRS)	X^2	4134.36	
	df (K-constants-1)	60	
	Critical X^2	79.082	
Note: *** $p < 0.01$; ** $p < 0.05$; n.s. = not significant			

The MNL model can be used to get a first impression of the variables influencing travel mode choice behaviour. The MNL model described in Table 19 is significant, as X^2 is larger than the critical Chi-square value for the degrees of freedom (df) of this model. The MNL model has a McFadden Rho-Square value (ρ^2) of 0.336. For an acceptable fit, this value should at least be between 0.2 and 0.4. Therefore, this model provides an adequate explanation and can give a first impression of the attributes influencing travel mode choice behaviour. Variables are considered significant when the p-value is <0.05. Figure 34 and 35 show the part-worth utilities per variable, allowing easy comparisons. Dummy coded variables need to be compared with the base-level of that specific attribute. For the numeric variables (absolute values), the part-worth utilities can be multiplied with the absolute value to find the influence of a specific level, as a linear relationship is assumed between the levels.

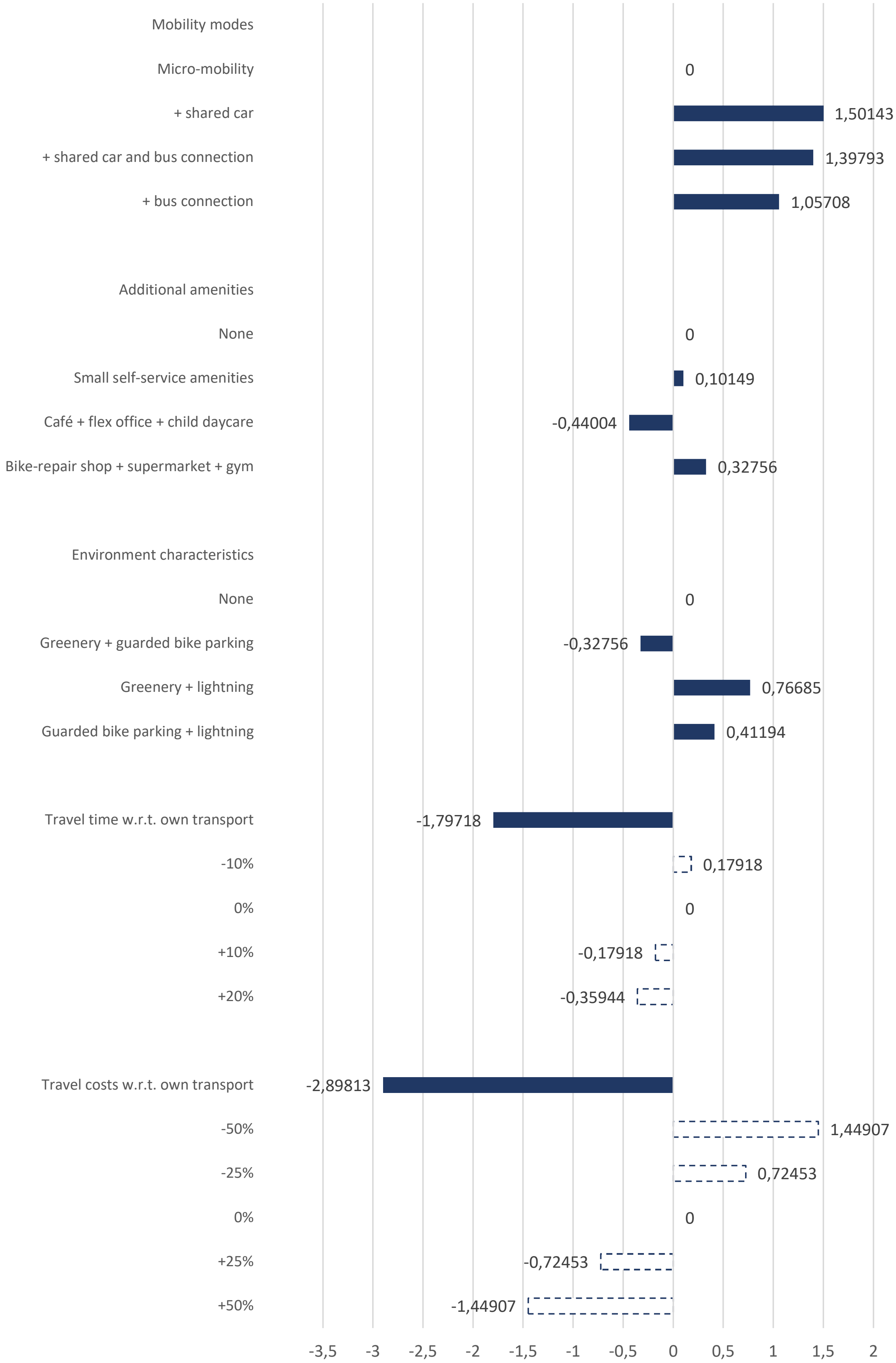

Figure 34: Part-worth utilities of main effects attributes MNL model.

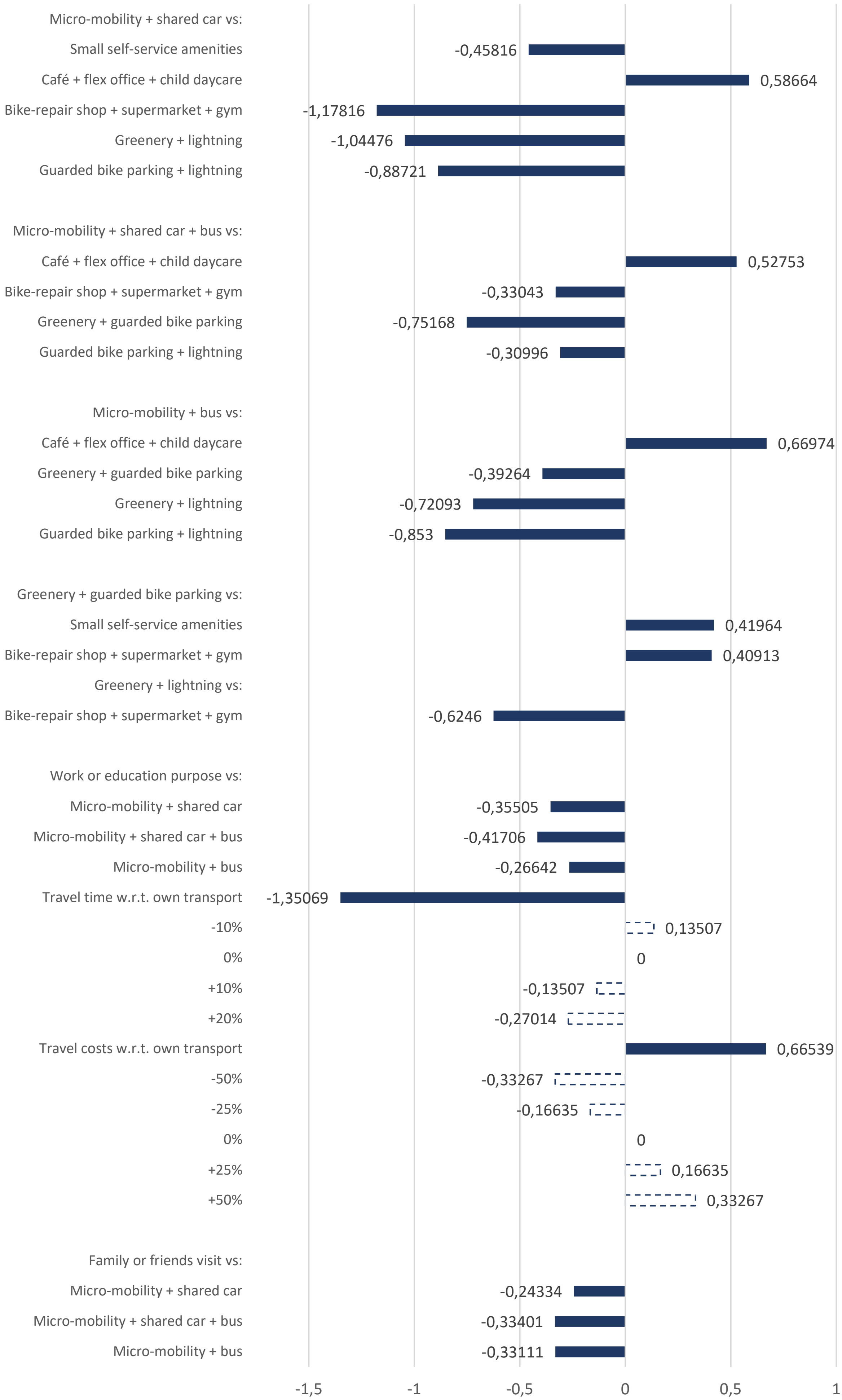

Figure 35: Part-worth utilities of interaction effects attributes MNL model.

Main MNL effects

Respondents were asked to choose between travelling by one of the mobility hubs or travelling by their usual mode of transport. The usual mode of transport variable (constant) has a large significant value, indicating that most respondents choose to travel by their usual mode of transport. Car owners' usual mode of transport (car constant) also has a positive significant value, which indicates that respondents that own a car, also often choose to travel by their usual mode of transport. Within the main effects, there is one value larger than the usual mode of transport value: travel costs relative to own mode of transport. The travel costs value is negative, indicating that if the travel costs for travelling by modes offered at a hub are lower than the travel costs for individuals' usual transport mode, individuals are more likely to travel via a hub. So, travel costs is an important determining factor. Next to costs, travel time also has a large negative significant value. Indicating that if travelling via a hub is faster than the own transport mode, this increases the likelihood of individuals travelling by modes offered at a hub. The travel time value is quite large, indicating that this is an important determining factor too.

All available mobility modes levels have a positive significant effect, indicating that adding a shared car or bus connection next to the micro-mobility options increases the attractiveness of the hub. Comparing the different levels of the available mobility modes at the hub, it can be noted that the hubs which offer a shared car and micro-mobility has the highest value. The option which offers both a shared car and bus connection has a lower value than the option which only offers an additional shared car. Based on this, it could be stated that offering a shared car at a mobility hub increases the attractiveness of the hub the most.

The additional amenities offered at the hub have small positive or negative values of which the option with small self-service functions (parcel lockers, medicine lockers, and laundry machines) is not significant. These small effects indicate that the effect of only adding amenities to the base hub is small. Adding the combination of a community café, flex offices and child daycare has a negative effect and adding a gym, supermarket and bike repair shop has a slightly positive effect.

The environmental characteristics that can be added to the hub have significant positive or negative values. Adding the combination of green and a guarded bike parking (noted that a non-guarded bike parking is always present) has a negative effect. The other two combinations have a positive effect. Based on this, it could be stated that smart lighting is the main factor creating a positive effect.

Interaction MNL effects

Next to the significant main effects, there are also significant interaction effects. First of all, it can be noted that combining the available mobility modes with the possible amenities combinations, leads to negative significant values for self-service functions and the combination of supermarket, gym and bike repair shop. However, combining the mobility modes with a community café, flex offices and child daycare leads to a significant positive interaction effect. To give an example, combining micro-mobility and a shared car with a café, flex offices and child daycare leads to a value of 1.64803 (1.50143 – 0.44004 + 0.58664). This value is higher than only implementing one of these attributes alone, indicating that it adds value to offer these attributes together.

Besides, the environment characteristics have a significant negative effect when combined with the mobility modes alternatives. Surprisingly, almost all of these effects have a larger negative value than the positive main effect value for these attributes. Indicating it is not beneficial to implement lighting, greenery or a guarded bike parking. It was not expected that the environment attributes would have negative effects, as the interviewees indicated that environmental attributes influence the perceived quality and comfort of a hub and may influence the feeling of safety. Only combining the option micro-mobility, shared car and bus connection with a guarded bike parking and smart lighting would be beneficial, leading to a value of 1.49991 (-0.30996 + 0.41194 + 1.39793). This value is higher than implementing one of these attributes on its own, implying that it is beneficial to combine this attributes together.

It can be noted that the values of the part-worth utilities of the interaction effects are still lower than the value for the usual mode of transport. This indicates that a hub also needs to be either faster than the usual mode of transport, or cheaper. If that is the case, the individuals can be tempt to use mobility modes offered at a mobility hub.

Trip purpose MNL effects

Lastly, the trip purpose also has an influence on mobility mode choice behaviour. Combining the dummy coded trip purposes with the mobility modes leads to small significant negative effects. The base level is the trip purpose "day trip". Therefore, these negative effects indicate that individuals would rather use these modes when going on a day trip than travelling to work, education, friends or family. Further, when combining the trip purpose "work or education" with travel time and travel costs, this leads to significant values. The work (or education) combined with travel time effect has a negative value, indicating that if the hub is faster, travelling by a hub is more likely. The work (or education) combined with travel costs has a positive value, indicating that even if a hub is more expensive, travelling by a hub is still desired when going to work or school. This could be explained by students having a free public transport card and individuals travelling to work often getting travel reimbursements. Therefore, the costs for travelling by modes offered at mobility hubs are often not covered by the individual using the mode for these trip purposes.

Summary MNL model

The MNL model gives a first insight into the effect of certain attributes on the attractiveness of mobility hubs. The MNL model shows that costs and time are the main determining attributes. The availability of shared cars or a bus connection, next to the micro-mobility modes, is a determining factor too. Offering a combination of amenities or environmental attributes, has mixed small effects. Only combining a café, flex offices, and child daycare with one of the mobility mode alternatives seems to have a significant positive effect. Further, it becomes clear that the mobility modes offered at a hub are mostly preferred when going on a day trip. Lastly, it can be stated that the travel costs aspect is not considered as important when individuals are travelling to work. The MNL results are mostly in line with the expected findings, only the negative effect of environment characteristics was not expected. Altogether, the MNL results are considered promising for the LCM analysis.

Latent Class Model

The MNL model gave an insight into general mobility mode preferences. As an addition to this, LCM's can explore whether subgroups with comparable preferences for mobility mode choice exist within the sample. Table 20 gives an overview of the model performance statistics for running the LCM's with different numbers of classes. The LCM's were estimated up to five classes with 150 iterations, however, only the models with two and three classes turned out to have significant results. The model with four classes turned out to be already singular at 100 iterations and the model with five classes turned out to be too large to run in Nlogit. The models with two and three classes have desirable values for the McFadden ρ^2 and adjusted McFadden $\rho^2_{adjusted}$ ranging between 0.490 and 0.529 indicating a better goodness of fit compared to the MNL model (ρ^2 of 0.336). Next to this, both LCM's have a lower AIC and BIC value than the MNL model, which indicates a better model performance as well.

Table 20: Overview model fit statistics MNL and LCM.

Model fit statistics		2 classes	3 classes	4 classes	5 classes	MNL
LL(β)		-11030.95	-10224.05	Error: model is singular at 100 iterations	Error: model has too many parameters	-14405.06
LL(0)		-21699.79	-21699.79			-21699.79
ρ^2		0.4917	0.5288			0.336
$\rho^2_{adjusted}$		0.4900	0.5266			-
Likelihood ratio test	X^2	21337.69	22951.48			4134.36
	K	127	191			63
	Critical X^2					
AIC		22315.9	20830.1			28936.1
BIC		22607.44	21268.56			29080.74
Class prob.	1	0.45676	0.37064			
	2	0.54324	0.29973			
	3		0.32963			

Based on the adjusted McFadden $\rho^2_{adjusted}$, AIC and BIC values, it can be stated that the model with three classes performs best. For this model, the class probabilities are almost evenly distributed. Besides, the model with two classes contains one class with an extremely high value (>7) for the usual mode of transport variable which is not desirable. The model with three classes will be elaborated in more detail and is given in Table 21. Appendix J shows the complete Nlogit output for the three-classes LCM. The classes are determined based on the preferences and utilities of the hub attributes and trip purposes. Again a linear relationship is assumed between the levels of the costs and time attributes.

Table 21: Result latent class model with three classes.

Main effects Attributes and levels	Class 1 β		Class 2 β		Class 3 β	
Usual mode of transport	4.62669	***	2.54901	***	0.43767	**
Car owners usual mode of transport	1.92971	**	-0.89832	***	2.10580	***
Mobility modes available						
Micro-mobility (base)	-	-	-	-	-	-
Micro-mobility and shared car (mob1)	-2.69829	n.s.	1.75180	***	1.57304	***
Micro-mobility, shared car and bus connection (mob2)	-5.40009	n.s.	1.30332	***	1.63326	***
Micro-mobility and bus connection (mob3)	0.55077	n.s.	0.85781	***	0.97882	***

Main effects Attributes and levels	**Class 1** β		**Class 2** β		**Class 3** β	
Additional amenities						
No amenities present (base)	-	-	-	-	-	-
Parcel lockers, medicine lockers and laundry machines (self-service) (fac1)	-3.65821	n.s.	0.38395	*	-0.31027	n.s.
Café, flex office and child daycare (fac2)	-9.71594	n.s.	0.71163	***	-0.52052	*
Bike-repair shop, supermarket and gym (fac3)	-3.54078	n.s.	1.16120	***	0.08326	n.s.
Environment characteristics						
No environment characteristics present (base)	-	-	-	-	-	-
Greenery and guarded bike parking (env1)	-11.9581	n.s.	0.35201	n.s.	-0.01541	n.s.
Greenery and smart lighting (env2)	1.20538	n.s.	1.16120	***	0.28613	n.s.
Guarded bike parking and smart lighting (env3)	-11.3834	n.s.	0.28674	n.s.	0.10586	n.s.
Travel time relative to own mode of transport	10.8694	n.s.	-3.37961	***	-1.79006	***
-10%	-1.08694	-	0.33796	-	0.17901	-
0%	0.00000	-	0.00000	-	0.00000	-
+10%	1.08694	-	-0.33796	-	-0.17901	-
+20%	2.17388	-	-0.67592	-	-0.35802	-
Travel costs relative to own mode of transport	-7.02065	*	-4.44356	***	-3.20405	***
-50%	3.51033	-	2.22178	-	1.60203	-
-25%	1.75516	-	1.11089	-	0.80101	-
0%	0.00000	-	0.00000	-	0.00000	-
+25%	-1.75516	-	-1.11089	-	-0.80101	-
+50%	-3.51033	-	-2.22178	-	-1.60203	-
Significant interaction effects Level combinations	**Class 1** β		**Class 2** β		**Class 3** β	
Mob1 x fac2			0.69081	***	1.02590	***
Mob1 x fac3			-1.45707	***	-0.83066	***
Mob2 x fac2					0.59017	**
Mob3 x fac2					0.89775	***
Mob1 x env1			-1.04462	***	-0.44437	**
Mob1 x env2			-0.98558	***		
Mob1 x env3			-0.61356	***	-1.05321	***
Mob2 x env1			-0.80731	***		
Mob3 x env2			-0.79083	***		
Fac2 x env1			-1.04462	***		
Fac2 x env2			-0.98558	***		
Fac2 x env3			-0.61356	***		
Fac3 x env1					0.64251	***
Fac3 x env2			-1.74553	***	-0.71515	***
Significant trip purpose (interaction) effects Trip purpose and level combination	**Class 1** β		**Class 2** β		**Class 3** β	
Work or education x mob1			-0.36394	**	-0.72226	***
Work or education x mob2			-0.50777	***	-0.81117	***
Work or education x mob3			-0.42474	**		
Work or education x env1					-0.39096	**
Work or education x travel time			-1.71030	***		
-10%			0.17103	-		
0%			0.00000	-		
+10%			-0.17103	-		
+20%			-0.34206	-		

Significant trip purpose (interaction) effects Trip purpose and level combination	**Class 1** β		**Class 2** β		**Class 3** β	
Work or education x travel costs			1.10858	***	1.22709	***
-50%			-0.55429	-	-0.61355	-
-25%			-0.27715	-	-0.30677	-
0%			0.00000	-	0.00000	-
+25%			0.27715	-	0.30677	-
+50%			0.55429	-	0.61355	-
Using usual mode of transport to visit friends or family			-0.60765	***	0.50983	**
Family or friends x mob2			-0.37836	**		
Family or friends x travel time			-1.17485	**		
-10%			0.11749	-		
0%			0.00000	-		
+10%			-0.11749	-		
+20%			-0.23497	-		
Estimated class probabilities	**0.37064**	***	**0.29973**	***	**0.32963**	***
Note: *** p < 0.01 ; ** p < 0.05 ; * p < 0.1 ; n.s. = not significant						

Table 23 gives an overall insight into the three classes of the LCM. It can be observed that the first class is not interested in using a mobility hub. The usual mode of transport (constant) value and usual mode of transport for car owners value ("car constant") are quite high and significant. Besides, no other variables are significant, indicating that this group does not consider travelling by a hub. The second class has a lower significant usual mode of transport value, but still quite high, indicating that in this class individuals are still using their usual transport mode often. However, the usual mode of transport for car owners value is negative, indicating that individuals owning a car in this group mostly choose to travel by a hub. Next to the usual mode of transport values, a lot of hub attributes have a significantly positive or negative value, making it possible to examine which attributes could persuade individuals to use a hub. The last group, class three, has a quite low significant positive usual mode of transport value ($p < 0.05$). This indicates that most individuals in this group do use their usual mode of transport, however, are easily persuaded to travel by a hub, as already the value of the mobility modes offered at the hub is higher than the value for the usual mode of transport. On the other hand, the usual mode of transport for car owners has a significant high positive value. This indicates that the individuals that own a car in this class are most likely to use their usual mode of transport. Car owners in this group are less easily persuaded to travel by a mobility hub.

Figure 36 and 37 show the part-worth utilities per attribute level for all main effects and the significant interaction effects, making it easier to compare the decision-making of the three classes. Based on these part-worth utilities, detailed insights into the travel mode choices of the individuals in this group can be discovered leading to a more comprehensive understanding of the decision-making process. These detailed insights will be explained next for each class.

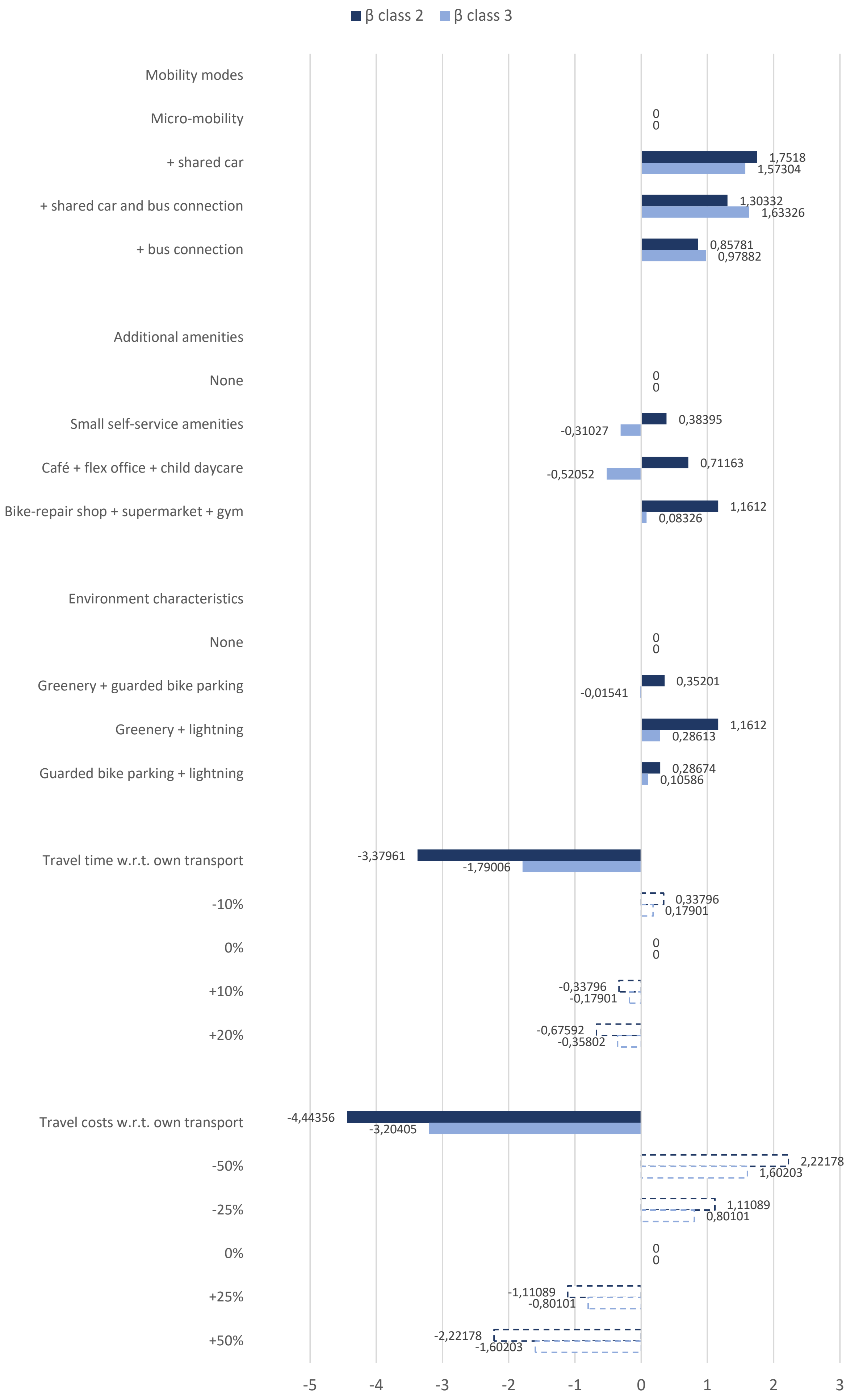

Figure 36: Part-worth utilities of main effects attributes LCM second and third class.

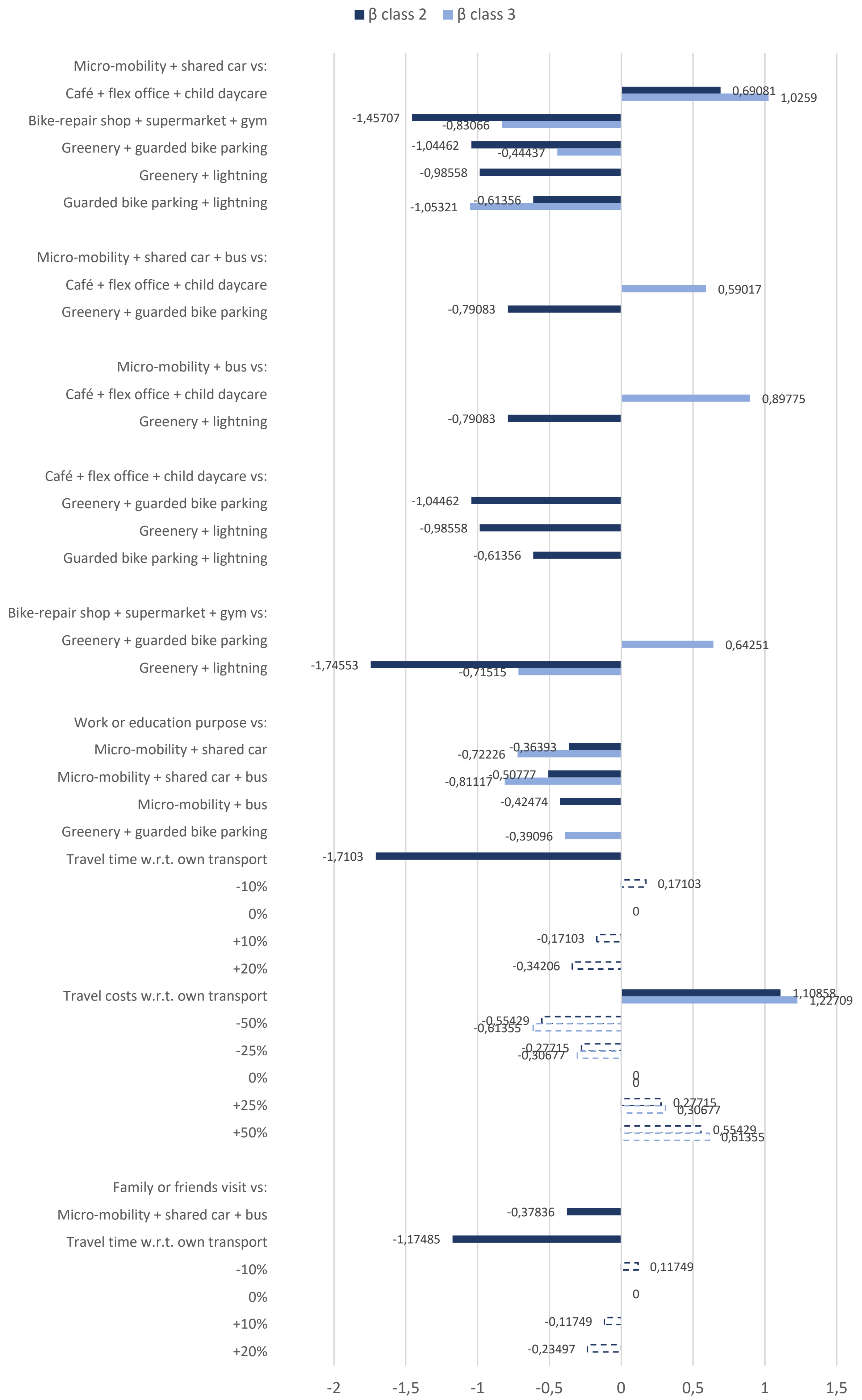

Figure 37: Part-worth utilities of interaction effects attributes LCM second and third class.

Class 1

The first class is the largest and chooses to travel by their usual mode of transport, which is indicated by a high significant positive value for the usual mode of transport. Also individuals owning a car in this class choose to travel by their usual mode of transport (significant positive value). All other variables are not significant for this class, making in it impossible to indicate which aspects influence their choice behaviour. This group therefore can be labelled as rigid usual transport mode users, who can hardly be triggered to travel by a mobility hub.

Class 2

The second class is more inclined to consider travelling by modes offered at a mobility hub. This group still has a quite high significant positive value for the usual mode of transport, which indicates that this mode is still mostly chosen. However, individuals owning a car in this class mostly travel by a hub, which is indicated by a negative value. Travel time and travel costs both have a significant negative value larger than the usual mode of transport value. This indicates that if travelling by a hub is cheaper and/or faster than using the usual mode of transport, individuals choose to travel by modes offered at a hub. As travel costs and travel time have the largest values, these are the most determining factors for class 2. Besides, class 2 members value the option to travel by a shared car, as the mobility hub which offers a shared car has the highest value compared to the other mobility modes alternatives. A bus connection also increases the attractiveness of hubs for this class. Furthermore, adding the combination of a café, flex offices, and child daycare, or the combination of a supermarket, gym, and bike-repair shop increases the attractiveness of hubs. However, the path-worth utilities of these combinations are smaller than the usual mode of transport value. Therefore, only adding these facilities would not always lead to individuals choosing to travel by a hub. Lastly, the combination of greenery and smart lighting increases the attractiveness of hubs as well.

The interaction effects give additional insights. All environment characteristics have a negative value as interaction. Only combining greenery and smart lighting still has a positive value overall, as the values of the interaction effects are smaller than the values of the main variables effects. For example, combining these with hubs offering a shared car still leads to a positive value of 1.927 (1.752 + 1.161 – 0.986). It does not add value to implement a guarded bike parking. Furthermore, combining micro-mobility and a shared car with a café, flex offices, and child daycare has a positive added value. Combining these aspects even leads to a higher positive value than the value for the usual mode of transport (1.752 + 0.712 + 0.691 > 2.550). This indicates that for this class, this combination should result in most of the class members travelling by a mobility hub. Combining micro-mobility and a shared car with a supermarket, gym and bike-repair shop has a significant negative value but still leads to an overall positive value (1.752 + 1.161 – 1.457 = 1.456), showing that this combination is possible but does probably not lead to the desired behaviour on a large scale.

Trip purposes influences travel mode decision-making as well. Class 2 members would rather use modes offered at hubs for day trips than travelling to work or educational purposes, hence the negative values for these attributes. Furthermore, travelling faster is of more importance when travelling for work, education, or family or friend visits, than for day trips (negative values). Lastly, for work or educational purposes, travelling by modes offered at a hub is still desired even if this is more expensive (positive value).

Class 3

Compared to the other classes, this class is the most inclined to travel by a hub, as the value for the usual mode of transport is the closest to zero. However, car owners in this class attach a high value to using their usual mode of transport. All main mobility attributes have a higher positive significant value than the constant value, indicating that offering a shared car and/or implementing a bus connection would already result in class members travelling via the hub. The most important determinants of travel choice behaviour are again travel time and travel costs. The hub is used if it is faster or cheaper than the usual mode of transport.

Considering the interaction effects, implementing the combination café, flex office, and child daycare with one of the mobility modes has a significant positive effect, making the hub more attractive. The environment characteristics have a negative influence when combined with other attributes except for combing a supermarket, gym, and bike-repair shop with a guarded bike parking and smart lighting. Therefore, implementing greenery, lighting or a guarded bike parking does not add value. Lastly, in line with class 2, costs are not considered as an obstructing factor when travelling for work or education by the class members.

Summary LCM

The LCM model with three classes has the best model fit statistics and performs better than the MNL model. A clear difference is notable between the first class and the other two classes. The first class is not considering travelling via a mobility hub, indicated by a high significant value for the usual mode of transport. The other two classes are inclined to travel via mobility hubs, if this is more beneficial. Individuals owning a car in class 2 are more inclined to use hubs than individuals owning a car in class 3. In the third class, the overall value for the usual mode of transport is quite low, indicating that respondents are easily convinced to travel by mobility hubs. Overall, class 2 and 3 members can be tempted to use hubs if it is faster, cheaper or favourable facilities are present. Costs are not considered as an obstructing factor when travelling for work or educational purposes.

Socio-demographics of the LCM classes

In the previous section, the results of the LCM with three classes excluding socio-demographic characteristics is described. In this section, socio-demographic characteristics are linked to the three classes using a tree classification model and bivariate analyses in SPSS. As the LCM ran in Nlogit is already quite large, it is chosen to not add the socio-demographics and other respondent related attributes, such as environmental awareness, in the Nlogit model, as these then would turn out to be not significant or the model could not run sufficient iterations. A tree model can give insights into what contributes to belonging in a certain class, while the LCM indicates what best explains the choices made by respondents. In addition to the three model, significant bivariate analyses can give insights into class memberships as well. So, the results of the tree model and bivariate analyses can give insights into the socio-demographic aspects that describe belonging to a certain class, but not into socio-demographic aspects influencing choice behaviour.

Tree classification model

A tree classification model, available in SPSS, is used to determine which respondent-related variables best predict the assignment of respondents to a certain class as this model identifies which variable best predicts the likelihood of belonging to a class. In the model, class membership is the dependent variable, and socio-demographic variables, urbanity levels, environmental awareness, car ownership, habit strength, and the occurrence of life-changing events are the independent variables. Figure 38 shows the results of this tree model classification, which indicates that household composition best predicts class membership. In the first class, the majority are families with children. In the tree model, household composition is the only significant variable.

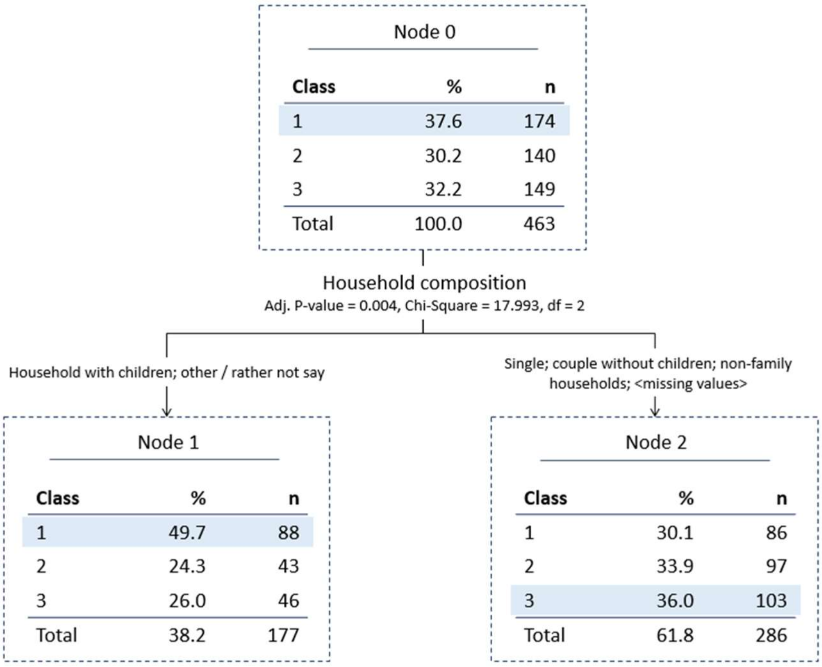

Figure 38: Tree classification model output SPSS.

Bivariate analyses

In addition to the tree model, bivariate analyses are conducted in SPSS. In the bivariate analyses, respondent-related attributes are tested one-by-one to class membership. There are only two variables which have a significant relationship with the dependent variable class membership: household composition (in line with the tree model) and age. Table 22 gives an overview of these significant relationships. Figures 39 and 40 visualize the distribution of respondents over the classes based on their age and household composition.

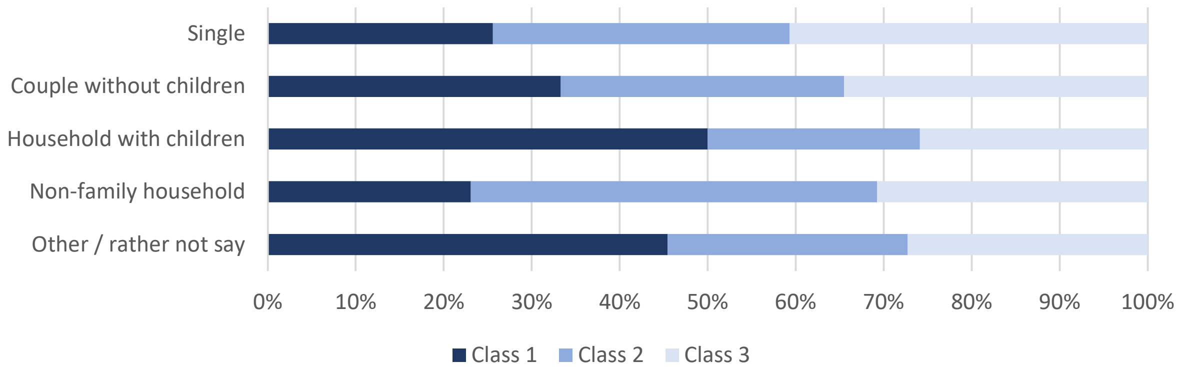

Figure 39: Respondents placed in classes based on their household composition.

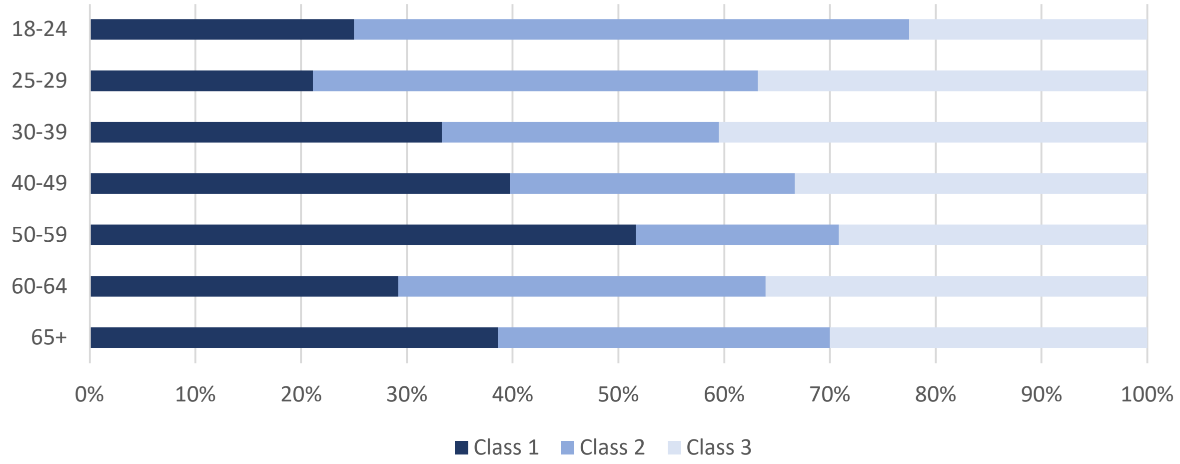

Figure 40: Respondents placed in classes based on their age.

Table 22: Overview age and household composition versus class membership.

Class		Age							
		18-24	25-29	30-39	40-49	50-59	60-64	65+	Total
1	Count	10	8	14	31	62	21	27	173
	% within class	5.8	4.6	8.1	17.9	35.8	12.1	15.6	100
	% within age	25.0	21.1	33.3	39.7	51.7	29.2	38.6	37.6
2	Count	21	16	11	21	23	25	22	139
	% within class	15.1	11.5	7.9	15.1	16.5	18.0	15.8	100
	% within age	52.5	42.1	26.2	26.9	19.2	34.7	31.4	30.2
3	Count	9	14	17	26	35	26	21	148
	% within class	6.1	9.5	11.5	17.6	23.6	17.6	14.2	100
	% within age	22.5	36.8	40.5	33.3	29.2	36.1	30.0	32.2
					X^2	**29.809**	**df=12**		**p = 0.003**

Class		Household composition (h.c.)					
		Single	Couple	Kids	Non-family	Other	Total
1	Count	22	57	83	6	5	173
	% within class	12.7	32.9	48.0	3.5	2.9	100
	% within h.c.	25.6	33.3	50.0	23.1	45.5	37.6
2	Count	29	55	40	12	3	139
	% within class	20.9	39.6	28.8	8.6	2.2	100
	% within h.c.	33.7	32.2	24.1	46.2	27.3	30.2
3	Count	35	59	43	8	3	148
	% within class	23.6	39.9	29.1	5.4	2.0	100
	% within h.c.	40.7	34.5	25.9	30.8	27.3	32.2
				X^2	**21.752**	**df=8**	**p = 0.005**

From Table 22, it can be concluded that 50% of the families with children belong to the first class. Besides, approximately 40% of the 40- to 49-year-olds and approximately 52% of the 50- to 59-year-olds belong to class 1 as well. The latter group is largely overrepresented in the sample. Therefore, the largest age group in the data sample belongs mostly to class 1. Besides, it can be concluded that approximately 46% of the respondents living in non-family households belong to class 2. Also, approximately 53% of the 18- to 24-year olds and approximately 42% of the 25- to 29-year-olds belong to the second class as well. The third class mostly consists of respondents who live alone (41%) or with a partner (35%). Lastly, approximately 41% of the 30- to 39-yearolds belong to the third class.

The overall relation between age and household composition has been tested and described in Section 4.3.1., showing the positive relation between the age groups 40- to 59 years old and the presence of children in the household. Besides, a positive relation between the age group 18-24 years old and respondents living in non-family households is indicated. Lastly, the relationship between age and household composition shows that 59.5% of the respondents between 30- and 39 years old are living alone or with a partner. The other 40.5% live in a household with children.

Classes with persona's

Based on the tree classification model and the additional significant bivariate analyses, socio-demographic variables can be used to identify persona's belonging to one of the three classes.

Class 1 – families with children living at home

The first class mainly consists of families with children living at home. Besides, mostly 40- to 59-year-olds respondents over the age of 65 are placed in this class. More than half of the largest age group in the sample (50-59 years old) belongs to this class. As stated before, class members stick to their usual mode of transport, which could be explained by the experienced hassle when travelling with children by other modes than the private car. A few respondents with children also left a comment in the questionnaire indicating this.

Class 2 – Students

The second class mainly consists of individuals who are living in non-family households. Besides, the respondents are mostly younger than 30 years old. Based on the results in Section 4.3.1., it can be stated that most individuals younger than 30 years live in (very) highly urbanized areas and have mostly up to a modal income. Based on these characteristics, it can be stated that students mostly belong to this class. This class has a high value for the usual mode of transport, which perhaps can be explained by younger individuals mainly living in highly urbanized areas, using their bicycles a lot. As stated before, class members can be pursued to use hubs, especially if this is faster and cheaper than travelling by the usual mode of transport. This can be explained by younger individuals having, generally, a lower income, which makes them consider transportation costs more. However, costs are not considered as an obstructing factor when travelling to work or education which could be explained by students having a free public transport card and work-related costs being covered by employers.

Class 3 – Young Urban Professionals

Respondents between the age of 30- and 39 years old, and respondents who are living alone or with a partner mainly belong to the third class. As stated before, 30- to 39-year-olds live mainly in highly urbanized areas and have an income which is higher than modal. Therefore, this group could be identified as Young Urban Professionals (YUP). As indicated before, this class can overall be easily convinced to make use of mobility hubs. Travel time and travel costs are the most important determinants of hub usage, however, this value is smaller than for the second class. This is can probably be explained by the fact that 30- to 39-year-olds have a higher income level than younger individuals.

Additional analysis classes

In order to answer the research questions in more detail, two additional analyses are conducted. First, the amenities that can be present at mobility hubs are analysed in more detail. Second, the flanking policies are discussed in relation to the class memberships to check whether certain policies could influence the behaviour of class members.

Amenities offered at hubs

In the questionnaire, respondents were asked to rank the individual amenities based on their perceived importance. Table 23 shows the average scores for each amenity. The scores are based on the ranking of respondents, where 1 indicated most important amenity and 9 indicated least important amenity. It can be concluded that a supermarket, parcel lockers and bike repair shop are the most relevant amenities to be present at a hub as indicated by the respondents. Especially a supermarket and parcel lockers add value, as these have very low average scores, which indicates that most respondents placed these in their top 3 amenities. Offering self-service laundry machines is indicated as the least important amenity. This could explain why the combination of parcel lockers, medicine lockers and laundry machines scores negatively in the SCE. Therefore, placing parcel and medicine lockers to a mobility hub could possibly stimulate hub usage. From Table 23, it also becomes clear that adding child daycare facilities to a hub is not beneficial as these are indicated as second to least important. It is surprising that this is also true for the first class, to which mostly families with children belong. Lastly, it can be stated that the ranking for the second and third class is in line with the total ranking. Only the first class deem a café more important than flex offices. This could be because to this class also a lot of 65-year-olds and over belong, which are mostly retired and therefore have no need for a flex office.

Table 23: Average amenities scores.

Amenities	Class 1		Class 2		Class 3		Total	
	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking
Supermarket	2.01	1	2.06	1	1.93	1	2.00	1
Parcel lockers	2.75	2	2.94	2	2.76	2	2.81	2
Bike repair shop	4.03	3	4.55	3	4.26	3	4.26	3
Medicine lockers	4.58	4	4.70	4	4.64	4	4.64	4
Flex office	5.91	7	5.10	5	5.29	5	5.34	5
Café	5.42	5	5.31	6	5.58	6	5.44	6
Gym	5.91	7	5.90	7	6.05	7	5.95	7
Child daycare	7.33	8	7.02	8	7.17	8	7.18	8
Laundry machines	7.40	9	7.43	9	7.31	9	7.38	9

Flanking policies

Next to the additional analysis for the amenities present at hubs. Flanking policies can be tested against the class memberships to check whether implementing certain measures could trigger less car usage, and potentially usage of mobility modes offered at mobility hubs. Therefore, the support of policies and self-stated car behaviour change is tested against the class memberships. Figures K.1 and K.2 in Appendix K show the policy support and self-stated car behaviour change for each class. Additionally, Figures K.3 and K.4 in Appendix K show these statistics for households with children and individuals over the age of 65 years, as these mostly belong to class 1 and are labelled as rigid travellers.

From Figure K.1 it can be concluded that all classes are most opposed to the parking policies and support the implementation of 30 km/h zones the most. Furthermore, it could be stated that class 1 is slightly more opposed to policies in general. This is in line with this class being rigid travellers, they are therefore the least supportive of measurements which try to change their behaviour. Analysing class 1 in more detail, Figure K.3 shows that individuals over the age of 65 years and families with children are also the most opposed to the parking measures and most in favour of implementing 30 km/h zones. Besides, households with children also support handing out shared mobility vouchers.

Based on Figure K.2, it can be stated that the pay for use and parking policies are most effective in reducing car usage according to self-stated behaviour. This is also true for individuals over the age of 65 years and families with children based on Figure K.4. Handing out shared mobility vouchers seems to have a positive effect on reducing car usage for members of class 1 and 3 as well. Implementing 30 km/h zones, redevelopment of public space and the reduction of parking permits seem to have the least impact on reducing car usage. However, these measures are generally more supported that the monetary policies, except for class 2. In class 2, the reduction of parking permits for households living in city centres is opposed as equally as the pay for use policy. This indicates that implementing this measurement would not be beneficial for class 2 as it will lead to resistance of individuals while it does not largely impact car usage. Lastly, it can be stated that, based on Figure K.4, that individuals over the age of 65 years, would use their car less if zero-emission zones were implemented.

So, flanking policies could additionally stimulate class members, including the rigid travellers of class 1, to use mobility hubs based on self-stated behaviour change.

4.3.3. Conclusion results

The results section described the descriptive analysis and model results of the SCE and additional relevant data collected from the questionnaire. The descriptive analysis descripted the data distribution, socio-demographic attributes, environmental awareness of the sample, mobility related statistics, and view of the sample on flanking policies. The model results part described the MNL model and LCM results, including the significant socio-demographic attributes which could be linked to the generated classes in the LCM. Excel, Nlogit and SPSS were used as analysis programs.

4.4. Conclusion stated choice experiment

The questionnaire, including the SCE, gives relevant insights into the aspects that influence mobility mode choice behaviour. Besides, research questions 3, 4, and 5 can be answered based on the found results.

First of all, it should be stated that the data sample is not representative for the Dutch population. Respondents are mainly living in the South of the Netherlands (provinces of Limburg and Noord-Brabant). The most outstanding characteristics of the sample are that approximately two-third of the respondents are males, 50- to 59-year-olds are the largest age group, and approximately 80% of the respondent is highly educated (> bachelor degree). Furthermore, the sample is overall environmentally aware. The sample has quite some knowledge about new mobility trends, such as shared mobility and mobility hubs. This is probably due to the distribution of the questionnaire among members of the SmartwayZ.NL travellers panel. Lastly, about 19% of the respondents indicated to have experienced life-changing events over the past twelve months.

Approximately 90% of the respondents has a private car available at home. The private car is a popular mode of transport, as it is indicated as the usual mode of transport for different trip purposes by at least 30% of the respondents. The car is especially used for trips with a destination outside of the municipality. Next to the car, the train and bicycle are popular mobility modes. Lastly, individuals indicate to often walk to destinations too.

Flanking mobility policies were tested to respondents' support and self-stated car behaviour change. Overall, car owners are more opposed to the implementation of mobility policies than non-car owners. Furthermore, it can be noted that policies that require a small car behaviour change are mostly supported, such as the implementation of 30 kilometres per hour zones. Policies that lead to increase monetary costs, such as the implementation of pay for use (toll roads), are less supported but lead to the largest self-stated reduction in car usage.

For car owners the habit strength was calculated. Surprisingly, car habit strength is not influenced by the occurrence of life-changing events, which is contradicting to literature (Haustein & Kroesen, 2022).

Answering sub-question 3, it can be stated that a relationship exists between the habit strength and policy support. This relationship indicates that a low habit strength results in a high value for policy support. However, the relationship between these two is weak, and therefore no practical implications can be based on this finding.

The SCE is used to test which hub attributes and trip purposes affect mobility mode choice behaviour. A LMN model and LCM are used to analyse the data collected from the SCE choice tasks. The LCM with three classes turned out the have the best model fit. Socio-demographic characteristics are tested against the class membership to determine the personas present in each class. Based on this, sub-question 4 can be answered. An overview of the most important results is given in Table 24.

Table 24: Overview of most important results of questionnaire and SCE.

		Class 1 – Families with children	Class 2 – students	Class 3 - YUP
Class Charact.	Age	40 – 59 and 65+	< 30	30-39
	Household composition	Household with children	Non-family households	Singles and couples
	Usage own transportation mode	Overall rigid	Overall rigid, but flexible car owners	Overall flexible, but rigid car owners
Hub attributes**	Faster	n.s.*	+	+
	Cheaper	n.s.	+	+
	Shared car	n.s.	+	+
	Bus connection	n.s.	+-	+
	Café, flex offices, child daycare	n.s.	+	+
	Supermarket, gym, bike-repair shop	n.s.	+-	n.s.
	Environment characteristics	n.s.	+-	-
Trip purpose	Day trip hub usage	n.s.	+	n.s.
	Work/education and cheaper	n.s.	-	-
	Work/education and faster	n.s.	+	n.s.
Flanking policies***	Pay for use	-+	-+	--
	Parking measurements	-+	-+	-+
	30 km/h zones	+-	+-	+-
	Zero-emission zones	++	++	++
	Shared mobility vouchers	++	+-	++

*n.s. = not significant.
**Regarding amenities it should be noted that in the SCE they were clustered in groups of three. Self-stated importances showed that individuals think having a supermarket or parcel lockers would be beneficial.
***The first +/- indicates the policy support factor and the second +/- indicates the effectiveness of the policy for decreasing car usage based on self-stated car behaviour change.

The first class is characterised by rigid usual mode of transport usage, class members do not consider using mobility hubs. In this class mostly families with children and individuals of 65 years old and over are present. Members of the second class are still overall rigid usual mode of transport users, however, individuals owning a car in this class consider using mobility hubs. This class is characterised by individuals living in non-family households (student households) and individuals being younger than 30 years old. Members of this class mainly consider using a hub if it is faster and cheaper than using their usual mode of transport. Besides, offering a shared car has a positive effect and adding a bus connection has a medium positive effect on the attractiveness of the hub. Adding a café, flex offices, and child daycare also increases the attractiveness of the hub. Adding a supermarket, gym, and bike-repair shop has a small positive influence on increasing the attractiveness of the hub. On the other hand, environment characteristics have a negative effect on hubs' attractiveness, except for adding the combination greenery and smart lighting. Furthermore, it is worth mentioning that travel costs are not an obstructing factor when travelling to work or educational purposes. In the third class, individuals who are most likely to be enticed to use mobility modes offered at a hub are present. However, it should be stated that rigid car users are also present in this class. The hub attributes that influence choice behaviour are mostly equal to the influencing attributes described for the second class, except that adding a bus connection has a larger positive effect on the attractiveness of hubs, and some not significant values as indicated in Table 26. So, hubs can more interesting when offering mobility modes that are faster and cheaper than the usual transportation mode of respondents. Furthermore, offering a shared car and/or a bus connection and adding additional amenities to hubs can have a positive effect on the attractiveness of mobility hubs as well. Environment characteristics, however, do have a negative effect. Lastly, it is important consider the neighbourhood socio-demographics in which mobility hubs are located. If this neighbourhood mainly consists of households with children or individuals over the age of 65 years, the chances of successful implementing a mobility hub a rather small.

However, municipalities can consider implementing flanking policies to increase the chance of mobility hubs being successful. Answering sub-question 5, the two flanking policies, which for all three the classes, seem to have the best balance between policy support and self-stated car behaviour change are the implementation of zero-emission zones and the handing out of shared mobility vouchers. The implementation of 30 kilometres per hour zones is most supported by all three classes, however, this flanking policy has the smallest effect on changing car usage behaviour. It could be useful to implement this policy for other goals of the municipality, such as increasing safety or decreasing pollution from cars, but this measure is not effective for decreasing car usage behaviour.

This chapter gave insights into attributes which can change mobility mode choice behaviour. Together with the results from the literature study and the interviews, the questionnaire and SCE results can answer the main research question. The overall findings will be discussed in Chapter 6, in which the research question will be answered as well. Before discussing, the practical implementation of the SCE results will be described first in Chapter 5.

5. Planning implications

To provide insights in the practical implications of the results of this research, three hubs in Eindhoven are selected as case study. These hubs are selected as they were discussed in the interview with the municipality of Eindhoven, providing details on the design of the hubs.

5.1. Background

In the beginning of 2024, the municipality of Eindhoven realized three neighbourhood mobility hubs in three different neighbourhoods: Vonderkwartier, De Bergen, and Irisbuurt (Figure 41). The mobility hubs are small-scaled, meaning they offer one shared car, one shared cargo bicycle, four shared bicycles and two to three shared scooters. There is no bus connection present. The locations of the hubs are selected based on a study on the lifestyles in the neighbourhoods, especially the Irisbuurt and De Bergen are selected based on this study, as indicated in the interview with the municipality of Eindhoven.

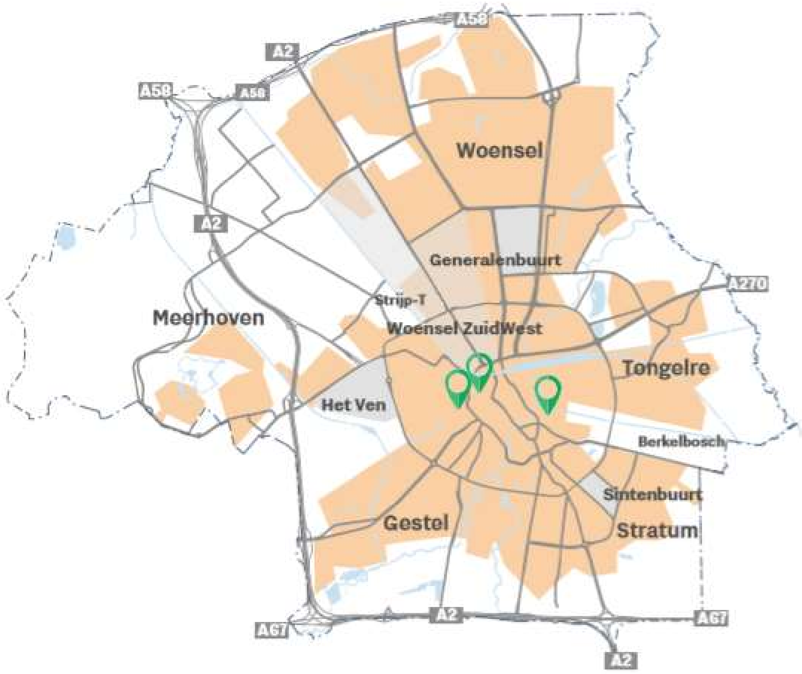

Figure 41: Overview hub locations Eindhoven adopted from Municipality of Eindhoven (n.d.).

The municipality of Eindhoven has expressed several goals with the implementation of the hubs. The hubs intend to stimulate individuals to use more sustainable mobility modes instead of private cars, benefiting from multimodality. Thereby, the hubs intend to be recognizable, fixed places with available shared mobility modes, rather than scattered places all around the city. This results in the reduction of “free-floating” shared mobility vehicles, which decreases nuisance of these vehicles and improves the city view. Thereby, the attitude of citizens towards shared mobility would, hopefully, also improve.

5.2. Assessing mobility hubs

To accurately describe the implications of the research for these mobility hubs, it is important to describe the demographics of the neighbourhoods. Especially since the hubs are specifically located in these neighbourhoods based on these characteristics. Table 25 provides the neighbourhoods’ statistics (Municipality of Eindhoven, 2024).

Table 25: Overview Eindhoven relevant neighbourhood statistics (Municipality of Eindhoven, 2024).

Neighbourhood	Vonderkwartier	De Bergen	Irisbuurt	Eindhoven	Dutch population
Inhabitants	3328	2906	2643	-	-
Man / woman	52.2 / 47.8 %	55.2 / 44.8 %	54.5 / 45.5 %	51.9 / 48.1 %	50.3 / 49.7 %
Age					
20-29	20.9%	35.2%	22.4%	18.2%	<14.5%*
30-39	17.5%	22.7%	22.1%	16.5%	12.8%
40-49	12.5%	9.2%	13.8%	12.4%	11.9%
50-59	11.8%	10.8%	10.1%	11.9%	14.3%
60+	19.1%	11.9%	15.3%	21.8%	20.9%
Household composition					
Single	38%	48%	42%	41%	18%
Couple without children	28%	33%	29%	27%	<49%***
Household with children	26%	11%	24%**	27%	29%
Non-family household	5%	6%		3%	<49%***

* Data for 18- t0 29 years old, see Table 17.
** Data not provided separately by the municipality of Eindhoven.
*** In Dutch population statistics, couples without children and non-family households are combined, see Table 17. Other / rather not say are excluded.

From Table 25, it becomes clear that people living in the three neighbourhood are relatively young. Compared to the age distribution of the complete municipality of Eindhoven, the percentage of people under the age of 40 years is overrepresented in these three neighbourhoods. Besides, the percentages of individuals living alone and individuals living in non-family households is also large in these neighbourhoods (> 38%). The percentage of individuals living together with a partner is also substantial in these neighbourhoods (>28%). Therefore, it could be stated that the inhabitants of these neighbourhoods are relatively young (< 40 years old) and mostly living alone or together with a partner. It however should be noted that in the Vonderkwartier, also a substantial part of households with children is present (26%).

Comparing the neighbourhood statistics with the three classes defined in the research the following findings stand out. First of all, it could be stated that the three neighbourhoods are rightly chosen. The three classes that result from the LCM analysis, show that households with children, 40- to 49-year-olds, and individuals older than 65 years do not consider using a mobility hub. On the other hand, the LCM result shows that individuals younger than 40 years old, individuals living in non-family households, and individuals living alone or with a partner, do consider using mobility hubs, if the conditions are right. Considering the neighbourhood statistics in more detail, it could be stated that the socio-demographic characteristics of the Irisbuurt and De Bergen are most favourable. In the Vonderkwartier, also quite some individuals above 60 years old and households with children reside.

Currently, the mobility hubs implemented in the three neighbourhoods are small-scaled, without a bus connection. Figure 42 provides an impression of the hubs.

Figure 42: Small-scaled neighbourhood hub Havensingel, Irisbuurt, Eindhoven.

In order to make the implemented hubs more attractive, and thereby more successful, the municipality of Eindhoven could consider implementing the following aspects. Regarding the hubs located in the neighbourhoods De Bergen and Irisbuurt, in which relatively young individuals mostly reside, adding a bus connection or a bus nearby, next to the already offered shared mobility modes, could be beneficial. This is already the case in De Bergen, where the hub is located next to a small sheltered bus stop. Next, it could be beneficial to add amenities such as a café, supermarket or flex offices, or provide these in the proximity of the hub. The hub in De Bergen is located at the Wilhelminaplein, where already cafés are present, which is beneficial. The hub located in the Irisbuurt is located at the Havensingel. No bus connection or additional amenities are present at the Havensingel, therefore, it could be especially beneficial for the municipality to consider to provide these at this hub, or in the future, consider placing hubs at locations where these amenities are present. The hub located at De Bergen is a good example of this. Next to the amenities which resulted from the LCM, it could also be beneficial to add parcel lockers, based on the self-stated preferences of individuals. Currently, the hubs do not consider environment characteristics, however, as these have a negative effect on the attractiveness of the hub based on the LCM results, the municipality should not implement additional environment characteristics, such as greenery. To stimulate hub usage more, it could be beneficial to implement zero-emission zones or hand-out mobility vouchers. The latter is also in line with individuals especially considering to use a mobility hub if it is cheaper than their usual mode of transport.

Regarding the hub located at the Vonderkwartier, the same applies as the hubs located at De Bergen and Irisbuurt. However, as in the Vonderkwartier also more households with children and individuals over the age of 60 years are living, hub implementation should be considered with more caution, as the LCM shows that these social groups do not consider using hubs. Therefore, these groups need additional steering. Implementing more flanking policies or working with a participation process, in which individuals could express their needs, could therefore be beneficial.

5.3. Conclusion planning implications

Overall, it could be stated that the location of the three hubs are rightly chosen by the municipality of Eindhoven. In the three neighbourhoods reside, overall, individuals of social groups who would consider using mobility hubs. It could be beneficial for the municipality to also experiment with the implementation of flanking policies, as these could stimulate a reduction of car usage and an increased use of modes offered at mobility hubs.

This chapter shows how the results of this research can be used to assess, and potentially improve, developed hubs. However, the results of this research can also be used to assess potential hub locations in the planning phase. Based on neighbourhood statistics, locations can be assessed, making it possible to choose strategic hub locations which increases the chance of successful hub implementations. For example, it is more beneficial to realize hubs in neighbourhoods where mostly young individuals are living (such as Witte Dame in Eindhoven) compared to neighbourhoods where families with children are residing (such as Bosrijk in Eindhoven) (Municipality of Eindhoven, 2024). Therefore, the results of this research can be used in the planning phase and designing phase of new hub implementations. For existing hubs, the results can be used to evaluate and adapt hubs to be more effective.

6. Discussion

In this chapter, the results of this research will be discussed. The main research question is addressed by reviewing and interpreting the findings regarding the different sub-research questions, providing a comprehensive overview of this research's contributions.

6.1. Literature study versus expert interviews

In literature, mobility hubs are presented as a means to contribute to more sustainable travel behaviour and thereby mitigate climate change by stimulating the mobility transition. Surprisingly, the interviewed experts see mobility hubs as a solution to another problem. Namely, the spatial distribution in cities. Of course, the environmental reasons were also important for the experts, but they were not the main reason to be interested in mobility hubs. Here, a clear difference between theory and practice is visible. This finding might have implications in the policies that best fit the purpose of the mobility hub. To give an example, municipalities might want to target day trip travellers in the weekends to reduce congestion and implement stricter parking policies in the weekend, while based on literature, policies more intended to improve the environment might be suggested, such as zero-emission zones. Further research might be necessary to better understand the differences in goals and what this means for decision-making on flanking policies.

The literature study and expert interviews contributed to answering the research question by providing a theoretical background, mobility hub definitions, and input for the questionnaire and SCE. The literature study shows that it is important to consider travel habits in making mobility policies. This is also recognized by interviewed experts. However the experts indicate to find it challenging to change current travel habits by implementing policies, especially regarding rigid car users. This research provides useful insights regarding flanking policies to stimulate behaviour change, which can be adopted by municipalities. However, more extensive research is desired on car travel habits and how to most effectively break them.

6.2. Stated Choice Experiment

In the results of the SCE, three classes are identified. The first class is characterized by respondents that are reluctant to change their usual travel mode, and are unlikely to use any form of mobility hub. This class is characterized by families with children and higher age groups. The second and third class are generally characterized by young people without children. These classes are, on the other hand, more open to use mobility hubs. Travel costs, travel time, and the different available shared mobility modes significantly contribute to the attractiveness of hubs. Surprisingly, amenities do not largely contribute, except for the combination of flex offices, café, and child daycare. The contributing effect of amenities largely differs per class and showed nonhomogeneous results compared to self-stated preferences of the respondents. This could be explained by the fact that SCE models preferred choices and behaviour more accurately and that respondents are not well aware of their own preferences which are reflected in the self-stated preferences. Due to the large differences, participation projects might be interesting because these provide the opportunity to have discussions with stakeholders. Municipalities could use participation projects to design hubs which specifically fit to the needs of individuals living in neighbourhoods in which hubs will be realized. It is expected that the attractiveness and usage of a hub will increase if individuals collaborate in the design.

Besides, where experts expected that environment characteristics, such as greenery and lighting, are important for mobility hub implementations as well, this perspective is not supported by this research. Environment characteristics even seem to have a negative effect. A potential reason for this could be that individuals may experience too much greenery as unsafe. Besides, it could also be possible that, as the environment characteristics are mentioned last in the overview table in the choice tasks, respondents did not thoroughly consider this and focussed more on the attributes mentioned before. Additional research is required to explain this finding.

Travel costs is the most important attribute for choosing to travel by modes offered at a mobility hub. If travelling by modes offered at a hub is cheaper than using the usual mode of transport, this makes a hub more attractive. Surprisingly, the only trips for which costs is not an obstructing factor are trips related to work or education. This is possibly because work related costs are often covered by employers, and educational costs are covered by the government in the Netherlands. Municipalities could, for example, target commuting behaviour for mobility hub usage because the monetary costs are not considered. It could be beneficial to partner with companies to create mobility plans for employees. However, it should be remembered that current commuting travel habits are strong and therefore hard to change or break. Long-term stimulation to use other mobility modes is needed. The fact that travel costs are determined as important can be linked to the attitude of individuals towards flanking policies. In this research, flanking policies with negative monetary consequences are not highly supported. However, handing out mobility vouchers is positively supported by respondents, and results in expected self-stated car travel behaviour change as well. Municipalities could, therefore, consider handing out mobility vouchers which reduce the costs of travelling by modes offered at mobility hubs.

The classes formed can be described based on age and household composition. Other socio-demographic and respondent-related attributes turned out to be not significant in relation to class membership, which is surprising. It was expected that environmental awareness, educational level and income would also describe the classes. This would suggest that education level, income, and environmental awareness do not determine the likelihood of choosing to travel by a mobility hub. To test this, it is suggested that future research considers these factors directly in the formulation of classes in the LCM. Especially the fact that income does not describe the classes directly is surprising since travel costs is the most important attribute for individuals choosing using a mobility hub.

Nevertheless, the classes provide municipalities with clear groups that can be considered when designing mobility hubs, and can be targeted to use mobility modes offered at hubs. Practical implications of the personas of these classes are presented in the case study which analysed three recently implemented mobility hubs in Eindhoven. This link between theory and practice makes this research unique and useful for both academics and practitioners.

6.3. Current mobility behaviour and flanking policies

Next to the results of the SCE, the questionnaire gathered a broader selection of attributes that influences travel behaviour. Based on literature, one of the factors that was expected to decrease the strength of a travel habit is the occurrence of life-changing events over the last twelve months. However, this effect was not significant in this study. This could possibly be explained by the fact that in this research the effect of life-changing events has specifically been tested for private car based habits, instead of travel habits overall. It could be the case that individuals move towards more flexible and convenient modes of transport after life-changing events, which in many cases is the use of the private car.

Furthermore, the questionnaire gave insights into the mobility modes available to individuals within 7.5 kilometres from home. It can be stated that more individuals have shared mobility modes available to them, based on their postal codes, than is currently indicated by themselves. This indicates that there are individuals who are sure that shared mobility modes are not available to them, while in reality they are. This shows a need to raise awareness among individuals, maybe by information campaigns. Municipalities need to find ways how to address individuals who potentially are willing to use other modes of transport. Without knowledge of alternatives, it is hard to stimulate behaviour change of individuals. They need to be aware alternatives exist.

Lastly, the questionnaire provided additional insights into the support and effect of flanking policies. Experts expressed the need to better understand which flanking policies lead to effectively changed travel behaviour towards increased mobility hub usage and decreased private car usage. In line with literature, the results of the questionnaire showed that flanking policies with a large “push” effect are least supported but lead to larger self-stated car behaviour change, and policies with “pull” effects are more supported but only have a small effect on car behaviour change. So, ironically, the measures that are supported most are generally expected to result in the lowest car behaviour change, such as the implementation of 30 kilometres per hour zones. Important to note is that the effects are self-reported. The literature study, however, also provided the insight that policies are most effective with higher acceptance, or even support, of individuals, and that pull measures are generally more accepted than push measures. It could therefore be stated that policy support and behavioural change should be well balanced by policymakers to design effective interventions stimulating the mobility transition by increasing mobility hub usage. Participation could be a method to increase policy support by making it possible to understand the needs of individuals, which could lead to increased support. To give an example, a policy that is highly opposed is the decrease of parking spaces. However, by organizing participation events with inhabitants, municipalities could show that a decreased number of parking spaces could lead to many benefits, such as more space for green or roads free of cars for children to play on. This may results in higher support rates, and with it effectiveness, of policies.

6.4. How can mobility hubs best be implemented?

This research answers the main research question: How can municipalities best implement mobility hubs to effectively change private car-based travel habits? The answer is based on the literature study, expert interviews, and questionnaire with stated choice experiment, providing answers to the different sub-questions and valuable insights into the various steps of mobility hub implementation for a reduction in private car usage.

Central in this study is that an effective implementation of mobility hubs can help in changing travel habits related to private car usage. How to assure effective implementation, however, is understudied in literature and also experts expressed that there are no best practices. This research shows that implementation is complex and decision-making and design activities can best follow a logical process to assure that the hub fits the objectives of the municipality. First, the municipality must determine the problem, for example climate change and congestion. Secondly, the desired behaviour needs to be determined and how the mobility hub can be part of the solution, in this case by reducing private car usage. Then, a specific social group can be targeted to determine suitable hub locations and allow more effective hub designs. The preferences of the target group then determine the design of the mobility hub, with specific attributes making a hub more attractive for this group. When the design and location of the hub are determined, flanking policies help to make the mobility hub more attractive and to change travel habits. The effectiveness and the likelihood of acceptance of the policies should be well balanced. To facilitate the decision-making process, a conversation starter has been developed which helps policymakers in developing effective mobility hubs. This conversation starter is presented in Appendix L.

7. Conclusion

This research on how to successfully implement mobility hubs to change private car-based travel habits holds significant scientific relevance. The research contributes as one of the first studies to include travel habits in the context of mobility hubs, and thereby considers a broad range of attributes to analyse behaviour. This broad range includes the consideration of not only mobility hub attributes and socio-demographics, but also trip purpose and flanking policies to increase insights on the effective implementation of mobility hubs.

The literature study contributes to scientific research by providing clear definitions on mobility hubs in general and specific typologies of neighbourhood and district hubs. In current literature, many different definitions exist, resulting in ambiguity and limited comparability of results. The different definitions have been combined in this literature study and provide a complete and unambiguous definition that can be used in future mobility hub research and describe the necessary and optional features of neighbourhood hubs, district hubs and mobility hubs in general. The expert interviews are a valuable addition to the research because of the practical insights related to mobility hub implementations. The experts expressed drivers and barriers for reducing private car usage and the insights they need for better decision-making. The combination of a literature review with expert interviews is uncommon in mobility hub literature, and this detailed input is used for the questionnaire and Stated Choice Experiment (SCE) design.

The questionnaire and SCE cover a broad range of topics to answer the different research questions. The SCE includes mobility hub attributes and provides detailed insights in travel mode choice behaviour. In the analysis, especially travel costs and travel time came forward as determining indicators, along with the available mobility modes at hubs. Amenities have a smaller influence, and smart lighting, greenery and a guarded bike parking show a negative influence on hub attractiveness, which differed from expert expectations. The three defined classes, and the socio-demographics attributes of these classes, can help decision-makers and adds new insights to literature on which characteristics of individuals make them (un)likely to change travel behaviour towards mobility hub usage. A limitation is that for shared mobility modes, amenities and environment characteristics attributes, the levels present a combination of options instead of individual options, which limits the design suggestions of hubs to these clusters. Lastly, it should be mentioned as a limitation that the data sample was not representative for the Dutch population. Therefore, results should be interpretated with caution.

The questionnaire also addressed habit strength, for which no significantly large relation is discovered with attitude towards municipal policies. Flanking policies and their expected policy support and car behavioural change are measured and their results are in line with literature. Push policies result in the most expected change, especially with monetary consequences involved, but result in the lowest policy support. For pull measures, the reversed effect is measured. As already mentioned, a limitation of rating the policies as opposed to considering them directly in the SCE is that a good understanding of preferences is assumed while this is often not the case in reality.

The practical implications show that the research results can be used in practice, providing insights to policymakers on how to use the outcomes. The hub example of Eindhoven showed how academic work can be translated to practical situations. Hereby, the risk that mobility hubs are targeting individuals who might never consider using mobility hubs, or that the hub considers attributes that do not contribute to changing car travel behaviour, can be limited. Municipalities can use the results as a first guideline towards rightly implementing mobility hubs. To further facilitate the decision-making process of policymakers, a conversation starter on how to hub is developed.

All in all, this research answers the main research question by considering a wide range of contributing attributes, and uses multiple research methods to do so. The research significantly contributes to existing literature by providing deeper understanding on how travel habits affects private car usage and the related effectiveness of mobility hub implementations. The study offers practical insights in reducing private car usage through targeted mobility hub implementation strategies focused on specific user groups and trip purposes, and enhances the understanding of flanking policies' support and expected behaviour change.

7.1. Societal relevance

Cities are responsible for a large share of worldwide global emissions and citizens experience the growing consequences of global warming, such as urban heat waves, drought and the risk of floodings. Moving towards more sustainable mobility, among others through the reduction of private car usage, is an important step towards more sustainable, healthy, and future-proof cities. Sustainable mobility is often multimodal to increase the effectiveness of sustainable mobility modes. Thereby, Multimodality is a highly anticipated means to reduce private car usage and to benefit from more sustainable transport modes, and can be facilitated at mobility hubs. The implementation of mobility hubs does, however, not necessarily lead to immediate large scale changes in travel behaviour. Multiple factors contribute to travel behaviour, and travel behaviour is sensitive for habit forming, making behavioural change more difficult. Municipalities struggle to make right decisions for successful mobility hub implementations with the intention to reduce private car usage. A better understanding on how to change travel behaviour and travel habits towards a reduction of private car usage and an increase in mobility hub usage is important for the sustainable transition of cities.

This research contributes to this need by providing new insights to policymakers on how to implement mobility hubs more effectively for reducing private car usage. Clear definitions with basic features are formed form mobility hubs and the two typologies that specifically address a reduction of private car usage, namely neighbourhood hubs and district hubs. The analysis of the SCE describes which mobility hub attributes are most effective for an increase in mobility hub usage for specific social groups and specific trips, providing detailed insights for policymakers. Thereby, flanking policies are presented along with the expected policy support and potential car usage behaviour change, so that policymakers can make better decisions on how to further stimulate sustainable travel while limiting the resistance against policies.

7.2. Recommendations for further research

For future research, already some recommendations were formulated in the discussion (Chapter 6). The most important recommendations are listed here.

A clear difference between literature and expert opinions can be recognized regarding the goal of mobility hubs (environmental versus spatial). Further research could focus on this gap studying what this gap means for decision-making on mobility hub implementation and flanking policies. It could also be meaningful for municipality to research how mobility hubs can exactly contribute to solving spatial distribution challenges, and how these mobility hubs should be organized and distributed at a larger (city) scale. Thereby, it is interesting to construct a SCE with flanking policies to better model actual behaviour based on these policies. In the SCE with flanking policies, the effects of travel costs and travel time need to be considered with caution as implementing flanking policies will result in an additional difference in travel costs and travel time.

Furthermore, amenities and specific environmental characteristics can be considered as separate attributes (with two levels: present or not present) in the SCE to collect more detailed information on each attribute. It should be noted that a large sample size is needed to get significant results as this method would lead to a large design.

This research mainly focussed on the physical environment of mobility hubs, and their functionalities. In future research, participation and digitalisation can also be considered as important aspects influencing mobility hub usage. In this research, for example, a complete integration through an app was assumed, which is not always standard. Using participation as a research tool, to consider the specific needs of individuals in certain areas or neighbourhoods could be useful to increase the likelihood of mobility hub usage. Especially since the comments on this research, which several participants left at the end of the questionnaire, ranged from very positive to very negative. Additional research, which takes into account considerations of individuals by participation projects could be useful.

Future research could also focus on exact trips for which mobility hubs could be used, and individuals could indicate which mobility mode offered at hubs they then would use for their trips. This exact trip can be based on real-life travels of respondents. Respondents can be asked to describe a trip they undertake most frequently, such as their commute to work, which makes it possible to consider travel distance to and location characteristics of destinations.

Lastly, it could be interesting to compare the results of this thesis with actual behaviour data. As more hubs are being realized in the Netherlands and hub user data is collected by CROW, this data could be used to analyse whether implementing changes based on the results of this research actually contribute to an increased mobility hub usage. Hubs which have features in line with the results of this research, for example providing flex offices, could be compared to hubs which do not have these features.

All in all, this research presents a comprehensive overview which helps policymakers to develop more effective mobility hubs which can reduce private car usage. To facilitate the decision-making process, the conversation starter can be used as a tool by policymakers.

Bibliography

Alessandretti, L., Orozco, L. G. N., Saberi, M., Szell, M. & Battiston, F. (2022). Multimodal urban mobility and multilayer transport networks. *Environment and Planning B: Urban Analytics and City Science, 50*(8), 2038-2070. https://doi.org/10.1177/23998083221108190

Anderson, M.W. (2012). New Ecological Paradigm (NEP) Scale. *The Birkshire Encyclopedia of Sustainability: Measurements, Indicators, and Research Methods for Sustainability, 6,* 260-262. https://www.researchgate.net/publication/264858463

Arseneault, D. (2022). *Mobility Hubs: Lessons Learned from Early Adopters*. Institute of Transportation Studies, UCLA. https://doi.org/10.17610/T6N31C

Asgari, H., & Jin, X. (2019). Incorporating habitual behaviour into Mode choice Modeling in light of emerging mobility services. *Sustainable Cities and Society, 52*. https://doi.org/10.1016/j.scs.2019.101735

Bamwesigye, D., & Hlavackova, P. (2019). Analysis of sustainable transport for smart Cities. *Sustainability, 11*(7), 2140. https://doi.org/10.3390/SU11072140

Benison, M. & Anderson, M. (n.d.). *Future Mobility Hubs Supporting the transition towards sustainable journeys.* Retrieved November 23, 2023, from https://www.arup.com/perspectives/publications/research/section/future-mobility-hubs

Bertolini, L. (1999). Spatial development patterns and public transport: The application of an analytical model in the Netherlands. *Planning Practice and Research, 14*(2), 199–210. https://doi.org/10.1080/02697459915724

Bibri, S. E., & Krogstie, J. (2020). Smart Eco-City Strategies and Solutions for Sustainability: The Cases of Royal Seaport, Stockholm, and Western Harbor, Malmö, Sweden. *Urban Science, 4*(1), 11. https://doi.org/10.3390/urbansci4010011

Blad, K., de Almeida Correia, G. H., van Nes, R., & Annema, J. A. (2022). A methodology to determine suitable locations for regional shared mobility hubs. *Case Studies on Transport Policy, 10*(3), 1904–1916. https://doi.org/10.1016/j.cstp.2022.08.005

Borgers, A. (2021). *Urban Research methods: Discrete choice models*. [Slide show; Lecture Eindhoven University of Technology].

Bueno, A. P. (2021). *Identifying and quantifying mobility hubs* [Master thesis]. Swiss Federal Institute of Technology Zurich.

Burghard, U., & Dütschke, E. (2019). Who wants shared mobility? Lessons from early adopters and mainstream drivers on electric carsharing in Germany. *Transportation Research Part D, Transport and Environment, 71, 96–109.* https://doi.org/10.1016/j.trd.2018.11.011

Carden, L., & Wood, W. (2018). Habit formation and change. *Current Opinion in Behavioural Sciences, 20, 117-122*. https://doi.org/10.1016/j.cobeha.2017.12.009

CBS. (2021). *Hoeveel reisden inwoners van Nederland en hoe?* cbs.nl. Retrieved August 22, 2023, from https://www.cbs.nl/nl-nl/visualisaties/verkeer-en-vervoer/personen/hoeveel-reisden-inwoners-van-nederland-en-hoe-

CBS. (2022). *Kerncijfers per postcode*. cbs.nl. Retrieved March 15, 2024, from https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/gegevens-per-postcode

CBS. (2024a). *Voltijd*. cbs.nl. Retrieved February 9, 2024, from https://www.cbs.nl/nl-nl/visualisaties/dashboard-beroepsbevolking/voltijd

CBS. (2024b). *Deeltijd*. cbs.nl. Retrieved February 2, 2024, from https://www.cbs.nl/nl-nl/visualisaties/dashboard-beroepsbevolking/deeltijd

CBS. (2024c). *Stedelijkheid*. cbs.nl. Retrieved March 15, 2024, from https://www.cbs.nl/nl-nl/nieuws/2022/39/meer-afval-per-inwoner-in-minst-verstedelijkte-gebieden/stedelijkheid

CBS. (2024d, May 31). *Regionale kerncijfers Nederland*. opendata.cbs.nl. Retrieved June 11 25, 2024, from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/70072ned/table?ts=1714034135109

CBS. (2024e). *Mannen en vrouwen*. cbs.nl. Retrieved April 25, 2024, from https://www.cbs.nl/nl-nl/visualisaties/dashboard-bevolking/verdeling/

CBS. (2024f, June 7). *Bevolking; geslacht, leeftijd en burgelijke staat, 1 januari*. opendata.cbs.nl. Retrieved June 11, 2024, from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/7461BEV/table?fromstatweb

CBS. (2024g). *Bevolking; hoogst behaald onderwijsniveau en herkomst*. cbs.nl. Retrieved April 25, 2024, from https://www.cbs.nl/nl-nl/cijfers/detail/85453NED?q=opleidingsniveau

CBS. (2024h, May 15). *Arbeidsdeelname; kerncijfers*. opendata.cbs.nl. Retrieved June 11, 2024, from https://opendata.cbs.nl/#/CBS/nl/dataset/85264NED/table?dl=9F1C6

CBS. (2024i). *Werkenden*. cbs.nl. Retrieved April 25, 2024, from https://www.cbs.nl/nl-nl/visualisaties/dashboard-arbeidsmarkt/werkenden

CBS. (2024j, May 15). *Arbeidsdeelname; kerncijfers seizoengecorrigeerd*. opendata.cbs.nl. Retrieved June 11, 2024, from https://opendata.cbs.nl/#/CBS/nl/dataset/85224NED/table?dl=9F1C2

CBS. (2024k, May 15). *Hoeveel personenauto's zijn er in Nederland?* cbs.nl. Retrieved June 11, 2024, from https://www.cbs.nl/nl-nl/visualisaties/verkeer-en-vervoer/vervoermiddelen-en-infrastructuur/personenautos

CDP. (2022). *Protecting People and the Planet: Putting people at the heart of city climate action.* CDP Worldwide. Retrieved from https://cdn.cdp.net/cdp-production/cms/reports/documents/000/006/567/original/CDP_Cities_Protecting_People_and_the_Planet.pdf?1665068434

CDP. (2021). *Cities on the route to 2030: building a zero emissions, resilient planet for all.* CDP Worldwide. Retrieved from https://cdn.cdp.net/cdp-production/cms/reports/documents/000/005/759/original/CDP_Cities_on_the_Route_to_2030.pdf?1621329680

CoMoUk. (2019). *Mobility Hubs Guidance*. Retrieved from https://www.como.org.uk/documents/comouk-mobility-hubs-guidance

CROW. (2009). Maximale fietsafstanden variëren per reisdoel. Retrieved on January 8, 2024, from https://fietsberaad.nl/Kennisbank/Maximale-fietsafstanden-varieren-per-reisdoel/#:~:text=In%20Nederland%20wordt%20als%20maximale%20fietsafstand%20vaak%207%2C5,het%20vervoersgedrag%20van%20de%20inwoners%20van%20de%20staat.

CROW. (2022). *Handreiking Naar een samenhangend netwerk van mobiliteitshubs en knooppunten*. CROW-KpVV. Retrieved from https://www.mobiliteitshubs.nl/wat-is-een-mobiliteitshub

CROW. (2024). Dashboard deelmobiliteit. Retrieved on May 14, 2024, from https://dashboarddeelmobiliteit.nl/

Dewies, M., Denktaş, S., Giel, L., Noordzij, G., & Merkelbach, I. (2022). Applying Behavioural Insights to Public Policy: An Example From Rotterdam. *Global Implementation Research and Applications, 2*(1), 53–66. https://doi.org/10.1007/s43477-022-00036-5

Diao, M. (2019). Towards sustainable urban transport in Singapore: Policy instruments and mobility trends. *Transport Policy, 81,* 320–330. https://doi.org/10.1016/j.tranpol.2018.05.005

Dodman, D., Hayward, B., Pelling, M., Castan Broto, V., Chow, W., Chu, E., Dawson, R., Khirfan, L., McPhearson, T., Prakash, A., Zheng, Y., & Ziervogel, G. (2022). Cities, settlements and key infrastructure. In: H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (eds.). *Climate change 2022: Impacts, adaptation and vulnerability* (pp. 907-1040). Cambridge University Press. https://doi.org/10.1017/9781009325844.008

Dubois, G., Sovacool, B., Aall, C., Nilsson, M., Barbier, C., Herrmann, A., Bruyère, S., Andersson, C., Skold, B., Nadaud, F., Dorner, F., Moberg, K. R., Ceron, J. P., Fischer, H., Amelung, D., Baltruszewicz, M., Fischer, J., Benevise, F., Louis, V. R., & Sauerborn, R. (2019). It starts at home? Climate policies targeting household consumption and behavioural decisions are key to low-carbon futures. *Energy Research and Social Science, 52,* 144–158. https://doi.org/10.1016/j.erss.2019.02.001

Fabozzi, F. J., Focardi, S. M., Rachev, S. T., & Arshanapalli, B. G. (2014). Appendix E: Model Selection Criterion: AIC and BIC. *The Basics of Financial Econometrics: Tools, Concepts and Asset Management Applications*, 399–403. https://doi.org/10.1002/9781118856406.app5

Foltýnová, H. B., Vejchodská, E., Rybová, K., & Květoň, V. (2020). Sustainable urban mobility: One definition, different stakeholders' opinions. *Transportation Research. Part D, Transport and Environment, 87*. https://doi.org/10.1016/j.trd.2020.102465

Gallo, M., & Marinelli, M. (2020). Sustainable mobility: A review of possible actions and policies. *Sustainability, 12*(18). https://doi.org/10.3390/su12187499

Geurs, K., Grigolon, A., Münzel, K., Gkiotsalitis, K., Duran-Rodas, D., Büttner, B., Kirchberger, C., Pappers, J., Ramirez, L. M., Graf, A., Hansel, J., Gkrava, R., & Klementschitz, R. (2023). The Smarthubs integration ladder: a conceptual model for the categorisation of shared mobility hubs. *Transport Reviews, 44*(1), 112–139. https://doi.org/10.1080/01441647.2023.2239499

Haustein, S., & Kroesen, M. (2022). Shifting to more sustainable mobility styles: A latent transition approach. *Journal of Transport Geography, 103*. https://doi.org/10.1016/j.jtrangeo.2022.103394

Heller, R. (2022). *Positieve energie in de stad: innovatie voor een duurzame transitie* [Lectorale rede]. Amsterdam University of Applied Sciences.

Hensher, D. A., Rose, J. M., & Greene, W. H. (2015). *Applied Choice Analysis* (second edition). Cambridge University Press. https://doi.org/10.1017/CBO9781316136232

Hensher, D.A., & Stopher, P.R. (2021). *Behavioural travel modelling* (first edition, Vol. 12). Routledge. https://doi.org/10.4324/9781003156055

Hoerler, R., Stoiber, T., & del Duce, A. (2023). Push and pull strategies to increase the uptake of small electric vehicles. *Transportation Research. Part D, Transport and Environment, 116*. https://doi.org/10.1016/j.trd.2023.103638

Holden, E., Banister, D., Gössling, S., Gilpin, G., & Linnerud, K. (2020). Grand Narratives for sustainable mobility: A conceptual review. *Energy Research & Social Science, 65*. https://doi.org/10.1016/j.erss.2020.101454

Holotová, M., Hagyová, L., Holota, T., & Cagánová, D. (2023). Sustainable Urban Mobility-Multimodality as a Chance for Greener Cities: Evidence from Slovakia. In: Cagáňová, D., Horňáková, N. (eds). *Industry 4.0 Challenges in Smart Cities* (pp.107-118). EAI/Springer Innovations in Communication and Computing. https://doi.org/10.1007/978-3-030-92968-8_7

Huizenga, P. (2022, February 3). [Mobility hubs]. Retrieved on January 8, 2024, from https://blog.ptvgroup.com/nl/stad-en-mobiliteit/mobiliteitshubs-dit-is-wat-je-moet-weten/

Kemperman, A. D. A. M. (2000). *Temporal aspects of theme park choice behaviour : modeling variety seeking, seasonality and diversification to support theme park planning*. [Phd Thesis 1 (Research TU/e / Graduation TU/e), Built Environment]. Eindhoven University of Technology. https://doi.org/10.6100/IR542240

Kemperman, A. D. A. M. (2022). Urban Research Methods: Discrete Choice Models & Stated Choice Experiments. [Slide show; Lecture Eindhoven University of Technology].

Kuss, P., & Nicholas, K. A. (2022). A dozen effective interventions to reduce car use in European cities: Lessons learned from a meta-analysis and transition management. *Case Studies on Transport Policy, 10*(3), 1494–1513. https://doi.org/10.1016/j.cstp.2022.02.001

Linder, N., Giusti, M., Samuelsson, K., & Barthel, S. (2021). Pro-environmental habits: An underexplored research agenda in sustainability science. *Ambio, 51*(3), 546–556. https://doi.org/10.1007/s13280-021-01619-6

Macea, L. F., Márquez, L., & Soto, J. J. (2023). How do the affective and symbolic factors of private car driving influence car users' travel behaviour in a car restriction policy scenario? *Transport Policy, 140*, 100–113. https://doi.org/10.1016/j.tranpol.2023.07.001

Machado, C. A. S., De Salles Hue, N. P. M., Berssaneti, F. T., & Quintanilha, J. A. (2018). An overview of shared mobility. *Sustainability, 10*(12). https://doi.org/10.3390/su10124342

Melkonyan, A., Gruchmann, T., Lohmar, F., & Bleischwitz, R. (2022). Decision support for sustainable urban mobility: A case study of the Rhine-Ruhr area. *Sustainable Cities and Society, 80.* https://doi.org/10.1016/j.scs.2022.103806

Meulepas, J., de Boer, A., Krumm, P., van der Linde, L., Alferink, B., Bartman, C., Prudhomme van Reine, C., & Taylor, D. (2021). Ontwikkelplan mobiliteitshubs West-Brabant. Retrieved from https://www.brabant.nl/-/media/199b4b4d3bf4407c822df1cfa208c867.pdf

Milieu Centraal. (n.d.). Alles over autodelen en huren. Retrieved on May 17, 2024, from https://www.milieucentraal.nl/duurzaam-vervoer/alternatieven-voor-de-auto/alles-over-autodelen-en-huren/

Ministry of Infrastructure and Water Management. (2022). Landelijk reizigersonderzoek 2022. Retrieved from https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2023/03/01/landelijk-reizigersonderzoek-2022/2023-04-05-Landelijk-Reizigersonderzoek-2022.pdf

Miramontes, M., Pfertner, M., Rayaprolu, H. S., Schreiner, M., & Wulfhorst, G. (2017). Impacts of a multimodal mobility service on travel behaviour and preferences: user insights from Munich's first Mobility Station. *Transportation, 44*, 1325–1342. https://doi.org/10.1007/s11116-017-9806-y

Municipality of Eindhoven. (2024). Eindhoven – in cijfers. Retrieved on May 18, 2024, from https://eindhoven.incijfers.nl/jive

Municipality of Eindhoven. (n.d.). [Map municipality of Eindhoven]. Retrieved on May 18, 2024, from https://www.eindhovenduurzaam.nl/energie-warmte/aardgasvrij/in-welke-buurten-zijn-we-al-bezig

Natuur en Milieu. (2020). mobiliteitshubs. Retrieved from https://natuurenmilieu.nl/app/uploads/Brochure-Mobiliteitshubs-1.pdf

O'Driscoll, C., Crowley, F., Doran, J., & McCarthy, N. (2024). How the relationship between socio-demographics, residential environments and travel influence commuter choices. *Regional Studies, 58*(3), 636–653. https://doi.org/10.1080/00343404.2023.2199779

Ogunkunbi, G. A., & Meszaros, F. (2023). Preferences for policy measures to regulate urban vehicle access for climate change mitigation. *Environmental Sciences Europe*, *35*(1). https://doi.org/10.1186/s12302-023-00745-0

Prochaska, J. O. (2008). Decision making in the transtheoretical model of behaviour change. *Medical Decision Making, 28*(6), 845–849. https://doi.org/10.1177/0272989X08327068

Province of Noord-Holland. (2023). *Hubstrategie provincie Noord-Holland* (No. KHM4HWDQZXHN-629667062-311:1.0). Provincie Noord-Holland. https://www.noord-holland.nl/dsresource?objectid=6457beab-cca0-474c-be5a-d1953ee2f273&type=PDF

Rahman, M. (2023). Commute mode switch and its relationship to life events, built-environment, and attitude change. *Transportation Research, Part D, Transport and Environment, 120*. https://doi.org/10.1016/j.trd.2023.103777

Rahman, M., & Sciara, G. (2022). Travel attitudes, the built environment and travel behaviour relationships: Causal insights from social psychology theories. *Transport Policy, 123,* 44–54. https://doi.org/10.1016/j.tranpol.2022.04.012

Ramos, É. M. S., Bergstad, C. J., Chicco, A., & Diana, M. (2020). Mobility styles and car sharing use in Europe: attitudes, behaviours, motives and sustainability. *European Transport Research Review*, *12*(1). https://doi.org/10.1186/s12544-020-0402-4

Rijksoverheid. (2021). *Woononderzoek Nederland*. Woononderzoek.nl. Retrieved April 25, 2024, from https://woononderzoek.nl/mosaic/dashboard/1--kerncijfers

Rijksoverheid. (2023, March 28). *Omgevingsprikkels*. Kcbr.nl. Retrieved January 8, 2024, from https://www.kcbr.nl/beleid-en-regelgeving-ontwikkelen/beleidskompas/3-wat-zijn-opties-om-het-doel-te-realizeren/31-beleidsinstrumenten/communicatie/omgevingsprikkels

Rongen, T., Lenferink, S., Arts, J., & Tillema, T. (2023). The peripheral mobility hub as a multi-sided platform? Applying a Fuzzy Delphi to identify promising stakeholder interactions. *Research in Transportation Business and Management, 47*. https://doi.org/10.1016/j.rtbm.2023.100953

Rongen, T., Tillema, T., Arts, J., Alonso-González, M. J., & Witte, J. (2022). An analysis of the mobility hub concept in the Netherlands: Historical lessons for its implementation. *Journal of Transport Geography*, *104*. https://doi.org/10.1016/j.jtrangeo.2022.103419

Roukouni, A., Junyent, I. A., Casanovas, M. M., & De Almeida Correia, G. H. (2023). An Analysis of the Emerging “Shared Mobility Hub” Concept in European Cities: Definition and a Proposed Typology. *Sustainability, 15*(6), 5222. https://doi.org/10.3390/su15065222

Short, J. R., & Farmer, A. (2021). Cities and Climate Change. *Earth, 2*(4), 1038–1045. https://doi.org/10.3390/earth2040061

Social Change UK. (2019). *The COM-B Model of Behaviour*. Retrieved September 25, 2023, from https://social-change.co.uk/files/02.09.19_COM-B_and_changing_behaviour_.pdf

Sodiq, A., Baloch, A. A. B., Khan, S. A., Sezer, N., Mahmoud, S., Jama, M., & Abdelaal, A. (2019). Towards modern sustainable cities: Review of sustainability principles and trends. *Journal of Cleaner Production, 227,* 972–1001. https://doi.org/10.1016/j.jclepro.2019.04.106

Steg, L., & De Groot, J.I.M. (2018). *Environmental psychology: An Introduction*. John Wiley & Sons Ltd. https://doi.org/10.1002/9781119241072

Stern, P. C. (2000). Toward a coherent theory of environmentally significant behaviour. *Journal of Social Issues, 56*(3), 407–424. https://doi.org/10.1111/0022-4537.00175

Sun, L., Yang, S., Li, S., Zhang, Y. (2020). Does education level affect individuals’ environmentally conscious behaviour? Evidence from Mainland China. *Social Behaviour and Personality: an international journal, 48*(9), 1-12. https://doi.org/10.2224/sbp.8488

Train, K. E. (2009). *Discrete choice methods with simulation* (second edition). Cambridge University Press. https://doi.org/10.1017/CBO9780511805271

TUMI. (2021, September). *Transport demand management – push and pull*. Retrieved January 8, 2024, from https://transformative-mobility.org/multimedia/transport-demand-management-push-and-pull/

UITP. (April, 2023). *Mobility hubs: steering the shift towards integrated sustainable mobility*. Retrieved September 25, 2023, from https://cms.uitp.org/wp/wp-content/uploads/2023/06/Policy-Brief-Mobility-hubs-web.pdf

Van Aken, J., & Berends, H. (2018). *Problem Solving in Organizations: A Methodological Handbook for Business and Management Students* (third edition). Cambridge University Press. https://doi.org/10.1017/9781108236164

Vereniging Deltametropool. (2013). *Knooppuntenmilieus*. Retrieved November 23, 2023, from https://deltametropool.nl/app/uploads/2019/07/20130530_Handout_uitleg_typologieen_vlinders_web.pdf

Verplanken, B., & Orbell, S. (2019). Habit and Behaviour Change. In Sassenberg, K., & Vliek, M.L.W. (eds.), *Social Psychology in Action: Evidence-Based Interventions from Theory to Practice* (pp. 65-78). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-13788-5_5

Verplanken, B., & Whitmarsh, L. (2021). Habit and climate change. *Current Opinion in Behavioural Sciences, 42,* 42–46. Elsevier Ltd. https://doi.org/10.1016/j.cobeha.2021.02.020

Wallsten, A., Henriksson, M., & Isaksson, K. (2021). The Role of Local Public Authorities in Steering toward Smart and Sustainable Mobility: Findings from the Stockholm Metropolitan Area. *Planning Practice and Research, 37*(5), 532-546. https://doi.org/10.1080/02697459.2021.1874638

Weustenenk, A. G., & Mingardo, G. (2023). Towards a typology of mobility hubs. *Journal of Transport Geography, 106*. https://doi.org/10.1016/j.jtrangeo.2022.103514

Whitmarsh, L., Poortinga, W., & Capstick, S. (2021). Behaviour change to address climate change. *Current Opinion in Psychology, 42*, 76-81. https://doi.org/10.1016/j.copsyc.2021.04.002

Witte, J.-J., Alonso-González, M., & Rongen, T. (2021). *Verkenning van het concept mobiliteithub* (ISBN 978-90-8902-245-5). Ministerie van Infrastructuur en Waterstaat. Retrieved November 23, 2023, from https://www.kimnet.nl/binaries/kimnet/documenten/rapporten/2021/05/31/verkenning-van-het-concept-mobiliteitshub/Rapport+Verkenning+Mobiliteitshub_pdfA.pdf

Zwikker R., Riever, E., Shachaf, T., Aglitati, S., Scholten, B., Van Langevelde, C., Van De Wall, R., Gerretsen, P., & Soret, L. (2021). *Hubs in bestaande wijken: Verkennend onderzoek naar ruimtelijke inpassing en impact*. Vereniging Deltametropool. Retrieved November 22, 2023, from https://www.dropbox.com/s/wp0op7ceehu2m5u/hubs-bestaande-wijken_rapport_dropbox.pdf?e=1&dl=0

Appendix A: Background literature hub definition and typologies

This appendix shows the overview of the background literature on which the hub definition and typologies in this research are based (Table A1 and Table A2). In Table A1, relevant hub definitions are stated. The specific elaborations of the concepts of hubs differ between several authors. The most important phrases that connect the definitions together are therefore underlined. Regarding Table A2, as stated before, only hubs that can be reached without a car and that are on local or (inter)regional scale, are considered in this research. Besides, private hubs are excluded (indicated in dark orange).

Table A 1: Overview relevant mobility hub definitions found in literature.

Mobility hub definition	Author(s)	Source
"Mobility hubs are described as clusters of either new, shared, or electric mobility services available at designated locations where travel demand is high, which can be integrated into conventional public transport services."	Rongen et al. (2022)	Scientific paper
"A focal point in the transport network that seamlessly integrates different modes, especially mass public transport, shared and active mobility. It combines supportive multimodal infrastructure such as charging points and placemaking strategies. A hub maximizes access to mobility and other resources, while ensuring a transfer between modes for first- and last-mile connectivity."	UITP (2023)	Report
"A hub is a physical node in a multimodal mobility network, where various journeys and transport modes converge. A hub functions, on the one hand, as the start-, transfer-, or end endpoint of a journey, and, on the other hand, as a place where it is pleasant to stay and where there is space for additional facilities such as, for example, a parcel point."	Province of Noord-Holland (2023)	Report
"Multimodal mobility hubs, commonly known as 'Mobility Stations' in Germany, are multimodal transport nodes that facilitate intermodal transfers by providing different mobility options in close proximity. Here public transport (PT) plays a central role usually in connection with an additional shared mobility service. Beyond the concept of Bike and Ride (B+R) or Park and Ride (P+R), the multimodal mobility service at Mobility Stations is integrated either through information (multimodal trip planners), marketing, tariffs (mobility packages) and/or access (multimodal smart cards)."	Miramontes et al. (2017)	Scientific paper
"A shared mobility hub is a location where multiple sustainable transport modes come together at one place, providing a seamless connection between modes, offering besides public transport several shared mobility options, but also potentially including other amenities, ranging from retail, workplaces, to parcel pick-up points like lockers."	Blad et al. (2022)	Scientific paper
"A mobility hub is a recognisable place with an offer of different and connected transport modes supplemented with enhanced facilities and information features to both attract and benefit the traveller."	CoMoUK (2019)	Report
"A Mobility Hub is a connectivity place where different travel options like biking, public transport, and shared mobility come together. Additionally, we may also include side services like parking stations for different transport modes such as cars or bicycles. The main idea is that these places provide access to a whole ecosystem of mobility services to connect the city most effectively and efficiently. They intend to help an individual to get to their final destination as fast and easy as possible and to ease transfers."	Bueno (2021)	Master Thesis

Mobility hub definition	Author(s)	Source
"Hubs are physical links between modes of transport that, in addition to their mobility function, can also serve as focal points for spatial development. Hubs exist at different scales, from a neighbourhood facility to an (inter)national mainport. Hubs also differ in the transport services that are offered there. This can be multimodal interchange but also access to shared mobility and light electric freight vehicles. Hubs can also interact with nearby facilities."	Witte et al. (2021)	Report
"Mobility hubs are seen as an essential link to enable flexible and seamless travel in the mobility chain. Mobility hubs are multimodal interchanges of different orders, sizes, and facility levels. They are physical locations where mobility services and flows converge in an attractive environment."	CROW (2022)	Report
"A hub is a public transport point and/or a clustered, space-efficient parking solution for multiple target groups that enables a seamless transfer from one mode of transport to another. Mobility hubs are therefore an essential link in the system of shared mobility. Each traveller can reconfigure his or her journey every time, tailored to his or her needs at that moment; spatially this comes together at mobility hubs. Besides serving as an interchange from car or bike to public transport, it is also a place where functions can be added (catering, parcel wall) or users can stay (flex workplaces)."	Meulepas et al. (2021)	Report
"A mobility hub is a high-quality physical location that combines a diverse range of sustainable and active means of transport combined with pleasant accommodation opportunities. Travellers have freedom of choice and can easily change to other means of transport. The hub is more than a connection point for means of transport. A mobility hub is an attractive and recognizable environment, which is comfortable and safe. It is pleasant for travellers to stay and transfer. Besides, it is also a pleasant place for local residents and others."	Natuur en Milieu (2020)	Report

Table A 2: Overview relevant mobility hub definitions found in literature.

Hub name	Level of amenities	Variety of modes	Geographical location	Operation scale	Source	Source type	Shared mobility present	Amenities present
Community hub (=private hub)	-	Low	Neighbourhood, no car needed to reach hub	Local	Weustenenk and Mingardo (2023)	Scientific paper	cars, bicycles and scooters	-
Neighbourhood hub	Medium	Medium	Neighbourhood, no car needed to reach hub	Local	Weustenenk and Mingardo (2023)	Scientific paper	cars, bicycles, mopeds and an PT connection by bus or tram	Have a higher level of quanity and complexity of both services and facilities, such as package pick-up, grocery stores.
Suburban hub	-	Low	Suburbs, car needed to reach hub	Local	Weustenenk and Mingardo (2023)	Scientific paper		
City district hub	High	High	District, no car needed to reach hub	(Inter)-regional	Weustenenk and Mingardo (2023)	Scientific paper	Trains, busses, etro's, trams, taxis, and shared mobility come together.	Small retail facilities and package pick up points.
City edge hub	Low	Low	Edge of city, car needed to reach hub	(Inter)-regional	Weustenenk and Mingardo (2023)	Scientific paper		
City centre hub	High	High	City centre, no car needed to reach hub	National	Weustenenk and Mingardo (2023)	Scientific paper		
Neighbourhood hub	-	Low	Neighbourhood, no car needed to reach hub	Local	Province of Noord-Holland (2023)	Report	Bikes, cargo bikes and scooters	-
District hub	Low	Medium	Neighbourhood, no car needed to reach hub	Local	Province of Noord-Holland (2023)	Report	Bikes, cargo bikes, scooters and cars	Parcel locker and, optionally, flex work spaces and catering
Zone hub ("streekhub")	-	Low	Core of small cities, car needed to reach hub	(Inter)-regional	Province of Noord-Holland (2023)	Report		
City hub	High	High	City centre, no car needed to reach hub	National	Province of Noord-Holland (2023)	Report		
Region hub - city outskirts hub	Low	Medium	Edge of city, car needed to reach hub	(Inter)-regional	Province of Noord-Holland (2023)	Report		
Region hub - corridor hub	Low	Medium	Greater distance from cities, car needed to reach hub	National	Province of Noord-Holland (2023)	Report		
Residential mobility hub (=private hub)	-	Low	Neighbourhood, no car needed to reach hub	Local	Blad et al. (2022)	Scientific paper		
City mobility hub	-	High	City centre, no car needed to reach hub	National	Blad et al. (2022)	Scientific paper		
Regional mobility hub	-	Medium	Edge of city, car needed to reach hub	(Inter)-regional	Blad et al. (2022)	Scientific paper		
Microhub	-	Medium	Neighbourhood, no car needed to reach hub	Local	Zwikker et al. (2021)	Report	Bikes, cargo bikes and scooters	-
Small hub	-	Medium	Neighbourhood, no car needed to reach hub	Local	Zwikker et al. (2021)	Report	Bikes, cargo bikes and scooters	-
Medium hub	-	Medium	District, no car needed to reach hub	Local	Zwikker et al. (2021)	Report	Bikes, cargo bikes and scooters	-
Large hub	-	Medium	District, no car needed to reach hub	Local	Zwikker et al. (2021)	Report	Bikes, cargo bikes and scooters	-

Table A 2 continued.

Hub name	Level of amenities	Variety of modes	Geographical location	Operation scale	Source	Source type	Shared mobility present	Amenities present
Neighbourhood hub	-	Low	Neighbourhood, no car needed to reach hub	Local	Arseneault (2022)	Report	Bikes and scooters	-
Central hub	-	Medium	District, no car needed to reach hub	Local	Arseneault (2022)	Report	Bikes, scooters and cars	Passenger pick-up points
Regional hub	Medium	High	City centre, no car needed to reach hub	National	Arseneault (2022)	Report		
City hub	High	High	City centre, no car needed to reach hub	National	CROW (2022)	Report		
Cityring hub (=P+R)	-	Low	Edge of city, car needed to reach hub	(Inter)-regional	CROW (2022)	Report		
City edge hub	Low	Medium	Edge of city, car needed to reach hub	(Inter)-regional	CROW (2022)	Report		
Region hub	Low	High	Greater distance from cities, car needed to reach hub	National	CROW (2022)	Report		
Neighbourhood hub	Low	Low	Neighbourhood, no car needed to reach hub	Local	CROW (2022)	Report	Bikes, steps, scooters and cars	Travel information, shops and potentially: catering, restaurants, waiting areas, parcel lockers, flex offices and meeting spaces
Village hub	Low	Low	Core of small cities, no car needed to reach hub	(Inter)-regional	CROW (2022)	Report	Bike, steps, scooters and cars	Travel information, shops and potentially: catering, restaurants, waiting areas, parcel lockers, flex offices and meeting spaces
Transit-oriented development hub	High	High	City centre, no car needed to reach hub	National	Rongen et al. (2022)	Scientific paper		
P+R hubs	Low	Medium	Greater distance from cities, car needed to reach hub	(Inter)-regional	Rongen et al. (2022)	Scientific paper		
Micromobility hub	-	Low	Neighbourhood, no car needed to reach hub	Local	UITP (2023)	Report	Bikes and steps	-
Neighbourhood hub	-	Low	Neighbourhood, no car needed to reach hub	Local	UITP (2023)	Report	Bikes, steps, scooters and cars	-
Key destination hub	-	Medium	Greater distance from cities, car needed to reach hub	(Inter)-regional	UITP (2023)	Report		
Local interchange hub	-	Medium	District, no car needed to reach hub	Local	UITP (2023)	Report	Bikes, scooters, cars, tram and bus connection	Covered waiting area and actual travel information
Village hub	-	Medium	Core of small cities, no car needed to reach hub	(Inter)-regional	UITP (2023)	Report	Bikes and bus connection	-
Suburban interchange hub	-	Medium	Edge of small cities, car needed to reach hub	(Inter)-regional	UITP (2023)	Report		
Large interchange hub	High	High	City centre, no car needed to reach hub	National	UITP (2023)	Report		

Table A 2 continued.

Hub name	Level of amenities	Variety of modes	Geographical location	Operation scale	Source	Source type	Shared mobility present	Amenities present
Large interchanges / city hubs	Medium	High	City centre, no car needed to reach hub	National	CoMoUK (2019)	Report		
Transport corridor / linking hubs	High	High	District, no car needed to reach hub	(Inter)-regional	CoMoUK (2019)	Report	regional rail or tram, local bus, taxi, DRT feeder service, bike share, cargo bike share, share cars	Covered waiting areas, safer crossings, package delivery lockers, wi-Fi / phone charging, play equipment, kiosk for refreshments
Business park / new housing development hubs	High	High	Edge of city, no car needed to reach hub	Local	CoMoUK (2019)	Report	regional rail or tram, local bus, taxi, DRT feeder service, bike share, cargo bike share, share cars	Covered waiting areas, improved public realm, art / planting / play equipment, package delivery lockers.
Suburbs / mini hubs	Low	Medium	Neighbourhood, no car needed to reach hub	Local	CoMoUK (2019)	Report	Local bus, DRT feeder services, micro-mobility	Traffic calming and street repairs, parklet, community exercise equipment
Village hubs	Low	High	Core of small cities, no car needed to reach hub	(Inter)-regional	CoMoUK (2019)	Report	regional rail or tram, local bus, DRT feeder service, taxi, bike share, cargo bike share, share cars	covered waiting area, package delivery lockers.
Tourism hubs	Medium	High	Edge of city, car needed to reach hub	National	CoMoUK (2019)	Report		
Neighbourhood hub	-	Low	Neighbourhood, no car needed to reach hub	Local	Witte et al. (2021)	Report	Small-scale hub in neighbourhood	
District hub	Low	Medium	District, no car needed to reach hub	Local	Witte et al. (2021)	Report	Large-scale hub in neighbourhood	
Region hub	Low	High	Greater distance from cities, car needed to reach hub	(Inter)-regional	Witte et al. (2021)	Report		
City edge hub / city centerring hub	Low	High	Edge of city, car needed to reach hub	(Inter)-regional	Witte et al. (2021)	Report		
City hub	High	High	City centre, no car needed to reach hub	National	Witte et al. (2021)	Report		
(inter)national hub	High	High	Greater distance from cities, car needed to reach hub	Inter-national	Witte et al. (2021)	Report		
Parking hub (P+R)	Medium	Medium	Edge of city, car needed to reach hub	(Inter)-regional	Natuur en Milieu (2020)	Report		
Street / mini hub	-	Low	Neighbourhood, no car needed to reach hub	Local	Natuur en Milieu (2020)	Report	Bike, scooter, cargo bike and optional car	Optional: flex offices, charging points, parcel lockers, community café, playgarden or sport facilities
Central public transport hub	High	High	City centre, no car needed to reach hub	National	Natuur en Milieu (2020)	Report		
Business park hub	-	Low	Edge of city, car needed to reach hub	Local	Natuur en Milieu (2020)	Report		
Urban node hub	High	High	City centre, no car needed to reach hub	National	Meulenpas et al. (2021)	Report		

Table A 2 continued.

Hub name	Level of amenities	Variety of modes	Geographical location	Operation scale	Source	Source type	Shared mobility present	Amenities present
City hub	Low	Medium	District, no car needed to reach hub	Local	Meulenpas et al. (2021)	Report	Bike, scooter, step and car	Toilet, vending machine, parcel lockers
Highway hub	Medium	High	Greater distance from cities, car needed to reach hub	(Inter)-regional	Meulenpas et al. (2021)	Report		
Peripheral road hub	Low	Medium	Greater distance from cities, car needed to reach hub	(Inter)-regional	Meulenpas et al. (2021)	Report		
Regional hub (stations)	High	High	Core of small cities, no car needed to reach hub	National	Meulenpas et al. (2021)	Report		
Local hub	Low	Medium	Core of small cities, no car needed to reach hub	(Inter)-regional	Meulenpas et al. (2021)	Report	Bike, scooter, step and car	Toilet, vending machine, parcel locker, flex offices and community café

Additional information:

- Community components defined by Benison and Anderson (n.d.) are playground, food truck, pop-up market, delivery lockers and vending machines, co-working spaces, smart street lights.
- Environmental components defined by Benison and Anderson (n.d.) are plants and green pockets, community garden with smart rainwater features, pocket parks, space to gather and community seating.
- Social safety and environmental quality are mentioned as necessity for hubs by Meulenpas et al. (2021).
- Basic facilitating amenities are available: seating, toilet, kiosk and water tap according to Natuur en Milieu (2020)
- Experiment with new features: This makes the hub an attractive place at the neighbourhood or street level and promotes support for the mobility hub according to Natuur en Milieu (2020)
- Safety: Use proper street lighting to improve (the feeling of) safety. Additionally, hiring staff at the hub (during certain times of the day) can not only enhance safety but also improve the service level at the hub according to Natuur en Milieu (2020).
- Social safety is a necessity for the successfulness of a hub (it is a pull-factor) according to Witte et al. (2021).
- Province of Noord-Holland (2023) state that the goal of neighbourhood hubs and district hubs is shared mobility as alternative for private car usage.
- UITP (2023) state that the goal of neighbourhood hubs is increasing multimodal trips, walking, cycling and public transport, and reducing private use of cars. Besides an goal is to improve the public realm.

Appendix B: Background literature flanking policies

This appendix provides the overview of relevant flanking policies and their corresponding push and pull effects in Table B1.

Table B 1: Overview mobility measures including their push and/or pull effects.

Policy	Push	Pull	Both
Parking management and restricted zones (Gallo & Marinelli, 2020; TUMI, 2021)	X		
Car limited zones (TUMI, 2021)	X		
Permanent or temporary car bans (TUMI, 2021)	X		
Congestion management (TUMI, 2021)	X		
Road pricing schemes (Diao, 2019; TUMI, 2021)	X		
30 km/h zones (Gallo & Marinelli, 2020)	X		
Pricing policies / taxation / toll (Gallo & Marinelli, 2020; Melkonyan et al., 2022)	X		
Low/zero-emission zones or traffic regulated zones (Macea et al., 2023; Melkonyan et al., 2022; Ogunkunbi & Meszaros, 2023)	X		
Congestion charging schemes (Diao, 2019; Macea et al., 2023)	X		
License plate lottery or license plate restriction charging policy (Macea et al., 2023)	X		
Reducing road capacity (Macea et al., 2023)	X		
Additional Registration Fee (ARF) and requirement to obtain Certificate of Entitlement when buying private cars (Diao, 2019)	X		
CO_2-pricing schemes (Melkonyan et al., 2022)	X		
Integrated mobility-sharing action plan (Gallo & Marinelli, 2020; Kuss & Nicholas, 2022)		X	
High service frequency (TUMI, 2021)		X	
Comfortable stops and surroundings (TUMI, 2021)		X	
Cycle networks and pedestrian connections (Gallo & Marinelli, 2020; TUMI, 2021)		X	
Mobility services (e.g. free public transport pass) (Kuss & Nicholas, 2022)		X	
Public transport priorities (TUMI, 2021)		X	
(personalized) travel planning / carpooling schemes (Kuss & Nicholas, 2022; Rongen et al., 2023)		X	
Gamification (through competition app) (Kuss and Nicholas, 2022)		X	
Information campaigns (Whitmarsh et al., 2021)		X	
Environmental cues (Rijksoverheid, 2023)		X	
Financial incentives / mobility vouchers (Rijksoverheid, 2023)		X	
Built environment rearrangement (5-minute cities) (Diao, 2019)		X	
Parking and traffic control (revenues are invested in public transport) (Kuss & Nicholas, 2022)			X
Adjustment of traffic light time-cycles (TUMI, 2021)			X
Public awareness campaigns, marketing and participation (TUMI, 2021)			X
Enforcement and penalizing (TUMI, 2021)			X
Congestion charging (and revenues are invested in public transport) (Kuss & Nicholas, 2022)			X
Workplace parking charging (and revenues are invested in public transport) (Kuss & Nicholas, 2022)			X
Limited traffic zone (and revenues are invested in public transport) (Kuss & Nicholas, 2022)			X
Reduction of road space (TUMI, 2021)			X

Appendix C: Interview set-up

This appendix shows the semi-structured interview set-ups. Different parties are interviewed. therefore some questions are altered based on the party that is interviewed, for example, municipalities versus provinces. The grey questions are additional questions which could be asked in case there is additional time during the interviews.

Municipalities/provinces

Structure

1. Short introduction round.
    a. Who are you? What is your role within the municipality? Have you been working for the municipality for a long time?
2. Explanation of research.
3. Explanation of structure of interview.
    a. Briefly discuss first three topics.
    b. Elaborate from section 3 onwards.
4. Ask permission to record the interview.
    a. Handle information with care and anonymously.
    b. Data will be stored at TU/e OneDrive and therefore protected against data leaks.

Interview

Section 1: current situation

1. What role do sustainable mobility forms and private cars currently play within your municipality/city/province?
    a. Multiple choice: Do you experience problems in your municipality/province due to the use of private cars? If so, which ones?
        i. Climate
        ii. Congestion
        iii. Space usage
        iv. Health of residents (e.g. declining air quality)
        v. Safety
        vi. Other ….
    b. Which kind of car journeys mainly cause this problem? What is the travel motive?
        i. Commuting out of the city
        ii. Commuting inside the city
        iii. Tourists/ leisure activities
        iv. Inner-city travel
        v. Other …
            1. Travel within urban areas
            2. From rural areas to cities and the other way around
            3. From city to city
            4. Within rural areas

c. In which part of the city/municipality/province do these problem occur? In which neighbourhood?
    i. Centre
    ii. City outskirts
    iii. Other …

Section 2: future mobility vision

1. How do you see the role of sustainable mobility modes on the one hand and the role of the private car on the other hand within your municipality/city/province in ten years? Do you expect the role of private cars to change in the short term?
2. If you want to reduce car use and/or car ownership, how do you plan to achieve this? And do behaviour-changing measures play a role in this?
3. Do you as municipality/province experience challenges/problems in changing car use and/or ownership? If so, what are they?
    a. What is the reason for these problems/challenges?
    b. Do you think people use their cars out of habits or other considerations?
        i. Yes? Follow up! No? Test if it is applicable?
    c. Do you think better alternatives are offered in the municipality/province than using a private car?
        i. If yes, do you have the impression that people continue using cars despite better alternatives, or do you already see a shift and what is then causing this shift?

Section 3: Mobility hubs

1. What is your definition of a mobility hub?
2. What is your vision on multimodality and specifically on mobility hubs, excluding central stations?
    a. Is this a method that is currently applied? If so, in which ways? And are they successful? What is the purpose of the hub?
        i. How many? Which locations? Inside or outside the city? What transport options offered? Etc.
    b. If not, do you see potential in applying mobility hubs to reduce car usage? And what would be the goal of the hub?
    c. Do you think a physical hub alone is sufficient to change car behaviour/habits?
        i. Yes, why do you think that?
        ii. No, what else do you think is needed to encourage people to use hubs on the following themes:
            1. Functionality
            2. Flanking policies
            3. Location characteristics
            4. Behaviour change
    d. What are the obstacles that the municipality can influence for implementing hubs?
        i. And what is needed to overcome these obstacles?
3. For which journey types are hubs interesting? Which car journeys can be replaced by multimodality at mobility hubs?
    a. Commuting out of the city
    b. Commuting inside the city
    c. Tourists/ leisure activities

   d. Inner-city travel
   e. Other …
      i. Travel within urban areas
      ii. From rural areas to cities and the other way around
      iii. From city to city
      iv. Within rural areas
4. For which target group do you think mobility hubs are most interesting?
   a. Which social group do you think will be pioneers to use a hub?
5. Which role does your municipality/province play in the implementation of a mobility hub?
   a. Is the municipality/province responsible for implementation? Or is there a significant role for the market? And why?

Concluding question: Would you use a hub? Why or why not? Or what would be necessary for you to use a hub?

Market parties

Structure

5. Short introduction round.
      b. Who are you? What is your role within your organization? Have you been working for this organization for a long time?
6. Explanation of research.
7. Explanation of structure of interview.
   a. Briefly discuss first three topics.
   b. Elaborate from section 3 onwards.
8. Ask permission to record the interview.
   a. Handle information with care and anonymously.
   b. Data will be stored at TU/e OneDrive and therefore protected against data leaks.

Interview

Part 1: Current situation and future mobility vision

1. How do you see the role of sustainable mobility forms and private cars currently in the Netherlands?
   a. Do you see problems caused by the use of private cars? If so, what are they? And what type of car journeys mainly cause these problems?
2. How do you see the role of sustainable mobility modes and private cars in ten years? What role does your organisation play in this?
   a. Do you see the role for parking facilities changing? Perhaps in the future in cooperation with public transport?

Part 2: Mobility hubs

1. What is your definition of a mobility hub?
2. What is your vision on multimodality and specifically on mobility hubs, excluding central stations?

a. Are the hubs currently being implemented successful? And what is the purpose of these hubs?
   i. How many? Which locations? Inside or outside the city? What transportation modes offered? Etc.
b. For future hubs, what are the prerequisites for successful implementation? Are there specific locations?

3. Do you think a physical hub alone is sufficient to change car behaviour/habits?
   a. Yes, why do you think that?
   b. No, what else do you think is needed to encourage people to use hubs on the following themes:
      i. Functionality
      ii. Flanking policies
      iii. Location characteristics
      iv. Behaviour change
4. For which journey types are hubs interesting? Which car journeys can be replaced by multimodality at mobility hubs?
   a. Commuting out of the city
   b. Commuting inside the city
   c. Tourists/ leisure activities
   d. Inner-city travel
   e. Other …
      i. Travel within urban areas
      ii. From rural areas to cities and the other way around
      iii. From city to city
      iv. Within rural areas
5. For which target group do you think mobility hubs are most interesting?
   a. Which social group do you think will be pioneers to use a hub?
6. What role do market parties play in the implementation of mobility hubs?
7. When is a potential mobility hub interesting enough to invest in?
   a. For car parking parties: There are currently many parking garages in urban centres owned by private parties. Do you see potential, perhaps in cooperation with the municipality, to convert these into mobility hubs? Why/why not?

Appendix D: Experimental design

This appendix shows the experimental design which is used for the Stated Choice Experiment (SCE). An experimental design with five attributes with each four levels for which it is possible to estimate interactions between three attributes (mobility modes, amenities and environmental characteristics). The fractional factorial design descripted in Table D1 is be used to create the profiles for the SCE. Table D2 and D3 show the experimental design in textual form for car owners and non-car owners.

Table D 1: Fractional factorial design for experiment with interaction effects of the first three columns.

Experimental design with interaction effect					
#	**Mobility modes available**	**Additional amenities**	**Environmental characteristics**	**Travel time relative to own transportation**	**Travel costs relative to own transportation**
1	0	0	0	0	0
2	0	0	1	1	2
3	0	0	2	2	3
4	0	0	3	3	1
5	0	1	0	1	1
6	0	1	1	0	3
7	0	1	2	3	2
8	0	1	3	2	0
9	0	2	0	2	2
10	0	2	1	3	0
11	0	2	2	0	1
12	0	2	3	1	3
13	0	3	0	3	3
14	0	3	1	2	1
15	0	3	2	1	0
16	0	3	3	0	2
17	1	0	0	1	1
18	1	0	1	0	3
19	1	0	2	3	2
20	1	0	3	2	0
21	1	1	0	0	0
22	1	1	1	1	2
23	1	1	2	2	3
24	1	1	3	3	1
25	1	2	0	3	3
26	1	2	1	2	1
27	1	2	2	1	0
28	1	2	3	0	2
29	1	3	0	2	2
30	1	3	1	3	0
31	1	3	2	0	1
32	1	3	3	1	3

Table D 1 continued.

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
33	2	0	0	2	2
34	2	0	1	3	0
35	2	0	2	0	1
36	2	0	3	1	3
37	2	1	0	3	3
38	2	1	1	2	1
39	2	1	2	1	0
40	2	1	3	0	2
41	2	2	0	0	0
42	2	2	1	1	2
43	2	2	2	2	3
44	2	2	3	3	1
45	2	3	0	1	1
46	2	3	1	0	3
47	2	3	2	3	2
48	2	3	3	2	0
49	3	0	0	3	3
50	3	0	1	2	1
51	3	0	2	1	0
52	3	0	3	0	2
53	3	1	0	2	2
54	3	1	1	3	0
55	3	1	2	0	1
56	3	1	3	1	3
57	3	2	0	1	1
58	3	2	1	0	3
59	3	2	2	3	2
60	3	2	3	2	0
61	3	3	0	0	0
62	3	3	1	1	2
63	3	3	2	2	3
64	3	3	3	3	1

Table D 2: Textual format experimental design for car owners.

Experimental design with interaction effect car owners					
#	**Mobility modes available**	**Additional amenities**	**Environmental characteristics**	**Travel time relative to own transportation**	**Travel costs relative to own transportation**
1	Shared bicycle, shared cargo bicycle and shared scooter	-	-	-10%	-50%
2	Shared bicycle, shared cargo bicycle and shared scooter	-	Greenery and guarded bike parking	0%	0%
3	Shared bicycle, shared cargo bicycle and shared scooter	-	Greenery and smart lighting	10%	25%
4	Shared bicycle, shared cargo bicycle and shared scooter	-	Guarded biking and smart lighting	20%	-25%
5	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	0%	-25%
6	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking.	-10%	25%
7	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	20%	0%
8	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	10%	-50%
9	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	10%	0%
10	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking.	20%	-50%
11	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	-10%	-25%
12	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	0%	25%
13	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	20%	25%
14	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking.	10%	-25%

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
15	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	0%	-50%
16	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	-10%	0%
17	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	-	0%	-25%
18	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	Greenery and guarded bike parking.	-10%	25%
19	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	Greenery and smart lighting	20%	0%
20	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	Guarded biking and smart lighting	10%	-50%
21	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	-10%	-50%
22	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking.	0%	0%
23	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	10%	25%
24	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	20%	-25%
25	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	20%	25%
26	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking.	10%	-25%
27	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	0%	-50%
28	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	-10%	0%

Table D 2 continued.

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
29	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	10%	0%
30	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking.	20%	-50%
31	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	-10%	-25%
32	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	0%	25%
33	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	-	10%	0%
34	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	Greenery and guarded bike parking	20%	-50%
35	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	Greenery and smart lighting	-10%	-25%
36	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	Guarded biking and smart lighting	0%	25%
37	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	20%	25%
38	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking	10%	-25%
39	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	0%	-50%
40	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	-10%	0%
41	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	-10%	-50%
42	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking	0%	0%

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
43	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	10%	25%
44	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	20%	-25%
45	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	0%	-25%
46	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking	-10%	25%
47	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	20%	0%
48	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	10%	-50%
49	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	-	20%	25%
50	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	Greenery and guarded bike parking	10%	-25%
51	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	Greenery and smart lighting	0%	-50%
52	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	Guarded biking and smart lighting	-10%	0%
53	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	10%	0%
54	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking	20%	-50%
55	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	-10%	-25%
56	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	0%	25%

Table D 2 continued.

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
57	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	0%	-25%
58	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking	-10%	25%
59	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	20%	0%
60	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	10%	-50%
61	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	-10%	-50%
62	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking	0%	0%
63	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	10%	25%
64	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	20%	-25%

Table D 3: Textual format experimental design for non-car owners.

Experimental design with interaction effect non-car owners					
#	**Mobility modes available**	**Additional amenities**	**Environmental characteristics**	**Travel time relative to own transportation**	**Travel costs relative to own transportation**
1	Shared bicycle, shared cargo bicycle and shared scooter	-	-	-10%	-25%
2	Shared bicycle, shared cargo bicycle and shared scooter	-	Greenery and guarded bike parking	0%	25%
3	Shared bicycle, shared cargo bicycle and shared scooter	-	Greenery and smart lighting	10%	50%
4	Shared bicycle, shared cargo bicycle and shared scooter	-	Guarded biking and smart lighting	20%	0%
5	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	0%	0%
6	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking.	-10%	50%
7	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	20%	25%
8	Shared bicycle, shared cargo bicycle and shared scooter	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	10%	-25%
9	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	10%	25%
10	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking.	20%	-25%
11	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	-10%	0%
12	Shared bicycle, shared cargo bicycle and shared scooter	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	0%	50%
13	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	20%	50%
14	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking.	10%	0%

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
15	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	0%	-25%
16	Shared bicycle, shared cargo bicycle and shared scooter	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	-10%	25%
17	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	-	0%	0%
18	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	Greenery and guarded bike parking.	-10%	50%
19	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	Greenery and smart lighting	20%	25%
20	Shared bicycle, shared cargo bicycle, shared scooter and shared car	-	Guarded biking and smart lighting	10%	-25%
21	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	-10%	-25%
22	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking.	0%	25%
23	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	10%	50%
24	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	20%	0%
25	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	20%	50%
26	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking.	10%	0%
27	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	0%	-25%
28	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	-10%	25%

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
29	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	10%	25%
30	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking.	20%	-25%
31	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	-10%	0%
32	Shared bicycle, shared cargo bicycle, shared scooter and shared car	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	0%	50%
33	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	-	10%	25%
34	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	Greenery and guarded bike parking	20%	-25%
35	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	Greenery and smart lighting	-10%	0%
36	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	-	Guarded biking and smart lighting	0%	50%
37	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	20%	50%
38	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking	10%	0%
39	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	0%	-25%
40	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	-10%	25%
41	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	-10%	-25%
42	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking	0%	25%

Table D 3 continued.

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
43	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	10%	50%
44	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	20%	0%
45	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	0%	0%
46	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking	-10%	50%
47	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	20%	25%
48	Shared bicycle, shared cargo bicycle, shared scooter, shared car, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	10%	-25%
49	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	-	20%	50%
50	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	Greenery and guarded bike parking	10%	0%
51	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	Greenery and smart lighting	0%	-25%
52	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	-	Guarded biking and smart lighting	-10%	25%
53	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	-	10%	25%
54	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and guarded bike parking	20%	-25%
55	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Greenery and smart lighting	-10%	0%
56	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Small-scale self-service functions, such as parcel locker, medicine locker, and laundry machines	Guarded biking and smart lighting	0%	50%

Table D 3 continued.

#	Mobility modes available	Additional amenities	Environmental characteristics	Travel time relative to own transportation	Travel costs relative to own transportation
57	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	-	0%	0%
58	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and guarded bike parking	-10%	50%
59	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Greenery and smart lighting	20%	25%
60	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium work-related functions, such as community café, flex co-working spaces, and child daycare	Guarded biking and smart lighting	10%	-25%
61	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	-	-10%	-25%
62	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and guarded bike parking	0%	25%
63	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Greenery and smart lighting	10%	50%
64	Shared bicycle, shared cargo bicycle, shared scooter, and bus connection	Medium leisure-related functions, such as bike-repair shop, supermarket and gym	Guarded biking and smart lighting	20%	0%

Table D 4: Combination profiles in choice tasks, which are combined into four choice sets.

Combination profiles for choice tasks			
Choice set	**Choice task**	**Choice alternative A**	**Choice alternative B**
1	1	Profile 19	Profile 4
	2	Profile 37	Profile 43
	3	Profile 44	Profile 24
	4	Profile 6	Profile 15
	5	Profile 41	Profile 46
	6	Profile 59	Profile 17
	7	Profile 39	Profile 11
	8	Profile 26	Profile 61
2	9	Profile 23	Profile 20
	10	Profile 13	Profile 3
	11	Profile 16	Profile 56
	12	Profile 28	Profile 62
	13	Profile 36	Profile 12
	14	Profile 50	Profile 48
	15	Profile 7	Profile 63
	16	Profile 40	Profile 31
3	17	Profile 55	Profile 29
	18	Profile 42	Profile 27
	19	Profile 5	Profile 52
	20	Profile 57	Profile 9
	21	Profile 18	Profile 34
	22	Profile 14	Profile 30
	23	Profile 54	Profile 35
	24	Profile 10	Profile 1
4	25	Profile 25	Profile 51
	26	Profile 53	Profile 49
	27	Profile 2	Profile 21
	28	Profile 8	Profile 33
	29	Profile 38	Profile 22
	30	Profile 45	Profile 60
	31	Profile 58	Profile 32
	32	Profile 47	Profile 64

Appendix E: Questionnaire design

This appendix shows the complete questionnaire, except for the stated choice experiment tasks. One stated choice experiment task is shown in this appendix. In the complete questionnaire, respondents got eight or sixteen choice tasks, depending on whether they answered a second set of choice tasks. The complete sets are in line with the sets described in Appendix D. These sets also differ for car owners and non-car owners as also descripted before. Besides, only the English version of the questionnaire is given in this appendix, for respondents also a Dutch version was available. The hub impressions are adopted from Huizenga (2022).

Language: English - English | Change the language

Mobility behaviour linked to mobility hubs

Dear,

Thank you for your interest in participating in this online survey. My name is Rachelle Weerts and this survey is part of my graduation research at Eindhoven University of Technology (TU/e). The aim of this research is to gain insights into how you travel.

Completing this survey takes about 15 to 20 minutes. Your answers and other information provided by you are completely anonymous and will be kept confidential. The results will only be used for scientific research. You are participating in this survey voluntarily and you can, therefore, stop this survey at any time without reason. The survey is in line with the TU/e security guidelines.

If you have any questions, please feel free to send an e-mail to r.t.a.weerts@student.tue.nl.

Thank you in advance for participating in this research!

Kind regards,

Rachelle Weerts

Note: You can best fill in this survey on a computer, laptop or tablet. If you want to fill in this survey on your phone, you can best use landscape mode.

☐ **Consent for research**
Show policy

Next

Screening

This survey is only relevant if you are living in the Netherlands. If you are not living in the Netherlands, it is not needed to fill in this survey.

*Do you live in the Netherlands?

Choose one of the following answers

○ Yes

○ No

Mobility related questions

We start with some questions related to your travel behaviour and your knowledge about two mobility concepts.

*Which of the following mobility forms are available to you at home or/and within 7.5 kilometers from your home? Please select 'yes', 'no' or 'I do not know'.

7.5 kilometer is the distance most people are able to bike from home.

A private car is a car that is in your posession.

Shared mobility modes are characterized by the fact that you have to pay for them per minute or kilometer. Usually you can book these modes through an app on your mobile phone.

	Yes	No	I do not know
(Electric) bicycle	○	○	○
(Electric) scooter	○	○	○
(Electric) cargo bicycle	○	○	○
Bought private car	○	○	○
Private lease car	○	○	○
Private lease car through employer	○	○	○
Shared car	○	○	○
Shared bicycle	○	○	○
Shared cargo bicycle	○	○	○
Shared scooter	○	○	○
Small-scale public transport (bus, tram, metro)	○	○	○
Large-scale public transport (train)	○	○	○

*Are you familiar with shared mobility (e.g. shared bikes, shared scooters, shared cars)?

Choose one of the following answers

- ○ Yes, and I use it (often)
- ○ Yes, and I have used it before
- ○ Yes, but I have never used it
- ○ No

*Are you familiar with the concept 'mobility hub'?

Choose one of the following answers

- ○ Yes, and I know what a mobility hub is.
- ○ Heard of it before, but I do not know exactly what it means.
- ○ No

*If you have a car at your disposal, what is its energy source? If you do not have a car at your disposal, choose the option 'not applicable'. If you have several cars at your disposal, enter the energy source of the car you use the most.

An available car can also be a shared car, if you do not own a car.

Choose one of the following answers

- ○ Diesel
- ○ Petrol / Gasoline
- ○ Liquefied Petroleum Gas (LPG)
- ○ Electric
- ○ Hybrid (electricity + diesel / petrol)
- ○ Plug-in hybrid (electricity + diesel / petrol)
- ○ Not applicable
- ○ Other: ______

*Do you hold a public transport card?

Choose one of the following answers

- Yes, including subscription (business card, student card, off-peak hours discount etc.)
- Yes, without subscription
- No

*How would you usually travel to the following destinations? If you do not make one of the trips below, please select the option 'not applicable' for this trip.

Work	Please choose...
Educational purposes	Please choose...
Shopping or groceries	
Sport or hobby	
Visiting family or friends	
Day trip (leisure activity)	
Services or personal care (e.g. visiting General Practitioner)	

Please choose...
By foot
(Electric) bicycle
(Electric) scooter
(Electric) cargo bicycle
Bought private car
Private lease car
Private lease car through employer
Borrowed car from family or friends
Shared car
Shared bicylce
Shared cargo bicycle
Shared scooter
Bus
Tram
Metro
Train
Not applicable

*Can you indicate whether the final destination of the trips below are **mainly** located within your municipality or outside your municipality? If you do not make one of the trips below, please select the option 'not applicable' for this trip.

Work	Please choose...
Educational purposes	
Shopping or groceries	
Sport or hobby	Please choose...
Visiting family or friends	Please choose...
Day trip (leisure activity)	Please choose...
Services or personal care (e.g. visiting General Practitioner)	Please choose...

Please choose...
Destination located within my municipality
Destination located outside of my municipality
Not applicable

Transportation mode choices - Information

In this part of the survey, you are asked about your travel behaviour. Eight choices need to be made for which you indicate how you would travel. First you will get some information, after which an example question is shown. After the example question, the real questions will be asked.

This block first explains some of the concepts that will be used in this study. After which an example question is presented.

This section of the survey focuses on the mobility hub concept. A **mobility hub**, or hub in short, is a place where different forms of mobility come together. This makes it easy to **switch between different modes** of transport. Besides, a hub also provides the opportunity for **additonal facilities**, such as a café. Often mobility modes are linked through an **app** to enhance efficiency. Here you can watch a brief explanation of the definition of mobility hubs if desired.

This study focuses on neighbourhood and district hubs. These are mobility hubs that are located close to your residential location and are, therefore, easily accessible by foot or bike. These hubs usually do not accommodate a train connection, however, it is possible to travel to a trainstation via the hub.

This study will include the following mobility modes at mobility hubs: **shared bicycle, shared cargo bicycle, shared scooter, shared car and a bus connection**. Besides, the following facilities will be included: **parcel locker, medicine locker, community café, flex office, child daycare, bicycle repair shop, supermarket, gym and laundry machines**. Below you can find an overview with a brief explanation of the transport options and facilities that may not be familiar to you.

Mobility modes	**Shared bicycle**	**Shared cargo bicycle**	**Shared scooter**	**Shared car**
What does it look like?				
What is it?	A shared bicycle can be used to get from A to B against a small charge (usually per minute of use). After use, the bicycle can be placed (back) in a hub or in a certain area around the hub.	A shared cargo bicycle can be used to get from A to B against a small charge (usually per minute of use). After use, the cargo bicycle can be placed (back) in a hub or in a certain area around the hub.	A shared scooter can be used to get from A to B against a small charge (usually per minute of use). After use, the scooter can be placed (back) in a hub or in a certain area around the hub.	A shared car can be used to get from A to B against a charge (usually per km). After use, the car needs to be parked at a designated spot in a hub.

Facilities	**Parcel locker**	**Medicine locker**	**Flex office**	**Laundry machines**
What does it look like?				
What is it?	Parcels can be collected or shipped here (self-service).	Ordered medicines can be collected here (self-service).	A flex office offers space to work or meet. It is not needed to make a reservation beforehand.	Laundry can be washed here at a rate. Three sizes of drums are available (self-service).

In this part of the survey, also '**smart lightning**' is used. This is lightning which switches on when movement is detected. Therefore, the lightning is not continuous switched on, which saves energy.

You will be presented with a number of choices in the next section. You will be asked to make a total of eight choices about the way you would like to travel to your final destination. In the choice set, you can choose between **two different mobility hubs or your currently usual mode of transport**.

For the mobility hubs, **five components** are taken into account: **the mobility modes available at the hub, the facilities at the hub, the surroundings of te hub, the travel time and the travel costs**. These five components vary per hub that you are about to see.

It is important to note that in this study, it can be assumed that:

- The mobility hubs are always within 300 meter of your **residential location** and can therefore be reached **by foot within 5 minutes**.
- Near your **final destination**, mobility hubs are located as well. These hubs are located within 300 meter of your end destination and this destination can therefore also be reached **by foot within 5 minutes** walking form this hub. You can leave shared mobility vehicles at this hub.
- All means of transport on the hub are **seamlessly integrated through an app**, allowing you to easily and quickly plan and book your journey.
- All offered mobility modes at the hub are **always available** and the bus, if offered, comes four times an hour.
- All shared vehicles offered at the hub are **fully electric**.
- Travelling via a mobility hub is **always more sustainable** than travelling with a private motor vehicle.
- In the cost comparison between the mobility modes offered at the hub and private mobility modes, **all possible costs have been taken into account**. So, including for example maintenance costs.

Here is an example question:

You are planning to make the following **three trips** next week:

On a weekday, you will travel to your **workplace or school** (or other educational purposes). During the weekend, you will **visit family or friends** on Saturday and go on a **day trip** on Sunday. You have the option to make your trips through one of the hubs below or use your own mode of transport. How would you travel to your destination?

You indicated that your **usual travel modes** for the following trips are:

Work:

School or other educational purposes:

Visiting family or friends:

Day trip:

If you indicated somewhere 'not applicable', you can assume for this question that you use your car.

	Hub A	Hub B
		
Mobility modes available	Shared bicycle Shared cargo bicycle Shared scooter Bus connection	Shared bicycle Shared cargo bicycle Shared scooter
Additional functions	Community cafe Flex office Child daycare	-
Travel time compared to own mode of transport	20% slower than own mode of transport.	10% faster than own mode of transport.
Travel costs compared to own mode of transport	As expensive as own mode of transport.	25% more expensive than own mode of transport.
Environment	Greenery and smart lightning.	Greenery and guarded bike parking.

❓ The image shows the mobility modes and facilities presents. Besides it illustrates the environment of the hub.

Weekday trip to **work, school or other educational purposes**	Please choose...
Weekend visit to **family or friends**	Please choose... I use hub A I use hub B I use my usual mode of transport
Weekend **day trip**	

(Impression choice tasks for car owners)

How do you travel?

The real choice questions start now. You are asked to answer 8 questions. Every time you have to indicate how you are going to travel to your destination.

Repetition:

It is important to note that in this study, it can be assumed that:

- The mobility hubs are always within 300 meter of your **residential location** and can therefore be reached **by foot within 5 minutes**.
- Near your **final destination**, mobility hubs are located as well. These hubs are located within 300 meter of your end destination and this destination can therefore also be reached **by foot within 5 minutes** walking form this hub. You can leave shared mobility vehicles at this hub.
- All means of transport on the hub are **seamlessly integrated through an app**, allowing you to easily and quickly plan and book your journey.
- All offered mobility modes at the hub are **always available** and the bus, if offered, comes four times an hour.
- All shared vehicles offered at the hub are **fully electric**.
- Travelling via a mobility hub is **always more sustainable** than travelling with a private motor vehicle.
- In the cost comparison between the mobility modes offered at the hub and private mobility modes, **all possible costs have been taken into account**. So, including for example maintenance costs.

*Question 1:

You are planning to make the following **three trips** next week:

On a weekday, you will travel to your **workplace or school** (or other educational purposes). During the weekend, you will **visit family or friends** on Saturday and go on a **day trip** on Sunday. You have the option to make your trips through one of the hubs below or use your own mode of transport. How would you travel to your destination?

You indicated that your **usual travel modes** for the following trips are:

Work:

School or other educational purposes:

Visiting family or friends:

Day trip:

If you indicated somewhere 'not applicable', you can assume for this question that you use your car.

	Hub A	Hub B
		
Mobility modes available	Shared bicycle Shared cargo bicycle Shared scooter Shared car	Shared bicycle Shared cargo bicycle Shared scooter
Additional functions	-	-
Travel time com-pared to own mode of transport	20% slower than own mode of transport.	20% slower than own mode of transport.
Travel costs com-pared to own mode of transport	As expensive as own mode of transport.	25% cheaper than own mode of transport.
Environment	Greenery and smart lightning.	Guarded bike parking and smart lightning.

The image shows the mobility modes and facilities presents. Besides it illustrates the environment of the hub.

Weekday trip to **work, school or other educational purposes**	Please choose...
Weekend visit to **family or friends**	Please choose... I use hub A I use hub B I use my usual mode of transport
Weekend **day trip**	

(Total of eight choice tasks)

Additional choice questions

You can answer eight more choice questions if you have the time. You would help the research a lot with this.

*Do you want to answer eight additional choice questions?

Choose one of the following answers

- Yes
- No

(In case answered "yes", eight choice tasks are shown)

(Impression choice tasks for non-car owners)

How do you travel? - additional choices

The additional choice questions start now. You are asked to answer 8 questions. Every time you have to indicate how you are going to travel to your destination.

Repetition:

It is important to note that in this study, it can be assumed that:

- The mobility hubs are always within 300 meter of your **residential location** and can therefore be reached **by foot within 5 minutes**.
- Near your **final destination**, mobility hubs are located as well. These hubs are located within 300 meter of your end destination and this destination can therefore also be reached **by foot within 5 minutes** walking form this hub. You can leave shared mobility vehicles at this hub.
- All means of transport on the hub are **seamlessly integrated through an app**, allowing you to easily and quickly plan and book your journey.
- All offered mobility modes at the hub are **always available** and the bus, if offered, comes four times an hour.
- All shared vehicles offered at the hub are **fully electric**.
- Travelling via a mobility hub is **always more sustainable** than travelling with a private motor vehicle.
- In the cost comparison between the mobility modes offered at the hub and private mobility modes, **all possible costs have been taken into account**. So, including for example maintenance costs.

*Question 1:

You are planning to make the following **three trips** next week:

On a weekday, you will travel to your **workplace or school** (or other educational purposes). During the weekend, you will **visit family or friends** on Saturday and go on a **day trip** on Sunday. You have the option to make your trips through one of the hubs below or use your own mode of transport. How would you travel to your destination?

You indicated that your **usual travel modes** for the following trips are:

Work:

School or other educational purposes:

Visiting family or friends:

Day trip:

If you indicated somewhere 'not applicable', you can assume for this question that you use your bicycle or walk.

	Hub A	Hub B
		
Mobility modes available	Shared bicycle Shared cargo bicycle Shared scooter Shared car	Shared bicycle Shared cargo bicycle Shared scooter Bus connection
Additional functions	Community café Flex office Child daycare	Bicycle repair shop Supermarket Gym
Travel time com-pared to own mode of transport	10% faster than own mode of transport.	As fast as own mode of transport.
Travel costs com-pared to own mode of transport	25% more expensive than own mode of transport.	25% more expensive than own mode of transport.
Environment	Guarded bike parking and smart lightning.	Greenery and guarded bike parking.

The image shows the mobility modes and facilities presents. Besides it illustrates the environment of the hub.

Weekday trip to **work, school or other educational purposes**	Please choose...
Weekend visit to **family or friends**	Please choose... I use hub A I use hub B I use my usual mode of transport
Weekend **day trip**	

(Total of eight additional choice tasks)

Facilities

In this part, you are asked to more specifically indicate which facilities that can be present at mobility hubs are important / useful to you.

*Please rank the following facilities according to how important you think it is that these facilities are present at a hub. Start with the facility you think is the most important and end with the facility you think is the least important.

Drag or double-click on the facilities to arrange them.

Available items	Your ranking
Parcel lockers	
Medicine lockers	
Washing machines	
Community café	
Flex office	
Child daycare	
Bicycle repair shop	
Supermarket	
Gym	

(Questions for car owners)

Car usage related questions

In this part, you are aksed more about your car travel behaviour. Besides, you are asked about your view on municipal measures.

*You indicated that you have a car at your disposal. For your car travel behaviour, please indicate whether you strongly disagree (1) or strongly agree (7) with the following statements:

Using my car is something....

	1 (strongly disagree)	2	3	4 (neutral)	5	6	7 (strongly agree)
I do frequently	○	○	○	○	○	○	○
I do automatically	○	○	○	○	○	○	○
I do without having to consciously remember	○	○	○	○	○	○	○
That makes me feel weird if I do not do it	○	○	○	○	○	○	○
I do without thinking	○	○	○	○	○	○	○
That would require effort not to do	○	○	○	○	○	○	○
That belongs to my routine	○	○	○	○	○	○	○
I start doing before I realize I am doing it	○	○	○	○	○	○	○
I would find hard not to do	○	○	○	○	○	○	○
I have no need to think about doing	○	○	○	○	○	○	○
That is typically me	○	○	○	○	○	○	○
I have been doing for a long time	○	○	○	○	○	○	○

Information block:

Municipalities can introduce **additional measures** to discourage car use and encourage the use of alternative modes of transport. Reasons for municipalities to discourage car use are, for example, to increase road safety, to free up more space for greenery, and to minimize noise- and air pollution. Below is a summary table of some of these measures.

Measure	Explanation
Parking fee increases	Parking fees in cities will be increased. This will make it **more expensive to park** your car in cities.
Reduction of parking spaces	The number of parking spaces in cities will be reduced to make way for more green spaces. This **increases the search time** for a parking space.
Introduction zero-emission zones	Zero-emission zones will be introduced in city centres. This allows **only vehicles without combustion engines** to enter the centre.
Introduction 30 km/h zones	In cities, the maximum speed on all roads will be 30 kilometres per hour. This **increases travel time** for car users.
Distribution of shared mobility vouchers	Municipalities distribute vouchers for the use of shared mobility. This allows you to **try out shared mobility at a discount or even for free**.
Redevelopment public space (more one-way roads)	In cities, space is being redesigned. This includes more space for cyclists and pedestrians, and more greenery. To make space, roads disappear and certain roads are designed as one-way roads. **Travel time for car users increases** because it is more difficult to drive in and out of cities.
Introduction of pay for use (toll roads)	Pay for use (toll roads) will be introduced in cities. This means that when you drive a car into the centre of a city, you have to **pay a certain amount**.
Fewer parking permits	Residents in cities can get a **maximum of one parking permit** per household. As a result, it is no longer possible to park a second car in front of your door.

*For each measure, could you indicate whether you would support it? Please give your answer on a scale of 1 to 5, where 1 represents very much opposed to the measure and 5 represents very much in favour of the measure.

	1 (very much opposed to measure)	2	3 (neutral)	4	5 (very much in favour of the measure)
Parking fee increases	○	○	○	○	○
Reduction of parking spaces	○	○	○	○	○
Introduction zero-emission zones	○	○	○	○	○
Introduction 30 km/h zones	○	○	○	○	○
Distribution of shared mobility vouchers	○	○	○	○	○
Redevelopment public space (more one-way roads)	○	○	○	○	○
Introduction pay for use (toll roads)	○	○	○	○	○
Fewer parking permits	○	○	○	○	○

*For each measure, please indicate how your car travel behaviour changes because of this measure on a scale of 1 to 5, where 1 represents much less use of the car and 5 represents much more use of the car. If you choose to not use the car anymore, please select this option.

	1 (much less use of the car)	2	3 (no change in car usage)	4	5 (much more use of the car)	Not use the car anymore
Parking fee increases	○	○	○	○	○	○
Reduction of parking spaces	○	○	○	○	○	○
Introduction zero-emission zones	○	○	○	○	○	○
Introduction 30 km/h zones	○	○	○	○	○	○
Distribution of shared mobility vouchers	○	○	○	○	○	○
Redevelopment of public space (more one-way roads)	○	○	○	○	○	○
Introduction of pay for use (toll roads)	○	○	○	○	○	○
Fewer parking permits	○	○	○	○	○	○

(Questions for non-car owners)

non-car usage related questions

In this part, you are asked more about your travel reasons. Besides, you are asked about your view on municipal measures.

*If you do not own a private car and do not have one at your disposal: to which aspect is your reason for this related? Multiple answers possible.

Select all that apply

- ☐ Not in posession of a driver's license
- ☐ Financial considerations: I cannot afford it
- ☐ Financial considerations: I think it is too expensive
- ☐ Environmental considerations
- ☐ Health considerations
- ☐ No need for a car
- ☐ I prefer to use other modes of transportation
- ☐ There is already a hub in my neighbourhood with shared mobility which I use
- ☐ I have options for shared mobility which I use
- ☐ No reason
- ☐ Other: ______

Information block:

Municipalities can introduce **additional measures** to discourage car use and encourage the use of alternative modes of transport. Reasons for municipalities to discourage car use are, for example, to increase road safety, to free up more space for greenery, and to minimize noise- and air pollution. Below is a summary table of some of these measures.

Measure	Explanation
Parking fee increases	Parking fees in cities will be increased. This will make it **more expensive to park** your car in cities.
Reduction of parking spaces	The number of parking spaces in cities will be reduced to make way for more green spaces. This **increases the search time** for a parking space.
Introduction zero-emission zones	Zero-emission zones will be introduced in city centres. This allows **only vehicles without combustion engines** to enter the centre.
Introduction 30 km/h zones	In cities, the maximum speed on all roads will be 30 kilometres per hour. This **increases travel time** for car users.
Distribution of shared mobility vouchers	Municipalities distribute vouchers for the use of shared mobility. This allows you to **try out shared mobility at a discount or even for free**.
Redevelopment public space (more one-way roads)	In cities, space is being redesigned. This includes more space for cyclists and pedestrians, and more greenery. To make space, roads disappear and certain roads are designed as one-way roads. **Travel time for car users increases** because it is more difficult to drive in and out of cities.
Introduction of pay for use (toll roads)	Pay for use (toll roads) will be introduced in cities. This means that when you drive a car into the centre of a city, you have to **pay a certain amount**.
Fewer parking permits	Residents in cities can get a **maximum of one parking permit** per household. As a result, it is no longer possible to park a second car in front of your door.

*For each measure, could you indicate whether you would support it? Please give your answer on a scale of 1 to 5, where 1 represents very much opposed to the measure and 5 represents very much in favour of the measure.

	1 (very much opposed to measure)	2	3 (neutral)	4	5 (very much in favour of the measure)
Parking fee increases	○	○	○	○	○
Reduction of parking spaces	○	○	○	○	○
Introduction zero-emission zones	○	○	○	○	○
Introduction 30 km/h zones	○	○	○	○	○
Distribution of shared mobility vouchers	○	○	○	○	○
Redevelopment of public space (more one-way roads)	○	○	○	○	○
Introduction of pay for use (toll roads)	○	○	○	○	○
Fewer parking permits	○	○	○	○	○

Socio-demographic questions

In this part, you are presented with some personal questions. This information is needed to complete the scientifc research and conduct a comprehensive research. Once again, your answers are completely anonymous.

*What is your age?

Choose one of the following answers

- Younger than 18 years old.
- 18 years old to 24 years old.
- 25 years old to 29 years old.
- 30 years old to 39 years old.
- 40 years old to 49 years old.
- 50 years old to 59 years old.
- 60 years old to 64 years old.
- 65 years old and over.

*What is your gender?

Choose one of the following answers

- Male
- Female
- Other, or I would rather not say

*What is your highest completed level of education?

Choose one of the following answers

- Primary education
- Vocational education (or vmbo, mbo1, havo undergrand, vwo undergrad)
- Intermediate vocational education (or havo, atheneum, gymnasium, mbo2, mbo3, mbo4)
- Bachelor degree: higher education bachelor degree or university bachelor degree
- Master degree: higher education master degree, university master degree or doctor
- I would rather not say
- Other:

*What is your household composition?

Choose one of the following answers

- Single
- Single parent (with one or more children at home)
- Couple, without children
- Couple, with children
- Non-family household (this includes student households)
- I would rather not say
- Other:

*What is your current employment situation?

Choose one of the following answers

- I work full-time (35 hours or more per week)
- I work part-time (less than 35 hours per week)
- Not working, for example unemployed or retired
- I would rather not say
- Other:

*What is your total (gross) annual household income?

Choose one of the following answers

- Less than €20000 (up till 1/2 time modal income)
- €20000 till €40000 (1/2 time till 1 time modal income)
- €40000 till €60000 (1 time till 1 1/2 times modal income)
- €60000 till €80000 (1 1/2 times till 2 times modal income)
- More than €80000 (more than 2 times modal income)
- I would rather not say

*In the last 12 months, have you experienced any of the following changes in your life? Multiple answers possible. If you have not experienced any of the following changes, please select 'not applicable'.

Select all that apply

- New job
- Child birth
- Residential relocation
- Obtained driver's license
- Started living together (cohabiting)
- Stopped living together (cohabiting)
- Not applicable
- I would rather not say

What are the **four digits** of your postal code?

You can skip this question if you really wish to do so. However, the answer will only be used for scientific research and is really helpful.

Sustainability

This is te last question! We ask you some questions about your environmental beliefs.

Please indicate whether you (dis)agree with the statements on a scale of 1 to 5, where 1 represents strongly disagree and 5 represents strongly agree. There is no right or wrong answer, as these are your personal views.

You can skip this last question if you want. However, this question is really helpful for this scientific research.

	1 (strongly disagree)	2	3 (neutral)	4	5 (strongly agree)
We are approaching the limit of number of people the Earth can support.					
Humans have the right to modify the natural environment to suit their needs.					
When humans interfere with nature it often produces disastrous consequences.					
Human ingenuity will insure that we do not make the Earth unliveable.					
Humans are seriously abusing the environment.					
the Earth has plenty of natural resources if we just learn how to develop them.					
Plants and animals have as much right as humans to exist.					
The balance of nature is strong enough to cope with the impacts of modern industrial nations.					
Despite or special abilities, humans are still subject to the laws of nature.					
The so-called "ecological crisis" facing humankind has been greatly exaggerated.					
The Earth is like a spaceship with very limited room and resources.					
Humans were meant to rule over the rest of nature.					
The balance of nature is very delicate and easily upset.					
Humans will eventually learn enough about how nature works to be able to control it.					
If things continue on their present course, we will soon experience a major ecological catastrophe.					

Do you have any comments about this survey? Then you can leave them here.

Appendix F: Data modification steps

This appendix gives an overview of the data modification steps, which are:

1. Checking and modifying the “other” answer categories, as presented in Table F.1.
2. Checking and adjusting the postal codes and adding the degree of urbanization.
3. Calculating and adding the habit strength in a separate column.
4. Calculating and adding the NEP average score in a separate column.
5. Checking and modifying the “I do not know” answer option for mobility modes available at home.
6. Checking and deleting incomplete or double filled-in choice sets.

Table F 1: Modified "other" answers in dataset.

Respondent	Question	Data modification for “other” categories
690	G00Q4	Answer “petrol + electricity” is placed in the category “hybrid”.
496	G00Q4	Answer “ee” is placed in the category “electric”.
31	G05Q16	Answer “I have a motor” is placed in the category “I rather use other modes of transport”.
833	G05Q16	Answer “OV bike” is deleted as respondent already ticked “I rather use other modes of transport”.
888	G05Q16	Answer “currently no car, perhaps in the future” is deleted as this response is not relevant for this question.
972	G05Q16	Answer “I live in the city, so PT well arranged” is deleted as this response is not relevant for this question.
123	G06Q21	Answer “Mavo” is placed in category “vocational education”.
710	G06Q21	Answer “WO proaedeutic” is placed in the category “intermediate vocational education”.
827	G06Q21	Answer “HBO (voor Bachelor-master)” is placed in the category “bachelor”.
101	G06Q22	Answer “student household” is placed in category “non-family household”.
152	G06Q27	Answer “side job” is placed in category “I work parttime”.
259	G06Q27	Answer “student without a job” is placed in category “unemployed / retired”.
751	G06Q27	Answer “30-hours” is placed in category “I work parttime”.
884	G06Q27	Answer “ziektewet” is placed in category “unemployed / retired”.
958	G06Q27	Answer “retired” is placed in category “unemployed / retired”.
975	G06Q27	Answer “combination fulltime study and parttime job” is placed in category “I work parttime”.

Appendix G: Crosstabs socio-demographics SPSS

In this appendix, the crosstabs between the socio-demographic variables are given. Only the socio-demographic variables among which a relationship is expected are described. In the tables, r.n.s. stands for rather not say.

Table G 1: Bivariate analysis age versus education level.

Age x education level		Education level			Total
		Low / medium	Bachelor	Master	
Age	18-24	7 17.5%	20 50.0%	13 32.5%	40 100%
	25-29	1 2.6%	9 23.7%	28 73.7%	38 100%
	30-39	4 9.5%	18 42.9%	20 47.6%	42 100%
	40-49	11 14.1%	30 38.5%	37 47.4%	78 100%
	50-59	31 25.8%	53 44.2%	36 30.0%	120 100%
	60-64	19 26.4%	25 34.7%	28 38.9%	72 100%
	65+	22 31.4%	22 31.4%	26 37.1%	70 100%
Total		95	177	188	460
		Chi-square (X^2)	38.642	df = 12	p <0.001

Table G 2: Bivariate analysis age versus employment status.

Age x employment status		Employment status				Total
		Full-time	Part-time	Not working	Other/r.n.s.	
Age	18-24	14 35.0%	20 50.0%	5 12.5%	1 2.5%	40 100%
	25-29	24 63.2%	10 26.3%	3 7.9%	1 2.6%	38 100%
	30-39	28 66.7%	13 31.0%	1 2.4%	0 0.0%	42 100%
	40-49	58 74.4%	18 23.1%	1 1.3%	1 1.3%	78 100%
	50-59	77 64.2%	39 32.5%	3 2.5%	1 0.8%	120 100%
	60-64	40 55.6%	26 36.1%	4 5.6%	2 2.8%	72 100%
	65+	14 20.0%	11 15.7%	43 61.4%	2 2.9%	70 100%
Total		255	137	60	8	460
			Chi-square (X^2)	194.004	df = 18	p <0.001

Table G 3: Bivariate analysis age versus household composition.

Age x household composition		Household composition					
		Single	Couple	Kids	Non-family	Other/r.n.s.	Total
Age	18-24	7 17.5%	6 15.0%	5 12.5%	14 35.0%	8 20.0%	40 100%
	25-29	10 26.3%	18 47.4%	0 0.0%	10 26.3%	0 0.0%	38 100%
	30-39	11 26.2%	14 33.3%	17 40.5%	0 0.0%	0 0.0%	42 100%
	40-49	14 17.9%	13 16.7%	50 64.1%	0 0.0%	1 1.3%	78 100%
	50-59	18 15.0%	33 27.5%	67 55.8%	2 1.7%	0 0.0%	120 100%
	60-64	14 19.4%	36 50.0%	21 29.2%	0 0.0%	1 1.4%	72 100%
	65+	12 17.1%	51 72.9%	6 8.6%	0 0.0%	1 1.4%	70 100%
Total		86	171	166	26	11	460
				Chi-square (X^2)	280.152	df = 24	p <0.001

Table G 4: Bivariate analysis age versus yearly household income.

Age x yearly household income		Yearly household income					
		≤modal	1-1.5x modal	1.5 – 2x modal	≥ 2x modal	r.n.s.	Total
Age	18-24	15 37.5%	6 15.0%	3 7.5%	4 10.0%	12 30.0%	40 100%
	25-29	15 39.5%	8 21.1%	7 18.4%	4 10.5%	4 10.5%	38 100%
	30-39	5 11.9%	8 19.0%	11 26.2%	15 35.7%	3 7.1%	42 100%
	40-49	6 7.7%	14 17.9%	15 19.2%	32 41.0%	11 14.1%	78 100%
	50-59	9 7.5%	16 13.3%	21 17.5%	45 37.5%	29 24.2%	120 100%
	60-64	6 8.3%	10 13.9%	20 27.8%	24 33.3%	12 16.7%	72 100%
	65+	10 14.3%	24 34.3%	13 18.6%	11 15.7%	12 17.1%	70 100%
Total		66	86	90	135	83	460
				Chi-square (X^2)	90.809	df = 24	p < 0.001

Table G 5: Bivariate analysis age versus urbanity level.

Age x urbanity level		Urbanity level					
		Very highly urban	Highly urban	Moderately urban	Little urban	Non-urban	Total
Age	18-24	10 25.0%	10 25.0%	5 12.5%	11 27.5%	4 10.0%	40 100%
	25-29	20 54.1%	9 24.3%	4 10.8%	2 5.4%	2 5.4%	38 100%
	30-39	7 17.9%	14 35.9%	6 15.4%	10 25.6%	2 5.1%	42 100%
	40-49	14 18.4%	14 18.4%	19 25.0%	17 22.4%	12 15.8%	78 100%
	50-59	6 5.3%	38 33.6%	20 17.7%	29 25.7%	20 17.7%	120 100%
	60-64	6 8.6%	17 24.3%	19 27.1%	16 22.9%	12 17.1%	72 100%
	65+	3 4.3%	25 36.2%	19 27.5%	10 14.5%	12 17.4%	70 100%
Total		66	127	92	95	64	444
				Chi-square (X^2)	85.025	df = 24	p < 0.001

Table G 6: Bivariate analysis household composition versus employment status.

Household composition x employment status		Employment status				
		Full-time	Part-time	Not working	Other / r.n.s.	Total
Household composition	Single	46 53.5%	22 25.6%	15 17.4%	3 3.5%	86 100%
	Couple	88 51.5%	46 26.9%	34 19.9%	3 1.8%	171 100%
	Kids	110 66.3%	51 30.7%	4 2.4%	1 0.6%	166 100%
	Non-family	8 30.8%	14 53.8%	4 15.4%	0 0.0%	26 100%
	Other / r.n.s.	3 27.3%	4 36.4%	3 27.3%	1 9.1%	11 100%
Total		255	137	60	8	460
			Chi-square (X^2)	44.970	df = 12	p < 0.001

Table G 7: Bivariate analysis household composition versus yearly household income.

Household composition x yearly household income		Yearly household income					Total
		≤modal	1-1.5x modal	1.5 – 2x modal	≥ 2x modal	r.n.s.	
Household composition	Single	24 27.9%	27 31.4%	15 17.4%	7 8.1%	13 15.1%	86 100%
	Couple	16 9.4%	33 19.3%	40 23.4%	48 28.1%	34 19.9%	171 100%
	Kids	8 4.8%	20 12.0%	33 19.9%	79 47.6%	26 15.7%	166 100%
	Non-family	17 65.4%	4 15.4%	1 3.8%	0 0.0%	4 15.4%	26 100%
	Other / r.n.s.	1 9.1%	2 18.2%	1 9.1%	1 9.1%	6 54.5%	11 100%
Total		66	86	90	135	83	460
				Chi-square (X^2)	139.566	df = 16	p < 0.001

Table G 8: Bivariate analysis household composition versus urbanity level.

Household composition x urbanity level		Urbanity level					Total
		Very highly urban	Highly urban	Moderately urban	Little urban	Non-urban	
Household composition	Single	18 21.7%	27 32.5%	18 21.7%	13 15.7%	7 8.4%	86 100%
	Couple	26 15.7%	46 27.7%	34 20.5%	29 17.5%	31 18.7%	171 100%
	Kids	9 5.6%	46 28.7%	33 20.6%	47 29.4%	25 15.6%	166 100%
	Non-family	13 50.0%	4 15.4%	5 19.2%	4 15.4%	0 0.0%	26 100%
	Other / r.n.s.	0 0.0%	4 44.4%	2 22.2%	2 22.2%	1 11.1%	11 100%
Total		66	127	92	95	64	460
				Chi-square (X^2)	53.544	df = 16	p < 0.001

Table G 9: Bivariate analysis yearly household income versus employment status.

Yearly household income x employment status		Employment status				Total
		Full-time	Part-time	Not working	Other / r.n.s.	
Yearly household income	≤modal	19 28.8%	31 47.0%	13 19.7%	3 4.5%	66 100%
	1-1.5x modal	48 55.8%	18 20.9%	19 22.1%	1 1.2%	86 100%
	1.5 – 2x modal	51 56.7%	25 27.8%	12 13.3%	2 2.2%	90 100%
	≥ 2x modal	97 71.9%	30 22.2%	8 5.9%	0 0.0%	135 100%
	r.n.s.	40 48.2%	33 39.8%	8 9.6%	2 2.4%	83 100%
Total		255	137	60	8	460
			Chi-square (X^2)	49.587	df = 12	p < 0.001

Table G 10: Bivariate analysis yearly household income versus education level.

Yearly household income x education level		Education level: Low / medium	Bachelor	Master	Total
Yearly household income	≤modal	17 25.8%	31 47.0%	18 27.3%	66 100%
	1-1.5x modal	31 36.0%	27 31.4%	28 32.6%	86 100%
	1.5 – 2x modal	14 15.6%	37 41.1%	39 43.3%	90 100%
	≥ 2x modal	10 7.4%	45 33.3%	80 59.3%	135 100%
	r.n.s.	23 27.7%	37 44.6%	23 27.7%	83 100%
Total		95	177	188	460
		Chi-square (X^2)	48.815	df = 8	$p < 0.001$

Appendix H: Independent Samples T-test SPSS on flanking policies

This appendix shows the results of the independent sample T-test run in SPSS. This test is used to compare the mean values of two different groups; in this case car owners and non-car owners. Respondents had to indicate their support for a policy on a 5-point Likert scale; 1 represented very opposed to the measure, and 5 represented very in favour of the measure. Table H1 describes the results, a higher mean indicates overall more support for the policy. Table H2 shows the results of the Independent Samples T-test. The Levene's test indicates if the variance between the two groups is equal. If the p-value for this test is lower than 0.05, the row equal variances not assumed is used. A higher T-value indicates a higher difference between the group means, therefore, a high value for T and a low p-value indicate a large significant difference between two groups. A p-value which is larger than 0.05 indicates that there is no significant difference between the two groups.

Table H 1: Results Independent Samples T-test SPSS on flanking policies.

Policy	Car	#resp.	Mean	Std. Deviation	Std. Error Mean
Parking fee increases	No	53	3.11	1.325	0.182
	Yes	410	2.35	1.288	0.064
Reduction parking spaces	No	53	3.23	1.310	0.180
	Yes	410	2.19	1.243	0.061
Zero-emission zones	No	53	3.94	1.231	0.169
	Yes	410	3.00	1.349	0.067
30 km/h zones	No	53	4.19	0.982	0.135
	Yes	410	3.58	1.284	0.063
Shared mobility vouchers	No	53	3.62	1.228	0.169
	Yes	410	3.22	1.318	0.065
Redevelopment public space	No	53	3.74	1.243	0.171
	Yes	410	3.00	1.207	0.060
Pay for use	No	53	2.98	1.380	0.190
	Yes	410	2.81	1.483	0.073
Reduction parking permits	No	53	3.00	1.256	0.172
	Yes	410	2.68	1.166	0.058

Table H 2: Model statistics Independent Samples T-test SPSS on flanking policies.

		Levene's Test		t-test for equality of means						95% confi. interval of dif.	
Policy	Variance	F	p	t	df	One-sides p	Two-sided p	Mean difference	Std. Error difference	Lower	Upper
Parking fee increases	Equal	0.579	0.447	4.065	461	<0.001	<0.001	0.767	0.189	0.396	1.138
	Not equal			3.977	65.358	<0.001	<0.001	0.767	0.193	0.382	1.152
Reduction of parking spaces	Equal	0.144	0.705	5.702	461	<0.001	<0.001	1.041	0.183	0.682	1.400
	Not equal			5.474	64.690	<0.001	<0.001	1.041	0.190	0.661	1.421
Zero-emission zones	Equal	0.737	0.391	4.813	461	<0.001	<0.001	0.939	0.195	0.555	1.322
	Not equal			5.163	69.171	<0.001	<0.001	0.939	0.182	0.576	1.301
30 km/h zones	Equal	11.157	<0.001	3.325	461	<0.001	<0.001	0.608	0.183	0.249	0.968
	Not equal			4.082	77.044	<0.001	<0.001	0.608	0.149	0.311	0.905
Shared mobility vouchers	Equal	0.132	0.716	2.111	461	0.018	0.35	0.403	0.191	0.028	0.778
	Not equal			2.229	68.433	0.015	0.029	0.403	0.181	0.042	0.764
Redevelopment public space	Equal	1.129	0.289	4.134	461	<0.001	<0.001	0.731	0.177	0.384	1.078
	Not equal			4.043	65.336	<0.001	<0.001	0.731	0.181	0.370	1.092
Pay for use	Equal	2.209	0.138	0.809	461	0.209	0.419	0.174	0.215	-0.248	0.596
	Not equal			0.855	68.504	0.198	0.395	0.174	0.203	-0.232	0.579
Reduction parking permits	Equal	0.006	0.936	1.889	461	0.030	0.059	0.324	0.172	-0.013	0.662
	Not equal			1.784	64.131	0.040	0.079	0.324	0.182	-0.039	0.688

Appendix I: Nlogit output – Multinomial Logit Model

This appendix provides the complete MNL output of Nlogit including the coding command.

```
|-> Nlogit
    ; lhs=Choice
    ; rhs= nc, autonc, mobi1, mobi2, mobi3, facil1, facil2,
    facil3, safe1, safe2, safe3, tt, tc, mo1fa1, mo1fa2, mo1fa3,
    mo2fa1, mo2fa2, mo2fa3, mo3fa1, mo3fa2, mo3fa3,
    mo1sa1, mo1sa2, mo1sa3, mo2sa1, mo2sa3, mo3sa1, mo3sa2, mo3sa3,
    fa1sa1, fa1sa2, fa1sa3, fa2sa1,fa2sa2, fa2sa3, fa3sa1, fa3sa2, fa3sa3,
    wnc,wmo1,wmo2,wmo3,wfac1,wfac2,wfac3,wsa1,wsa2,wsa3,wtt,wtc,
    fnc,fmo1,fmo2,fmo3,ffac1,ffac2,ffac3,fsa1,fsa2,fsa3,ftt,ftc
    ; choices=0,1,2
    ; pds=nsets
    ; CheckData
    $
+-----------------------------------------------------------+
| Inspecting the data set before estimation.                |
| These errors mark observations which will be skipped.     |
| Row Individual = 1st row then group number of data block |
+-----------------------------------------------------------+
No bad observations were found in the sample

Iterative procedure has converged
Normal exit:   7 iterations. Status=0, F=    .1440506D+05

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function    -14405.06403
Estimation based on N =   19752, K =  63
Inf.Cr.AIC  =  28936.1 AIC/N =    1.465
----------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  **********  .1255 .1241
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
----------------------------------------
Response data are given as ind. choices
Number of obs.= 19752, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.       95% Confidence
  CHOICE|  Coefficient    Error        z    |z|>Z*          Interval
--------+--------------------------------------------------------------------
      NC|    2.02927***    .11987    16.93  .0000     1.79433   2.26420
  AUTONC|     .75672***    .05339    14.17  .0000      .65207    .86136
   MOBI1|    1.50143***    .12348    12.16  .0000     1.25941   1.74345
   MOBI2|    1.39793***    .12488    11.19  .0000     1.15317   1.64268
   MOBI3|    1.05708***    .14505     7.29  .0000      .77278   1.34137
  FACIL1|     .10149       .12783      .79  .4272    -.14905    .35202
  FACIL2|    -.44004***    .15303    -2.88  .0040    -.73996   -.14011
  FACIL3|     .32756**     .14319     2.29  .0222     .04692    .60821
   SAFE1|    -.32735**     .12929    -2.53  .0113    -.58076   -.07394
   SAFE2|     .76685***    .13674     5.61  .0000      .49886   1.03485
   SAFE3|     .41194***    .12684     3.25  .0012      .16334    .66054
      TT|   -1.79718***    .24964    -7.20  .0000    -2.28646  -1.30789
      TC|   -2.89813***    .09585   -30.24  .0000    -3.08599  -2.71027
```

MO1FA1	-.45816***	.13070	-3.51	.0005	-.71432	-.20200
MO1FA2	.58664***	.14569	4.03	.0001	.30109	.87219
MO1FA3	-1.17816***	.14199	-8.30	.0000	-1.45644	-.89987
MO2FA1	.15620	.13056	1.20	.2315	-.09968	.41209
MO2FA2	.52753***	.15000	3.52	.0004	.23355	.82152
MO2FA3	-.33043**	.13493	-2.45	.0143	-.59489	-.06597
MO3FA1	.14993	.13959	1.07	.2828	-.12366	.42352
MO3FA2	.66974***	.15664	4.28	.0000	.36273	.97676
MO3FA3	-.14480	.14427	-1.00	.3155	-.42755	.13796
MO1SA1	-.20322*	.11204	-1.81	.0697	-.42281	.01638
MO1SA2	-1.04476***	.13647	-7.66	.0000	-1.31224	-.77728
MO1SA3	-.88721***	.12420	-7.14	.0000	-1.13064	-.64378
MO2SA1	-.75168***	.11923	-6.30	.0000	-.98537	-.51799
MO2SA3	-.30996***	.11282	-2.75	.0060	-.53109	-.08883
MO3SA1	-.39264***	.11262	-3.49	.0005	-.61337	-.17191
MO3SA2	-.72093***	.13435	-5.37	.0000	-.98426	-.45761
MO3SA3	-.85300***	.13109	-6.51	.0000	-1.10993	-.59606
FA1SA1	.41964***	.13345	3.14	.0017	.15809	.68120
FA1SA2	-.13638	.12233	-1.11	.2649	-.37614	.10338
FA1SA3	.12281	.12101	1.01	.3102	-.11437	.35999
FA2SA1	.11272	.14561	.77	.4388	-.17267	.39811
FA2SA2	-.26146*	.13706	-1.91	.0564	-.53009	.00718
FA2SA3	.16868	.12365	1.36	.1725	-.07368	.41103
FA3SA1	.40913***	.14462	2.83	.0047	.12568	.69257
FA3SA2	-.62460***	.13998	-4.46	.0000	-.89895	-.35025
FA3SA3	.00707	.12918	.05	.9563	-.24610	.26025
WNC	-.09102	.13032	-.70	.4849	-.34645	.16440
WMO1	-.35505***	.11548	-3.07	.0021	-.58138	-.12872
WMO2	-.41706***	.10861	-3.84	.0001	-.62994	-.20418
WMO3	-.26642**	.11384	-2.34	.0193	-.48954	-.04330
WFAC1	.05087	.09897	.51	.6072	-.14310	.24485
WFAC2	.05500	.10376	.53	.5961	-.14837	.25837
WFAC3	.11693	.10680	1.09	.2736	-.09240	.32625
WSA1	-.10421	.11294	-.92	.3562	-.32556	.11714
WSA2	-.08343	.10048	-.83	.4064	-.28038	.11351
WSA3	-.13923	.10075	-1.38	.1670	-.33670	.05824
WTT	-1.35069***	.35918	-3.76	.0002	-2.05467	-.64671
WTC	.66539***	.13715	4.85	.0000	.39658	.93420
FNC	-.09920	.12763	-.78	.4370	-.34935	.15096
FMO1	-.24334**	.11212	-2.17	.0300	-.46308	-.02359
FMO2	-.33401***	.10623	-3.14	.0017	-.54221	-.12581
FMO3	-.33111***	.11216	-2.95	.0032	-.55093	-.11128
FFAC1	.05519	.09612	.57	.5658	-.13320	.24359
FFAC2	-.03577	.10158	-.35	.7247	-.23487	.16333
FFAC3	.05959	.10403	.57	.5668	-.14431	.26349
FSA1	-.05026	.11093	-.45	.6505	-.26767	.16715
FSA2	-.07928	.09906	-.80	.4235	-.27344	.11487
FSA3	-.08253	.09876	-.84	.4034	-.27608	.11103
FTT	-.23448	.35281	-.66	.5063	-.92597	.45701
FTC	.10334	.13526	.76	.4448	-.16176	.36845

***, **, * ==> Significance at 1%, 5%, 10% level.
Model was estimated on Apr 29, 2024 at 09:31:04 AM

Appendix J: Nlogit output – Latent Class Model

This appendix provides the complete LCM output of Nlogit for three classes including the coding command.

```
|-> Nlogit
    ; lhs=Choice
    ; rhs= nc, autonc, mobi1, mobi2, mobi3, facil1, facil2,
    facil3, safe1, safe2, safe3, tt, tc, mo1fa1, mo1fa2, mo1fa3,
    mo2fa1, mo2fa2, mo2fa3, mo3fa1, mo3fa2, mo3fa3,
    mo1sa1, mo1sa2, mo1sa3, mo2sa1, mo2sa3, mo3sa1, mo3sa2, mo3sa3,
    fa1sa1, fa1sa2, fa1sa3, fa2sa1,fa2sa2, fa2sa3, fa3sa1,
    fa3sa2, fa3sa3,
    wnc,wmo1,wmo2,wmo3,wfac1,wfac2,wfac3,wsa1,wsa2,wsa3,wtt,wtc,
    fnc,fmo1,fmo2,fmo3,ffac1,ffac2,ffac3,fsa1,fsa2,fsa3,ftt,ftc
    ; choices=0,1,2
    ; pds=nsets
    ;lcm
    ;parameters
    ;pts=3
    ;maxit=150
    ;CheckData
    $
+-----------------------------------------------------------+
| Inspecting the data set before estimation.                |
| These errors mark observations which will be skipped.     |
| Row Individual = 1st row then group number of data block |
+-----------------------------------------------------------+
No bad observations were found in the sample

Maximum of  150 iterations. Exit iterations with status=1

----------------------------------------------------------------------------
Latent Class Logit Model
Dependent variable               CHOICE
Log likelihood function    -10224.04873
Restricted log likelihood  -21699.78993
Chi-squared [191](P= .000)  22951.48239
Significance level               .00000
McFadden Pseudo R-squared      .5288411
Estimation based on N =   19752, K = 191
Inf.Cr.AIC  =  20830.1 AIC/N =    1.055
---------------------------------------
            Log likelihood R-sqrd R2Adj
No coefficients **********  .5288 .5266
Constants only  **********  .3793 .3763
At start values **********  .2898 .2864
Note: R-sqrd = 1 - logL/Logl(constants)
Warning:  Model does not contain a full
set of ASCs. R-sqrd is problematic. Use
model setup with ;RHS=one to get LogL0.
---------------------------------------
Response data are given as ind. choices
Number of latent classes =            3
Average Class Probabilities
     .371  .300  .330
LCM model with panel has     534 groups
Variable number of obs./group =NSETS
Number of obs.= 19752, skipped    0 obs
```

CHOICE	Coefficient	Standard Error	z	Prob. |z|>Z*	95% Confidence Interval	
	Random utility parameters in latent class -->> 1................					
NC|1	4.62669***	1.21244	3.82	.0001	2.25034	7.00303
AUTONC|1	1.92971**	.91197	2.12	.0343	.14228	3.71715
MOBI1|1	-2.69829	3.86851	-.70	.4855	-10.28043	4.88386
MOBI2|1	-5.40009	7.12218	-.76	.4483	-19.35931	8.55912
MOBI3|1	.55077	2.46557	.22	.8232	-4.28165	5.38320
FACIL1|1	-3.65821	5.94902	-.61	.5386	-15.31808	8.00165
FACIL2|1	-9.71594	11.53042	-.84	.3994	-32.31516	12.88328
FACIL3|1	-3.54078	4.38401	-.81	.4193	-12.13328	5.05171
SAFE1|1	-11.9581	8.80298	-1.36	.1743	-29.2116	5.2955
SAFE2|1	1.20538	1.78551	.68	.4996	-2.29416	4.70492
SAFE3|1	-11.3834	24.93783	-.46	.6481	-60.2606	37.4939
TT|1	10.8694	12.40062	.88	.3807	-13.4354	35.1742
TC|1	-7.02065*	3.61159	-1.94	.0519	-14.09925	.05794
MO1FA1|1	4.95365	6.82051	.73	.4677	-8.41430	18.32160
MO1FA2|1	-1.49994	1.57477	-.95	.3409	-4.58642	1.58655
MO1FA3|1	-3.46749	3.49687	-.99	.3214	-10.32123	3.38625
MO2FA1|1	9.86047	8.31848	1.19	.2359	-6.44344	26.16439
MO2FA2|1	3.68571	5.22963	.70	.4810	-6.56418	13.93560
MO2FA3|1	-5.22525	6.76674	-.77	.4400	-18.48782	8.03732
MO3FA1|1	-1.15159	8.83046	-.13	.8962	-18.45898	16.15580
MO3FA2|1	-6.08551	19.29396	-.32	.7525	-43.90098	31.72995
MO3FA3|1	2.87573	4.09954	.70	.4830	-5.15923	10.91069
MO1SA1|1	2.87679	2.13780	1.35	.1784	-1.31321	7.06680
MO1SA2|1	-2.04494	1.96542	-1.04	.2981	-5.89711	1.80722
MO1SA3|1	11.8409	25.29253	.47	.6397	-37.7315	61.4134
MO2SA1|1	-1.71081	4.20398	-.41	.6840	-9.95047	6.52884
MO2SA3|1	11.7709	26.19551	.45	.6532	-39.5713	63.1132
MO3SA1|1	2.37388	5.32682	.45	.6559	-8.06649	12.81426
MO3SA2|1	-2.97089	2.99540	-.99	.3213	-8.84176	2.89998
MO3SA3|1	-4.59659	23.81532	-.19	.8470	-51.27376	42.08057
FA1SA1|1	6.35693	6.29013	1.01	.3122	-5.97149	18.68535
FA1SA2|1	-2.66868	4.88194	-.55	.5846	-12.23711	6.89974
FA1SA3|1	-3.92613	6.73048	-.58	.5597	-17.11763	9.26538
FA2SA1|1	4.84114	6.24342	.78	.4381	-7.39574	17.07801
FA2SA2|1	-1.11389	2.41919	-.46	.6452	-5.85541	3.62763
FA2SA3|1	4.73382	4.41309	1.07	.2834	-3.91568	13.38332
FA3SA1|1	5.82308	7.76548	.75	.4533	-9.39699	21.04315
FA3SA2|1	.16187	3.63331	.04	.9645	-6.95928	7.28301
FA3SA3|1	11.8991*	6.98171	1.70	.0883	-1.7848	25.5830
WNC|1	.08434	1.37140	.06	.9510	-2.60354	2.77223
WMO1|1	3.49739	3.94469	.89	.3753	-4.23406	11.22884
WMO2|1	1.38649	4.39027	.32	.7521	-7.21828	9.99125
WMO3|1	-.78826	1.39158	-.57	.5711	-3.51570	1.93919
WFAC1|1	-1.29175	4.06424	-.32	.7506	-9.25751	6.67401
WFAC2|1	10.7084	11.44940	.94	.3496	-11.7320	33.1488
WFAC3|1	1.63530	1.39787	1.17	.2421	-1.10448	4.37508
WSA1|1	3.68409	6.15678	.60	.5496	-8.38298	15.75117
WSA2|1	1.00798	1.40827	.72	.4741	-1.75218	3.76813
WSA3|1	-7.02510	5.24246	-1.34	.1802	-17.30013	3.24993
WTT|1	-1.72491	10.92558	-.16	.8746	-23.13866	19.68884
WTC|1	.47047	2.75016	.17	.8642	-4.91974	5.86068
FNC|1	4.20685	2.86604	1.47	.1422	-1.41048	9.82418
FMO1|1	6.19729	4.52533	1.37	.1709	-2.67220	15.06678
FMO2|1	4.88964	4.93643	.99	.3219	-4.78559	14.56486
FMO3|1	-.52087	1.46152	-.36	.7216	-3.38540	2.34367
FFAC1|1	-8.26552	6.08641	-1.36	.1745	-20.19468	3.66363

FFAC2|1|	7.34456	11.31337	.65	.5162	-14.82924	29.51835
FFAC3|1|	1.22026	1.40787	.87	.3861	-1.53911	3.97963
FSA1|1|	9.35976	7.20018	1.30	.1936	-4.75234	23.47186
FSA2|1|	3.45916	2.18766	1.58	.1138	-.82858	7.74690
FSA3|1|	-1.48989	4.34416	-.34	.7316	-10.00428	7.02451
FTT|1|	-24.6586	18.64350	-1.32	.1860	-61.1992	11.8820
FTC|1|	-2.77504	3.18062	-.87	.3829	-9.00894	3.45886
|Random utility parameters in latent class -->> 2................						
NC|2|	2.54901***	.22024	11.57	.0000	2.11734	2.98068
AUTONC|2|	-.89832***	.11687	-7.69	.0000	-1.12738	-.66926
MOBI1|2|	1.75180***	.21680	8.08	.0000	1.32687	2.17673
MOBI2|2|	1.30332***	.22270	5.85	.0000	.86684	1.73980
MOBI3|2|	.85781***	.24891	3.45	.0006	.36995	1.34566
FACIL1|2|	.38395*	.21134	1.82	.0693	-.03026	.79816
FACIL2|2|	.71163***	.24787	2.87	.0041	.22581	1.19744
FACIL3|2|	1.16120***	.23465	4.95	.0000	.70129	1.62111
SAFE1|2|	.35201	.25448	1.38	.1666	-.14677	.85078
SAFE2|2|	1.16388***	.23033	5.05	.0000	.71245	1.61531
SAFE3|2|	.28674	.20764	1.38	.1673	-.12022	.69371
TT|2|	-3.37961***	.42890	-7.88	.0000	-4.22024	-2.53899
TC|2|	-4.44356***	.18829	-23.60	.0000	-4.81259	-4.07452
MO1FA1|2|	-.33190	.21970	-1.51	.1309	-.76250	.09871
MO1FA2|2|	.69081***	.22598	3.06	.0022	.24791	1.13372
MO1FA3|2|	-1.45707***	.22269	-6.54	.0000	-1.89353	-1.02060
MO2FA1|2|	.36211*	.21982	1.65	.0995	-.06872	.79295
MO2FA2|2|	.28297	.23041	1.23	.2194	-.16862	.73456
MO2FA3|2|	-.24042	.22480	-1.07	.2849	-.68103	.20019
MO3FA1|2|	.43960*	.23451	1.87	.0609	-.02004	.89924
MO3FA2|2|	.34374	.24172	1.42	.1550	-.13001	.81750
MO3FA3|2|	-.26350	.24103	-1.09	.2743	-.73590	.20890
MO1SA1|2|	-.71198***	.19701	-3.61	.0003	-1.09812	-.32585
MO1SA2|2|	-1.49045***	.23130	-6.44	.0000	-1.94380	-1.03710
MO1SA3|2|	-.76373***	.20706	-3.69	.0002	-1.16957	-.35790
MO2SA1|2|	-.80731***	.18583	-4.34	.0000	-1.17153	-.44309
MO2SA3|2|	.25139	.19560	1.29	.1987	-.13197	.63475
MO3SA1|2|	-.34839*	.19536	-1.78	.0745	-.73130	.03452
MO3SA2|2|	-.79083***	.22299	-3.55	.0004	-1.22789	-.35378
MO3SA3|2|	-.27960	.21786	-1.28	.1994	-.70660	.14741
FA1SA1|2|	-.17422	.26023	-.67	.5032	-.68427	.33583
FA1SA2|2|	-.29126	.21593	-1.35	.1774	-.71447	.13196
FA1SA3|2|	-.10001	.21658	-.46	.6443	-.52450	.32448
FA2SA1|2|	-1.04462***	.28372	-3.68	.0002	-1.60070	-.48854
FA2SA2|2|	-.98558***	.24918	-3.96	.0001	-1.47395	-.49720
FA2SA3|2|	-.61356***	.22158	-2.77	.0056	-1.04785	-.17927
FA3SA1|2|	-.41992	.27221	-1.54	.1229	-.95344	.11361
FA3SA2|2|	-1.74553***	.25236	-6.92	.0000	-2.24016	-1.25091
FA3SA3|2|	-.34580	.22357	-1.55	.1219	-.78399	.09238
WNC|2|	.03599	.21785	.17	.8688	-.39099	.46297
WMO1|2|	-.36394**	.18144	-2.01	.0449	-.71957	-.00832
WMO2|2|	-.50777***	.17424	-2.91	.0036	-.84927	-.16627
WMO3|2|	-.42474**	.17944	-2.37	.0179	-.77644	-.07305
WFAC1|2|	-.00483	.16414	-.03	.9765	-.32653	.31688
WFAC2|2|	.01736	.17508	.10	.9210	-.32579	.36050
WFAC3|2|	.20736	.18115	1.14	.2523	-.14768	.56240
WSA1|2|	.04954	.18484	.27	.7887	-.31274	.41181
WSA2|2|	-.07937	.17504	-.45	.6502	-.42243	.26370
WSA3|2|	-.23031	.16815	-1.37	.1708	-.55988	.09925
WTT|2|	-1.71030***	.57430	-2.98	.0029	-2.83592	-.58469
WTC|2|	1.10858***	.24789	4.47	.0000	.62272	1.59444
FNC|2|	-.60765***	.22369	-2.72	.0066	-1.04607	-.16922
FMO1|2|	-.22160	.18012	-1.23	.2186	-.57462	.13142

FMO2|2|	-.37836**	.17526	-2.16	.0309	-.72185	-.03486
FMO3|2|	-.31953*	.17612	-1.81	.0696	-.66471	.02564
FFAC1|2|	.01218	.16711	.07	.9419	-.31535	.33972
FFAC2|2|	-.03592	.17681	-.20	.8390	-.38247	.31063
FFAC3|2|	-.00511	.18510	-.03	.9780	-.36790	.35768
FSA1|2|	.19899	.18619	1.07	.2852	-.16593	.56390
FSA2|2|	-.09210	.17954	-.51	.6080	-.44399	.25980
FSA3|2|	-.05197	.16786	-.31	.7569	-.38096	.27703
FTT|2|	-1.17485**	.57784	-2.03	.0420	-2.30738	-.04231
FTC|2|	-.21619	.26212	-.82	.4095	-.72994	.29757
|Random utility parameters in latent class -->> 3................						
NC|3|	.43767**	.21893	2.00	.0456	.00857	.86677
AUTONC|3|	2.10580***	.11393	18.48	.0000	1.88250	2.32910
MOBI1|3|	1.57304***	.22269	7.06	.0000	1.13658	2.00951
MOBI2|3|	1.63326***	.21837	7.48	.0000	1.20527	2.06126
MOBI3|3|	.97882***	.25156	3.89	.0001	.48578	1.47187
FACIL1|3|	-.31027	.23834	-1.30	.1930	-.77740	.15686
FACIL2|3|	-.52052*	.27705	-1.88	.0603	-1.06353	.02249
FACIL3|3|	.08326	.25431	.33	.7434	-.41517	.58169
SAFE1|3|	-.01541	.21776	-.07	.9436	-.44221	.41138
SAFE2|3|	.28613	.25342	1.13	.2589	-.21057	.78283
SAFE3|3|	.10586	.22792	.46	.6423	-.34086	.55258
TT|3|	-1.79006***	.42637	-4.20	.0000	-2.62574	-.95439
TC|3|	-3.20405***	.17096	-18.74	.0000	-3.53912	-2.86898
MO1FA1|3|	-.18338	.24804	-.74	.4597	-.66952	.30277
MO1FA2|3|	1.02590***	.27289	3.76	.0002	.49105	1.56075
MO1FA3|3|	-.83066***	.25668	-3.24	.0012	-1.33373	-.32758
MO2FA1|3|	.23885	.24014	.99	.3199	-.23182	.70951
MO2FA2|3|	.59017**	.27305	2.16	.0307	.05499	1.12534
MO2FA3|3|	.04782	.23919	.20	.8416	-.42099	.51662
MO3FA1|3|	.34176	.25524	1.34	.1806	-.15850	.84202
MO3FA2|3|	.89775***	.28145	3.19	.0014	.34612	1.44939
MO3FA3|3|	.16060	.25537	.63	.5294	-.33993	.66112
MO1SA1|3|	-.44437**	.20266	-2.19	.0283	-.84159	-.04716
MO1SA2|3|	-.37271	.26268	-1.42	.1559	-.88755	.14213
MO1SA3|3|	-1.05321***	.24384	-4.32	.0000	-1.53113	-.57529
MO2SA1|3|	.11183	.22494	.50	.6191	-.32905	.55270
MO2SA3|3|	-.16656	.21311	-.78	.4345	-.58426	.25113
MO3SA1|3|	-.19660	.19151	-1.03	.3046	-.57194	.17875
MO3SA2|3|	.08818	.25045	.35	.7248	-.40270	.57905
MO3SA3|3|	-.15972	.23672	-.67	.4999	-.62369	.30425
FA1SA1|3|	.46248*	.23902	1.93	.0530	-.00599	.93095
FA1SA2|3|	-.05631	.21924	-.26	.7973	-.48602	.37340
FA1SA3|3|	.38983*	.22055	1.77	.0771	-.04243	.82209
FA2SA1|3|	.05857	.25227	.23	.8164	-.43588	.55301
FA2SA2|3|	-.37506	.23156	-1.62	.1053	-.82891	.07878
FA2SA3|3|	.14436	.21735	.66	.5066	-.28164	.57036
FA3SA1|3|	.64251***	.24317	2.64	.0082	.16591	1.11910
FA3SA2|3|	-.71515***	.24089	-2.97	.0030	-1.18728	-.24301
FA3SA3|3|	-.11089	.23967	-.46	.6436	-.58063	.35885
WNC|3|	-.18751	.23137	-.81	.4177	-.64098	.26597
WMO1|3|	-.72226***	.20695	-3.49	.0005	-1.12787	-.31665
WMO2|3|	-.81117***	.19861	-4.08	.0000	-1.20044	-.42190
WMO3|3|	-.34024*	.19913	-1.71	.0875	-.73053	.05004
WFAC1|3|	.11309	.16463	.69	.4921	-.20958	.43575
WFAC2|3|	-.05616	.17218	-.33	.7443	-.39363	.28132
WFAC3|3|	-.04151	.17694	-.23	.8145	-.38830	.30528
WSA1|3|	-.39096**	.18533	-2.11	.0349	-.75420	-.02773
WSA2|3|	-.10154	.16943	-.60	.5490	-.43362	.23054
WSA3|3|	-.01932	.17286	-.11	.9110	-.35812	.31948
WTT|3|	-.98833*	.58995	-1.68	.0939	-2.14461	.16795

```
   WTC|3|     1.22709***       .23352      5.25  .0000       .76939   1.68478
   FNC|3|      .50983**        .24047      2.12  .0340       .03851    .98115
  FMO1|3|     -.28488          .21483     -1.33  .1848     -.70593    .13617
  FMO2|3|     -.29279          .20727     -1.41  .1578     -.69903    .11345
  FMO3|3|     -.36529*         .21543     -1.70  .0900     -.78752    .05694
 FFAC1|3|      .01833          .17524       .10  .9167     -.32513    .36179
 FFAC2|3|     -.05519          .17896      -.31  .7578     -.40595    .29557
 FFAC3|3|      .16583          .18114       .92  .3600     -.18920    .52086
  FSA1|3|     -.33202*         .19156     -1.73  .0831     -.70748    .04343
  FSA2|3|     -.09369          .17299      -.54  .5881     -.43274    .24537
  FSA3|3|     -.28866          .18429     -1.57  .1173     -.64987    .07255
   FTT|3|      .58204          .63741       .91  .3612     -.66727   1.83135
   FTC|3|      .27622          .23615      1.17  .2421     -.18663    .73907
        |Estimated latent class probabilities.............................
 PrbCls1|      .37064***       .02118     17.50  .0000       .32913    .41215
 PrbCls2|      .29973***       .02248     13.33  .0000       .25567    .34379
 PrbCls3|      .32963***       .02301     14.33  .0000       .28453    .37473
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Apr 29, 2024 at 11:31:50 AM
-----------------------------------------------------------------------------

Error   1001: NOTE: Model is too large to add to REVIEW stack.
Error   1001: NOTE:Model is too large to save B and VARB.
```

Appendix K: Detailed figures flanking policies

This appendix gives more detailed insights into the policy support and self-stated car behaviour change due to flanking policies of the three classes defined in the LCM. Besides, as the first class is not intrigued to use mobility hubs at all, the social groups that are most present in class 1 are analysed in detail as well. This considers people over the age of 65 years and households with children living at home. Figures K.1 and K.2 give insights into the policy support and self-stated car behaviour change of the different classes. Figures K.3 and K.4 consider the social groups of class 1 in more detail.

From Figure K.3 it can be concluded that individuals over the age of 65 years are most opposed to measurements related to parking (decreased parking spaces and increased parking fees). This is also true for families with children. On the other hand, both are the most supportive the implementation of 30 km/h zones. Next to this, households with children are also supportive of the handing out of shared mobility vouchers.

From Figure K.4 it can be concluded that the implementation of pay for use would be most efficient in changing car usage of both individuals of 65+ years and households with children, as self-stated by these respondents. Furthermore, individuals of 65+ years would also use their car less if zero-emission zones were implemented. Also the reduction of parking spaces would have some influence on car usage. For households with children, the measurements which influence parking are also effective in reducing car usage. However, it should be mentioned that overall for both groups, more than half of the respondents indicate for each measure that this would not influence their car usage. The measurement which seems to have the least effect is implementing 30 kilometres per hour zones. This is, however, the most supportive measurement.

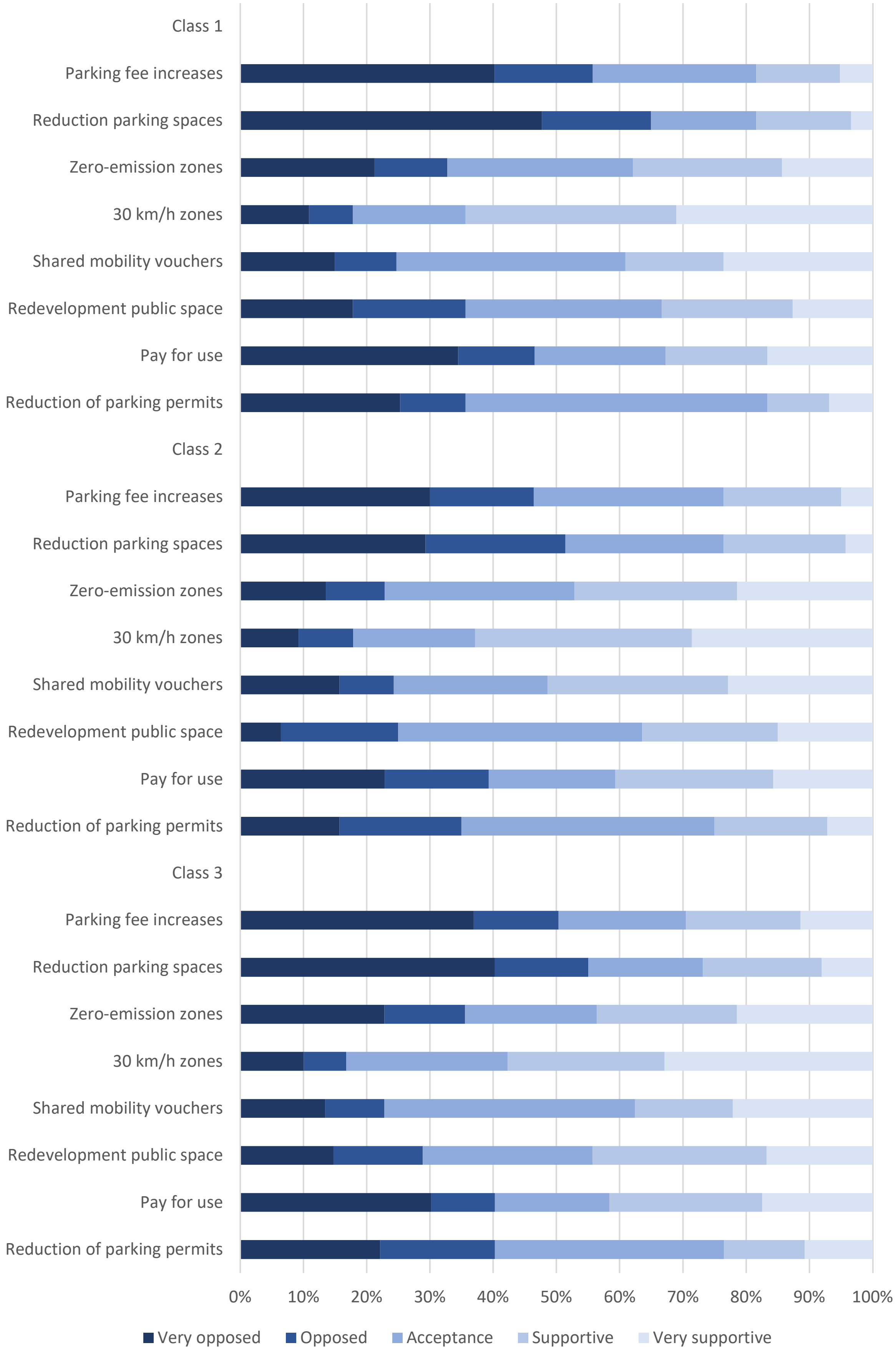

Figure K 1: policy support versus class membership.

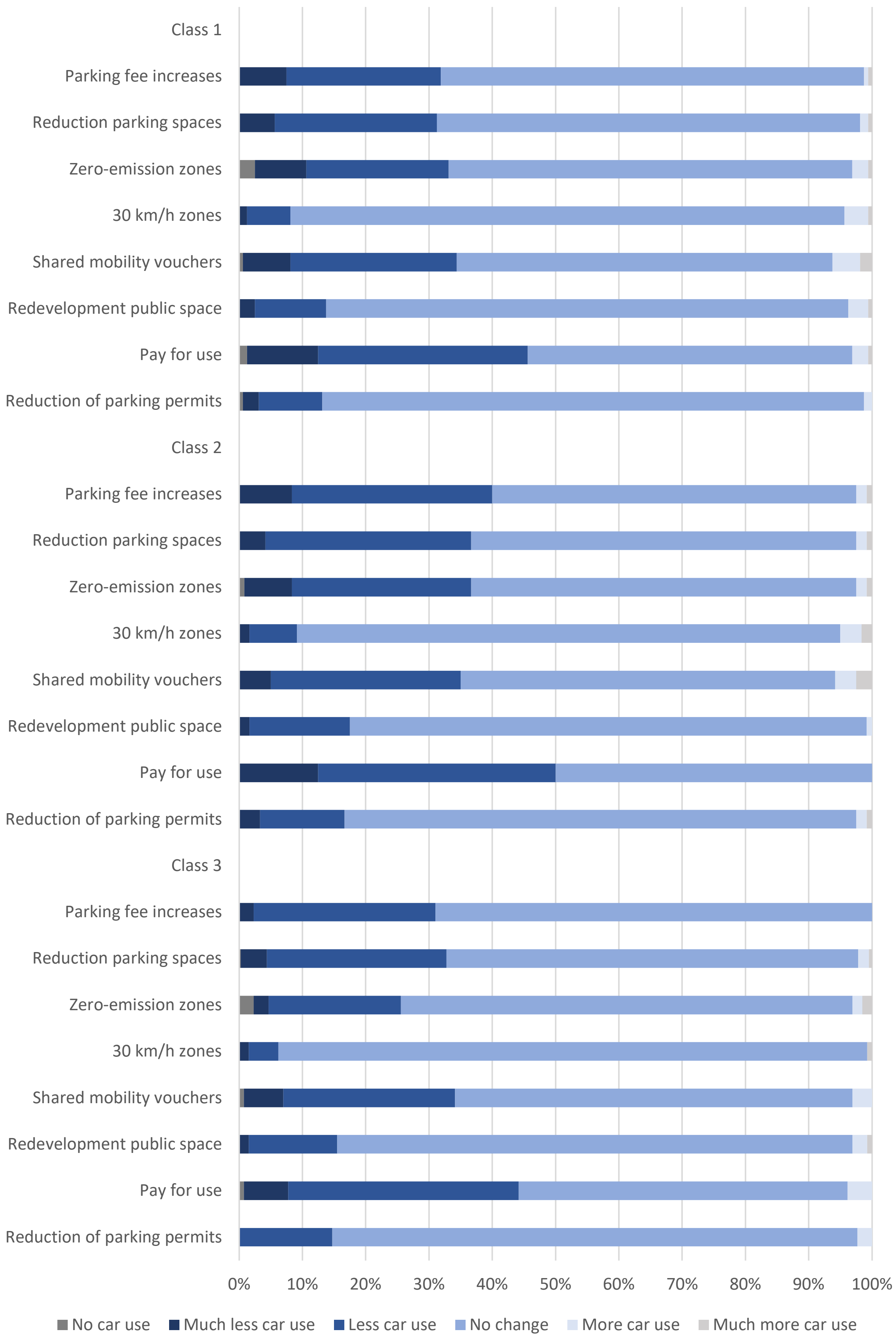

Figure K 2: Self-stated car usage behaviour change class members versus flanking policies.

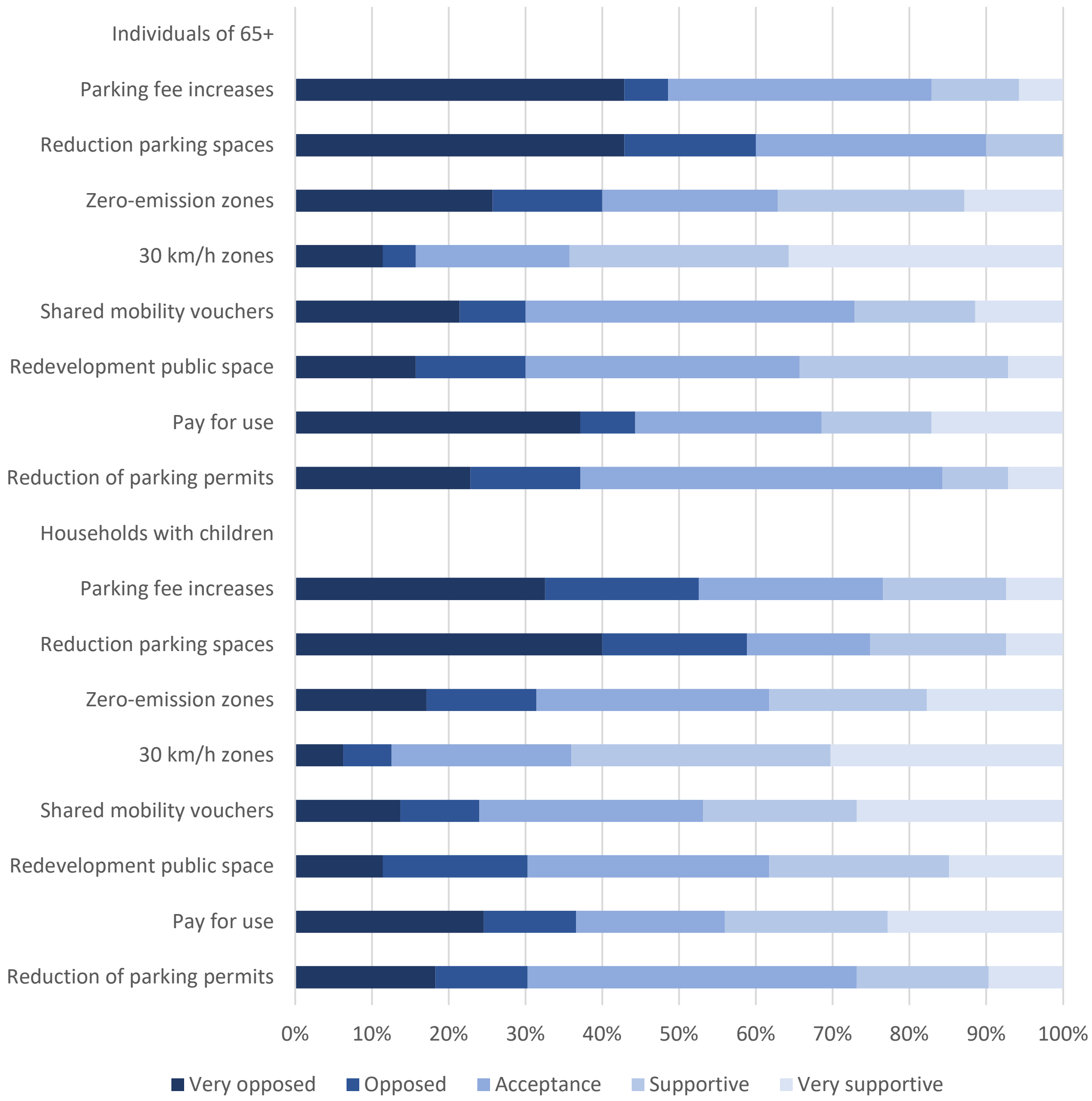

Figure K 3: policy support versus 65+ years and households with children.

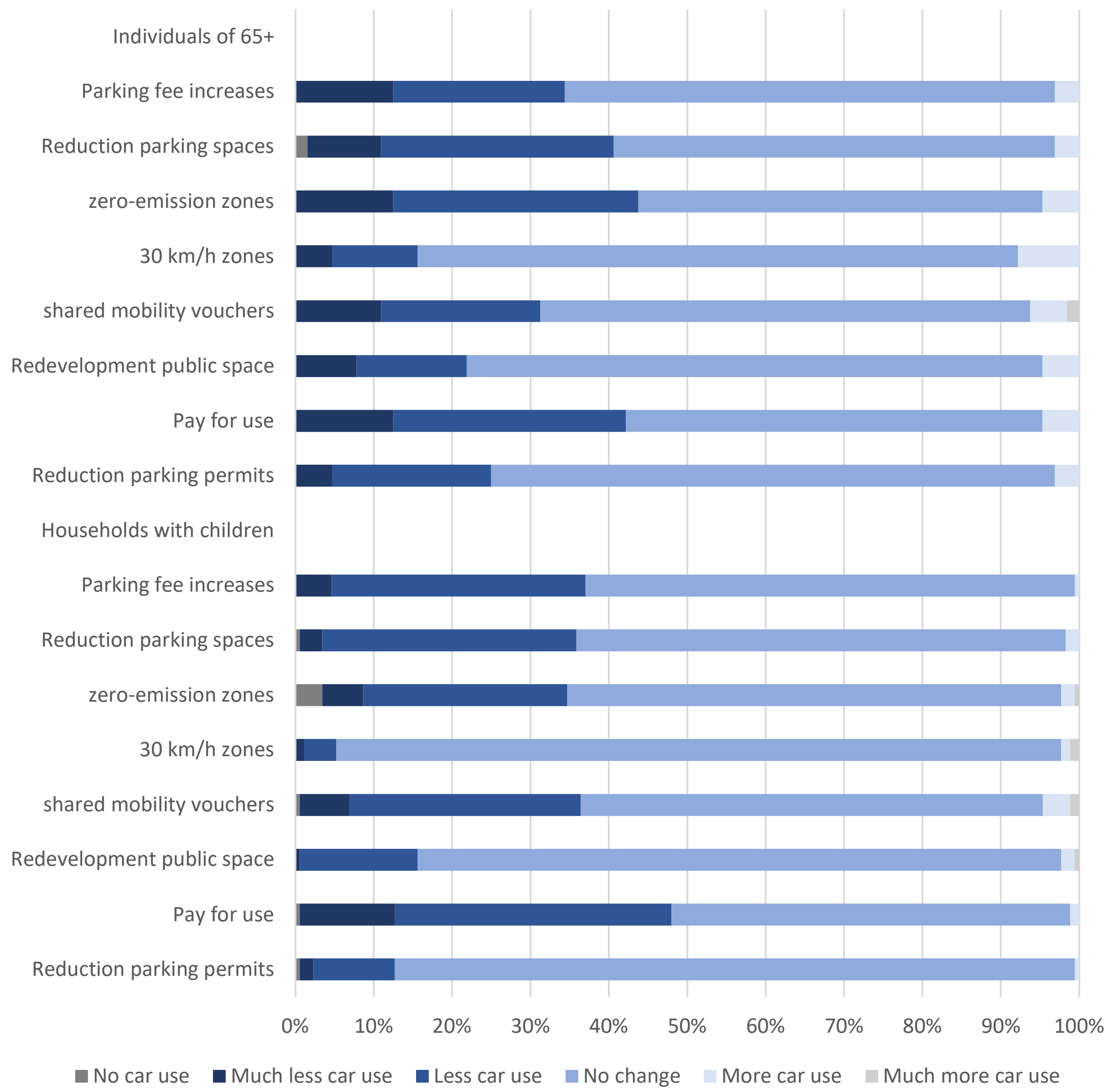

Figure K 4: Self-stated car behaviour change 65+ years and families with children versus flanking policies.

Appendix L: How to hub – conversation starter

This appendix shows the conversation starter which can be used by policymakers to start discussing about how to implement mobility hubs (displayed on page 186). The conversation starter has three main questions which helps to define the problem statement, the desired behaviour, and the social group which can best be targeted. Furthermore, the conversation starter shows for three target groups which hub attributes and flanking policies can best be implemented by showing a positive or negative effect of the attribute. The colours of the three groups correspond with the colours of the positive or negative effects. There are two black positive effects, these are general effects not related to a specific target group.

HOW TO HUB - CONVERSATION STARTER

How to use: Discuss the questions. Three target groups have a corresponding colour to the effects of policies or attributes on hub usage for that group

1. What is the goal?
2. What is the desired behaviour?
3. What is the target group?

Age

Household composition

<30 years
Non-family households

30-39 years
Singles and couples

40-59 and 65+ years
Elderly and families with children

Flanking policies to support hub implementation

Flanking policy	Support	Effectiveness
Pay for use (toll)	− − −	+ − +
Parking measures	− − −	+ + +
30 km/h zones	+ + +	− − −
Zero-emission zones	+ + +	+ + +
Shared mobility vouchers	+ + +	− + +

Attributes to increase hub attractiveness

HOW TO HUB AS A POLICYMAKER
Implementing mobility hubs to change car-usage habits: accelerating the green mobility transition

Master thesis

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