The importance of sociodemographics in transport policy:

an application of Latent Class Analysis to explore the impact of sociodemographics on travel behaviour profiles

N.M. Eichenauer

TU Delft

PBL Netherlands Environmental Assessment Agency

The importance of sociodemographics in transport policy:

an application of Latent Class Analysis to explore the impact of sociodemographics on travel behaviour profiles

by

Nadine Martje Eichenauer

to obtain the degree of

Master of Science

in Transport, Infrastructure and Logistics

at the Delft University of Technology

to be defended publicly on September 28th, 2023

Student number:	5330432	
Project duration:	September 2022 – September 2023	
Thesis committee:	Prof. dr. ir. Bert van Wee,	TU Delft, thesis committee chair
	Dr. Niels van Oort,	TU Delft, supervisor
	Dr. Jan Anne Annema,	TU Delft, supervisor
	Dr. Jeroen Bastiaanssen	Planbureau voor de Leefomgeving/ Netherlands Environmental Assessment Agency (PBL), supervisor

TU Delft

Preface

The thesis ”The importance of sociodemographics in transport policy: an application of Latent Class Analysis to explore the impact of sociodemographics on travel behaviour profiles” that I have been working on part-time for the past 12 months is the last step in obtaining my Master’s degree ’Transport, Infrastructure and Logistics’.

I would like to thank the PBL Planbureau voor de Leefomgeving and especially Jeroen Bastiaanssen for giving me the opportunity to do this research project with them. I was able to benefit from the rich expertise of the V&M team and was able to experience the national institute for strategic policy analysis in the fields of the environment, nature and spatial planning from the inside. Apart from Jeroen and the rest of the team, I would also like to thank my daily supervisors at TU Delft, Niels van Oort and Jan Anne Annema, who accommodated and supported my ambitious plan of writing a thesis while completing another master programme. I would also like to thank my graduation committee chair, Bert van Wee, for initially connecting me to the team at the PBL and inspiring me to delve deeper into transport and ethics. I would like to thank all committee members for their feedback and guidance throughout the process. I would also like to give a special thanks to Maarten Kroesen who met with me several times to assist me with understanding and building the Latent Class Model, familiarising myself with the programme Latent Gold and subsequently interpreting the findings. Lastly, I would like to thank my friends and family, who supported me throughout the process, and kept me sane and encouraged me to take a step back when I could not see it. I would especially like to thank those who endured hour-long discussions about my thesis, be it in the initial problem-finding stage or later on when building the latent class models or in the final stages when refining the storyline. A special thank you also goes out to Yves, Alice and Anna who proof-read my thesis and gave me very useful feedback, I am very grateful to have you.

I have learned a lot during this project, especially about latent class analysis, how to plan and go through with such a big project and a lot about myself. However, one very unexpected thing that I learned the hard way at the supposed end of this research project was that you are only ever as efficient as the IT system you’re relying on is. With that knowledge in mind, I am excited for the (academic) adventures that lie ahead!

Nadine Martje Eichenauer
Den Haag, September 2023[1]

[1] cover image by macrovector on Freepik

Summary

The options people have for their daily travels is relevant in at least two regards. First, it resembles to what extent people can partake in society by not being excluded through transport. Second, it shows how easily people could shift to more sustainable modes of transport. Travel options can be constrained in a spatial sense, for example, meaning that where someone lives there are just no good public transit connections. But they can also be constrained by other factors, such as whether or not someone travels with a child, what their disposable income is, what their cultural upbringing is and so on. Understanding specific travel profiles and what causes them will shed light on why people travel a certain way and give an idea of how that can be influenced through policy. Therefore, this research uncovers TB groups and how sociodemographic factors are connected to that by utilising Latent Class Analysis (hereafter LCA). Subsequently, the classes are mapped out to see the spatial distribution of TB, adding to the analysis by not only evaluating the effect of abstract sociodemographics but also visualising the geographic extent of TB (hereafter TB) differences. The analyses are conducted to answer the main research question:

"To what extent are different travel behaviour patterns associated with specific socio-demographic profiles and what are the implications for transport policy?"

This research contributes to the scientific field by showing the different roles of sociodemographics as well as spatial factors and thus takes a holistic perspective on the contexts in which TB takes place. First, a literature study was conducted to identify relevant factors to include in terms of indicator variables for TB as well as predictor variables in terms of factors influencing TB. The indicators assessed regarding TB are mode choice, travel distance and travel time because when taken together these factors resemble how spatial accessibility is measured but also show the mobility of travellers. The literature study also shed light on general TB theories and showed that people travel differently depending on their travel purpose. Therefore, in this thesis the analysis was performed on data of travels that are deemed necessary and non-avoidable (such as travelling for work and education) and leisure travels. As education travel differs to a certain extent from work travel, another dataset for work-related travels only was created to correct for the education travels. The data chosen to work with was the Onderweg in Nederland (ODiN) dataset from 2018 and 2019 as it both entails most of the factors identified as relevant in the literature study and represents the entire Dutch population.

After an initial descriptive analysis, the LCA was performed on the all travel purpose datasets by using the software Latent Gold. Mode choice, travel time and travel distance were chosen as the indicator variables to base the clustering on. Level of urbanisation, income levels, age, ethnic background, gender, level of education and whether or not someone travels with a child younger than 6 were included as active covariates. The inactive covariates were car ownership, household constellation and whether or not someone lives with a child younger than 12. The analysis was performed for up to 10 clusters. Subsequently, the different estimated models were interpreted and analysed which resulted in choosing an 8-class model for work and education and work only motives and a 7-class model for leisure travels. Out of the classes, 3 were car classes (4 for work and education and work only), 3 were active classes and one public transit class could be identified. Each model entailed two classes for rather similar travel distance and travel time categories, thus indicating that the most pivotal factor in TB differences is mode choice.
After the latent class model was finalised, the information from the predicted values output from Latent Gold was used to plot the probabilities of class membership on a map of the Netherlands. This was done to visualise the spatial dimension of TB and see what classes are especially present at certain location characteristics. It added to the analyses as the level of urbanisation indicator lacks the geographic component. Moreover, a visual, such as a map is easier to interpret than an abstract indicator.
The findings were subsequently analysed in terms of specific sociodemographic profiles as well as specific journey characteristics. All classes of all estimated models were first briefly presented. Then,

the findings for the different travel purposes were compared as it was found that all classes are rather similar in terms of journey characteristics and mode choice. Next, it was assessed whether the groups who choose sustainable modes (i.e. active modes or public transit) are substantially different from the groups who travel by car. The analysis showed that for work (and education) related travels, specific profiles can be identified for both car and sustainable travels, whereas for leisure the profiles are less clear-cut. Thereafter, the substitutability of clusters that have similar journey characteristics (i.e. travel distance and time) was assessed. Thus, it was investigated what factors play a significant role in making someone travel by a certain mode if journey characteristics are the same. Specifically, three journey types were identified, namely short journey, medium journey and long journey. The different modes used to make these journeys were car and active modes for short and medium distances and car and public transit for long journeys. It was found that for active modes and public transit, a clear spatial distribution along the Randstad area could be identified. However, the car mode is much less influenced by that, meaning that while being outside of the Randstad works as a deterrent for active modes and public transit, travelling by car is warranted by other factors, such as sociodemographic ones. This was followed by a comparison with accessibility maps developed by Bastiaanssen and Breedijk (2022) and it was shown that TB does not always match with what would be expected based on spatial accessibility only. It could thus be concluded that for certain modes, spatial accessibility is not sufficient for someone to choose them. In particular the factor of travelling with a child younger than 6 seemed a clear deterrent to using more sustainable modes even if one was located in the Randstad area.

Another ambition of this research was to show how interaction terms of different sociodemographics influence TB. Clear differences with regards to the travel motives could be identified and in all cases some interaction terms ranked higher than other plain covariates. From this, it could be concluded that future research should take interaction terms into account more regularly, as there seems to be much more to uncover in that regard. In this research, some of the interaction terms were not sufficiently represented in the dataset (which is the definition of a minority), so further analysing them by means of the LCA would lead to difficult-to-interpret results. The latent class model capitalises on distributions and differences and having a rather small number of cases for certain interaction terms skews the model and makes it very difficult to interpret meaningfully.

The last step of this research was aimed at hearing experts' opinions and ideas about the findings. Thus a focus group workshop with 8 researchers from the traffic and mobility (V&M) team at the Netherlands Environmental Assessment Agency (PBL) was held. At this workshop, three different topics of the research were discussed, namely general differences in travel motives, a correlation between 'disadvantaged' groups and sustainable travel modes, and the aforementioned substitution possibilities between different modes. Main conclusions from the workshop include that especially the medium-educated suburban medium-distance car travel class could be said to be motivated by more of a car-positive culture. Thus, it was indicated that people in this class probably fall into the residential-self-selection category. Hence, their car use should not be labelled a need but a preference. Moreover, the researchers stated that traditional gender roles still play a significant role in how people travel. What's more, they argued that more information and research is needed for specific classes that they struggled to unambiguously interpret. The classes identified in this research are a useful starting point for further in-depth research on specific groups' travel motivations.

Overall, this research has shed light on the relationship between sociodemographic factors and TB and its relationship with accessibility. It was shown that specific sociodemographic factors such as low income levels influence TB independent of other circumstances while other factors, such as gender are dependent on the other sociodemographics. Surprising travel classes, such as dedicated active travellers with seemingly no alternatives, showed different sociodemographic profiles depending on the travel purpose, yet they were present as a class for each of the travel purposes. Also surprisingly, it could be shown that for some groups, spatial circumstances play a significant role, such as for the active travellers for distances longer than 1.5 kilometres and for the public transit travellers while TB such as short car travels was present across urbanisation levels and across the Netherlands. It became apparent that people who are generally regarded more disadvantaged in society travel by sustainable modes more often, even if their trip covers the same distance or travel time as it would take by car.

Policy recommendations of this research are that a dialogue between employers and employees with regards to mode choice should be enhanced. Even if the same distances are covered, especially for work the choice for car is very dominant. While this might have to do with comfort, offering e-bikes for employees could be a good start to also facilitate a shift in thinking and culture. Furthermore, people with children need to be supported in switching to more sustainable modes by either providing more child care facilities also in rural areas or by making it easier to travel with a child in public transit. Related to this is the recommendations especially for public transit operators to provide more information about facilities around children on public transit vehicles. A last recommendation is to tap into the possibility offered by the fact that young people still use more sustainable modes than older people. Reasons for young adults switching to car at some point in their lives need to be investigated further. If their switch is due to life circumstances (such as having children), the aforementioned policy recommendation holds, as it also becomes apparent that once one has a car, one is more inclined to use it. Avoiding the need for young people to switch to a car seems one of the biggest recommendations that became apparent from this research. Moreover, recommendations for further research are specifically that data availability for minorities needs to be improved in order to uncover how people travel that are traditionally considered to be the most disadvantaged in society.

Contents

List of Figures

List of Tables

1

Introduction

How people travel and why they travel the way they do has become a key focus of research and politics in recent years. On the one hand, this debate concerns the normative claim that people should be able to reach desired destinations by whatever mode they want to (Bersch and Osswald, 2021; Lucas, Mattioli, et al., 2016). On the other hand, the debate evolves around a practical need to shift to more sustainable modes of transportation to mitigate climate change and pollution especially in urban areas (Molin et al., 2016). In this context, the question arises as to whether it is possible for people to substitute less sustainable modes such as car with more sustainable ones (Lucas, Bates, et al., 2016). In a way, aiming for mobility justice as well as aiming for sustainable transport work together as people who cannot reach certain destinations by any other mode than car also will not be able to switch to a more sustainable option (leaving electric cars and the like aside). Thus, it is important to have knowledge of the capacity and ease with which different people by reach their desired destinations by different modes both for mobility justice as well as to achieve a more sustainable future in terms of transport.

Recent political developments in the Netherlands show that these issues are in fact on the policy agenda (see e.g. Bastiaanssen and Breedijk, 2022 and Planbureau voor de Leefomgeving, 2022 on the topic of Brede Welvaart). It shows that policies should be created in the interest of the people, and thus it is relevant that policies affect people's ability to travel and reach their destinations in a just way. Also, it is necessary for policy makers to be aware where people could make different choices in their travel behaviour (e.g. go by bike instead of car) or where they are locked-in and have no other choice than to travel by car. Thus, by investigating people's capacity and ability to reach desired destinations by different modes, it becomes obvious where for example prohibitive policies would be successful and where (or for who) not. (Martens et al., 2019; Martens and Bastiaanssen, 2019; van Wee and Mouter, 2021; Molin et al., 2016).

The ability of reaching desired destinations, which can be limited by spatial and non-spatial circumstances, is conceptualised in the academic literature as accessibility. While the concept of accessibility is often defined in a spatial sense, just transport policies should also benefit people who live in an area with high spatial accessibility but are otherwise disadvantaged (Lucas, Bates, et al., 2016). Put simply, arbitrary factors should not play a role in whether one can travel where one needs to. It is generally agreed upon that someone's travel behaviour (hereafter 'TB') is the result of multiple different characteristics. For example, the built environment but also personal economic reality, and arbitrary factors such as socioeconomic circumstances like age, gender, ethnic background, household constellation, and education level can be factors influencing travel behaviour (Chowdhury and Van Wee, 2020; Bauman and Bull, 2007; Lynch and Atkins, 1988; Maat et al., 2005; van de Coevering, 2021; Lucas, Bates, et al., 2016). Nevertheless, to what extent each of these characteristics is relevant and how exactly this influence materialises is still underresearched. As is the role of different mobility styles within these groups. Moreover, often, the spatial component is given more attention than the other personal circumstances of an individual's travel ability. Nevertheless, it is crucial to have knowledge of both the personal non-spatial as well as spatial characteristics that influence TB. Investigating to what extent those factors are relevant allows for a more detailed understanding of TB patterns and possi-

bly enables a more accurate analysis of which groups travel a certain way and why and subsequently enables better policy making.

1.1. Main Aim

The aim of this research is two-fold. The first aim is of empirical nature, namely establishing to what extent there is a significant relationship between sociodemographic factors and travel behaviour and what its relevance is for policy making. Specifically, it is aimed at investigating specific profiles and combinations of sociodemographics that are associated with certain TB patterns. The greater the significant of the relationship identified between sociodemographics and TB, the greater the support for the claim that sociodemographic factors restrict mobility to the extent that one can speak of restricted accessibility. While the impact of personal characteristics such as age, income or gender on travel behaviour is not contested in the academic literature, at present there are few to no studies to assess this relationship on a national scale as the subsequent literature review will demonstrate. It will be established to what extent personal factors are reasons for specific travel patterns and what those travel patterns look like.

The second aim is of more of a methodological nature, namely to test to what extent the applied method of Latent Class Analysis (LCA) adds to more traditional measures of travel behaviour in the domain of mobility justice. It will be assessed to what extent applying a method such as LCA does justice to the many dimensions that make up and constrain TB while still being rather straight forward in interpretation.

1.2. Research Questions

Travel choices made based on personal circumstances are often disregarded as mere preferential differences and labelled irrelevant for policy making (see e.g. Miller, 2018; Martens et al., 2019). However, elsewhere (e.g. Chowdhury and Van Wee, 2020; Bersch and Osswald, 2021; Crass, 2020; Lynch and Atkins, 1988; Van Eenoo et al., 2022; Saeidizand et al., 2022; Lucas, Bates, et al., 2016) it is underlined that one must be cautious not to confuse mere preferences with needs that are deeply rooted in specific personal circumstances. By better understanding what the role of sociodemographic characteristics is and to what extent we can observe structural issues, policy making can be more efficient and effective in steering towards an equitable transport system (Lucas, Mattioli, et al., 2016). Thus, this research is concerned with investigating the role of personal characteristics in the wider debate of transport policy making and accessibility by answering the main research question:

”To what extent are different travel behaviour patterns associated with specific sociodemographic profiles and what are implications for transport policy?”

To answer the main research question, the following sub-questions are formulated:

1. What factors are known to influence travel behaviour?
2. In what way are existing travel behaviour patterns related to sociodemographics?
   (a) What makes people choose different modes when facing similar journey characteristics?
   (b) Are specific sociodemographic profiles associated with sustainable mode choice?
   (c) How do combinations of sociodemographics influence travel behaviour patterns?
3. What are implications of the observed relationship of sociodemographics and travel patterns for transport policy?

By first establishing how residents of the Netherlands travel and into what travel patterns their behaviour can be divided, and then assessing the role of sociodemographics in influencing travel behaviour, a more holistic view of different travel groups can be established which enables tailor-made policy-making. In order to get a more structured insight into people’s travel behaviour, the analyses conducted will be divided in different travel purposes because travel behaviour differs depending on a traveller’s purpose (see chapter 3). Generally, research question one sets out to establish what factors impact how people travel as a base for further analysis. Further analysis is aimed at investigating whether belonging to certain sociodemographic categories has any explanatory value in travel

behaviour and also whether combinations of certain factors add to that. Travel behaviour indicators to be focused on are mode choice, distance travelled as well as travel time.

In research question two, a Latent Class Analysis with the indicators of travel time, travel distance and mode choice and sociodemographic characteristics as predictor variables for class membership will be conducted. Those analyses will be conducted for different travel purposes and also for different interaction terms of the sociodemographics. This analysis focuses on comparing classes with different mode choice but similar journey characteristics (i.e. distance and time) to assess possible reasons for people to choose different modes while facing similar journeys. Overall, the second research question aims at establishing general behavioural clusters that are predicted by certain sociodemographics and combinations thereof. It is assumed that people show different travel behaviour for the different assessed modes as well as depending on their sociodemographics. By comparing needs and leisure travel analyses, it is aimed at establishing which impact can be attributed to mere preferences and which can be attributed to actual needs. Also, by comparing similar journey-classes, it can be uncovered what contributes to the decision making process for people to go by car or not. The findings are subsequently mapped onto the Netherlands, thereby showing the spatial dispersion of the travel behaviour patterns. It is hypothesised that groups that are disadvantaged on multiple axes (spatial, modal, social) show a significantly different travel behaviour than groups disadvantaged only on one or two of those axes. Moreover, especially the strength of the effect of the social dimension is very interesting as this is would support the hypothesis that mobility of some people is restricted so extensively that one must speak of restricted accessibility, working against the frequent neglect of such differences as mere preferences (see Miller, 2018; Lucas, Bates, et al., 2016).

Lastly, the implications of the findings need interpretation and contextualisation by experts. Thus, the quantitative analyses of research question two are followed by the analysis and interpretation of the results. This is done by discussion them with researchers and experts at the PBL, answering research question three. Another aim is to evaluate and judge the relevance and whether certain differences are problematic or not. It is interesting to investigate whether individual characteristics (if significant) could be taken into account structurally in policy making and to what extent possible differences even matter to policy making.

1.3. Relevance

The scientific contribution of this thesis stems from studying spatial as well as sociodemographic factors as contributing to travel behaviour choices by means of an LCA for the entirety of the Netherlands as well as for multiple different travel purposes. Regarding the societal and wider policy/managerial relevance, this research will contribute to the debate around the built environment, sociodemographic factors and travel behaviour and shed light on how to design better targeted policies. It further contributes to close epistemological gaps in the research field that have traditionally disregarded certain groups' travel behaviour as mere preferences or have overlooked how travel realities are different for different people.

1.4. Study Area

The area that will be studied is that of the entire Netherlands. This scope was chosen for multiple reasons. First, Dutch travel is known for having an above-average share of active travellers, specifically of bike travellers. This makes it a very interesting case to investigate sustainable travel. On the other hand, car trips still make up the majority of travels, thereby allowing for an interesting comparison of these modes. Second, the specific geographic makeup of the country, as showing a ring-like urbanisation structure (i.e. the Randstad) allows for a comparison of travel of people living in different urbanisation levels. And lastly, the data availability and expertise for the Netherlands enable this research to be done quantitatively as well as be interpreted and evaluated qualitatively with Dutch researchers. The Netherlands have a population of 17.7 million people (of which 8.8 million are female) living in 12 different regions. Of those, Zuid-Holland is the most dense, with 1391 people living per square kilometre, followed by Noord-Holland (1093) and Utrecht (923) (Centraal Bureau voor de Statistiek, 2021). The provinces with the least people per square kilometre are Drenthe (189), Friesland (196) and Zeeland (217). The biggest cities in terms of population numbers are Amsterdam (905.000), Rotterdam (656.000), The Hague (553.000) and Utrecht (362.000) (statista, 2022). 14% of the population has

been born abroad. A fifth of the population is older than 65 years, while 52% are between 25 and 65. 16% is aged 12-25 (Centraal Bureau voor de Statistiek, 2021). In this research, the study area will be divided in urban and rural areas, which will be analysed descriptively in more detail at a later stage.

The structure of this document is as follows. First, the central concepts and methodology will be explained, followed by a review of key debates in the academic literature. In the literature study, the choice of factors to be included in the LCA as well as the choice for the methodology of LCA itself will be explained. Moreover, relevant transport equity literature is reviewed for the later transport policy assessment. Subsequently, the dataset used for this thesis including the limitations that stem from it will be presented, followed by the results of the research. Specifically, first the data analysis and several Latent Class models are explained, outlined and analysed according to different focuses (i.e. assessing effects from the sociodemographic disadvantaged travellers perspective as well as from a transport policy sustainable travels perspective). Then, the results from the focus group workshop with experts from the PBL Netherlands Environmental Assessment Agency are outlined and analysed. Lastly, the findings are reflected upon, interpreted and related to the academic literature. As a result,recommendations for policy making, public transit operators and future research are formulated. The report will end with main conclusions that can be drawn from this research.

2

Research Methodology

2.1. Overview

This chapter focuses on explaining the methodology used to answer the aforementioned research questions (see table 2.1). Moreover, the different methods are justified in detail. As the overarching aim of this research is to establish to what extent specific travel behaviour patterns are associated with certain sociodemographic profiles, and what implications this brings for policy making, a mixed-methods approach was used. Accordingly, first the travel behaviour patterns and connection to sociodemographics were assessed based on quantitative data and by means of a quantitative method, namely Latent Class Analysis. In a second step, the findings were discussed with experts and researchers and related to relevant literature. The goal of applying qualitative methods to interpret and relate the findings to policy making in the Netherlands is to arrive at more meaningful conclusions and be able to understand the implications more in-depth.

2.1.1. Data

In order to be able to answer the main research question as well as the sub-questions, it was necessary to analyse quantitative data that is representative for the entire Dutch population. Furthermore, it was important that the factors that were identified as relevant to analyse in the literature study (see chapter 3) are present in the dataset. Additionally, the data had to represent pre-Covid-19 levels, as the travel behaviour of people was severely impacted by the pandemic. The mobility dataset ODiN (Onderweg in Nederland) from the years 2018 and 2019 proved to fit most of the requirements and was thus chosen to work with. Chapter 4 will present the dataset in detail and which preparation steps were taken in order to make it feasible to work with.

To what extent are different travel behaviour patterns associated with specific sociodemographic profiles and what are implications for transport policy?

Sub-question	**Method**
1. What sociodemographic factors are known to influence travel behaviour?	Literature Study
2. In what way are existing travel behaviour patterns related to sociodemographics?	Descriptive Analysis - SPSS Latent Class Analysis - Latent Gold
2a .What makes people choose different modes when facing similar journey characteristics?	Map creation Comparison
2b. Are specific sociodemographic profiles associated with sustainable mode choice?	Latent Class Analysis - Latent Gold
2c. How do combinations of socio-demographics influence travel behaviour patterns?	Latent Class Analysis - Latent Gold
3. What are implications of the observed relationship of socio-demographics and travel patterns for policy making?	Focus group interviews

Table 2.1: Methodology

2.2. Literature study

The goal of the first research question was to identify relevant factors that influence travel behaviour and also understand how travel behaviour itself should be quantified. It was also used to guide further analysis. This means that research question one aimed at identifying relevant theories about travel behaviour and influential factors in general and specifically for the Netherlands to build this analysis on. To find out which factors are known to influence TB and should be included in the subsequent analysis, first, a literature study was conducted. By assessing the state of the art research with regards to TB and relevant factors the research could be concretised and conceptualised in detail. In order to understand and analyse differences in TB and infer policy-relevant conclusions from it, it was important to identify indicators that meaningfully quantify transport behaviour. Hence, the literature study was used to identify which travel behaviour indicators were relevant to analyse as well as which sociodemographic factors (among other relevant factors) should be included in the analysis to lay a foundation for the following research steps. Furthermore, chapter 3 underpins why Latent Class Analysis should be used in this thesis from a state-of-the-art-research perspective and help find relevant factors to be included in it. The literature study was also used to contextualise and interpret the findings at a later stage.

2.3. Latent Class Analysis

Research question two is aimed at uncovering travel behaviour patterns as well as identifying how sociodemographics relate to these patterns. Travel behaviour patterns are defined as the combination of the travel behaviour indicators mode choice, travel distance and travel duration. It will be elaborated on further about the choice of these indicators in chapter 3. In order to assess which combinations of these indicators are most common and thereby identify which travel behaviour patterns exist in the Netherlands, a method had to be chosen that was able to find combinations in these indicators in the data. This method also had to accommodate including sociodemographic factors as predictor variables for the TB patterns in order to assess the role of sociodemographics. Latent Class Analysis is a method that is used to find underlying classes in the data based on certain indicators. It subsequently assigns each research unit to a specific class with a certain probability. The goal of LCA is to maximise homogeneity within clusters and minimise heterogeneity between clusters (Magidson and Vermunt, 2002) which means that units within each group should be as similar as possible while groups itself should be very different from one another. Thus, by means of applying LCA, combinations in these travel behaviour indicators could be assessed and grouped. Moreover, when building a Latent Class model it is possible to include specific covariates that predict membership in the classes that were formed on the basis of the TB indicators. Thus, assessing the effect of sociodemographic factors is also possible when doing LCA. To be able to conduct meaningful assessments of the difference of necessary travels and leisure travel, the data was filtered on travel purpose and saved as different datasets which then subsequently were used to perform the LCA. Therefore, in order to investigate to what extent specific TB patterns can be identified, and how sociodemographics are related to that, a Latent Class Model was built.

2.3.1. Specification

For the estimation of the model, the software Latent Gold will be used.
The frequency weights assigned to each entry in the ODiN dataset will also be used in the LCA as well so that the resulting model represents the TB of the population of the Netherlands. In order to keep the LCA meaningful and the model interpretable, the local independence assumption was relaxed. This means that the model was not run with more than 10 clusters, even if some of the indicators are associated within-classes (thus even if no perfect heterogeneity is achieved). The calculated bivariate residuals were checked to see which variables were strongly correlated to be informed for further analysis. From the 10 estimated models, the one with the best model-fit statistics while still being meaningfully interpretable was chosen (for more details, see below).

2.3.2. Covariates

Covariates (i.e sociodemographic factors) were included in the model to predict class membership. Conceptually, covariates are prior to the observed travel behaviour and thus can be assumed to also logically precede the latent variable of travel behaviour patterns. Hence, it is assumed that the covari-

ates cause the latent variable (i.e. travel behaviour patterns as a whole) which in turn causes the indicators (i.e. mode choice, travel distance and travel duration). The covariates may also be correlated. As the model estimates the new classes with covariates simultaneously, the latent class model as well as the classes themselves without covariates and with covariates can differ (Vermunt and Magidson, 2013). This, however, is not considered problematic because the real-life process is also assumed to be simultaneous (i.e. someone is not assumed to first have specific travel behaviour and then suddenly obtain a socio-demographic characteristic which in turn then alters their travel behaviour).
The basic probabilistic presentation of the latent class model does not allow for a more in-depth analysis of the effect of the covariates. Hence, once the model had been obtained it was re-parameterised as a logit model and thus able to predict membership to certain classes based on the characteristics of a research unit (Vermunt and Magidson, 2013). This is done to not only assess mere class composition but to also identify which factors contribute more or less to class membership.
Some variables may have to be included as inactive covariates rather than active ones if the direction of causality is not clear. This is the case with car ownership as it is contested in the academic literature to what extent car ownership is a result of the need to travel further/lack of other choices or whether further travel is partly caused by car ownership (Handy, Weston, et al., 2005; Pot et al., 2023; Kroesen, 2019b).

Once the model was estimated with the ODiN data, it could be used to make predictive statements about how a research unit with certain characteristics (i.e. covariates) was going to travel, what modes they might use, etc. Nevertheless, it is a probabilistic assignment, thus group assignment is not definite (Magidson and Vermunt, 2002).

2.3.3. Goodness-of-fit

Once the model was run with up to ten clusters, the relevant goodness of fit and model parsimony indicators were assessed. Especially the Bayesian Information Criterion (BIC) was used as a guiding criterion - the lower the value the better fitting the model. The BIC indicator is estimated by evaluating the log-likelihood (L) and correcting for the number of parameters (k) as well as the number of observations (n) (Magidson and Vermunt, 2002) and is estimated as shown below:

$$BIC = k\ln(n) - 2\ln(L) \tag{2.1}$$

Once the best-fitting cluster size had been obtained, the classification statistics were analysed in further detail. The bivariate residuals (BVR), for example,show how well the identified travel behaviour classes were separated and to what extent heterogeneity between classes was achieved. With LCA theory guides interpretation and modeling decisions as well. Thus, while the goodness-of-fit indicators was used to assess statistical fit, theory also guided decisions. This means that the model with the best model fit statistics while also making sense when interpreted was chosen. One rule of thumb for this is that models with classes smaller than 5% or bigger than 50% of the sample are generally not chosen.

2.4. Map creation and comparison

While it is necessary to understand the impact of sociodemographic factors on TB, and which profiles are identified by LCA, grasping the concrete spatial separation or extension of these profiles is necessary for a holistic interpretation of the profiles. Moreover, in order to relate the impact of sociodemographic of TB to that of spatial accessibility, it is crucial to visualise the findings from research question two and show in which areas of the Netherlands what TB patterns are more or less common. Thus, the 'estimated values' output from Latent Gold from research question two were merged with ODIN2018/2019 5-digit postcode data and subsequently visualised with the geo-information system AcrGIS Pro. The information on the administrative boundaries of the postcodes was obtained from the Statistics Netherlands (CBS) 'Wijk and Buurtkaarten 2019'.
The first step in this process entailed merging the data from the latent class model out of Latent Gold and ODIN from SPSS in Microsoft Excel. A search and match command was formulated to match the postcode data with the combinations of sociodemographics and class membership probabilities. Subsequently, per post code, the average probability of observing a specific travel behaviour (i.e. to be in a specific class) was calculated. It should be noted that the decision was made to weigh the maps according to the weights ascribed to people ('OD' in the dataset) and not to trips ('Verpl' in the dataset). This way, not only the most mobile people were represented in the maps. In the LCA, it was crucial to

look at a representative number of trips and how the sociodemographic makeup of their travellers is to be able to say something about the connection between travel behaviour and sociodemographics. In this research step, it was less interesting to look at the trips but it became more interesting to investigate how people from different areas would travel, which is a slight, yet relevant, difference.
These maps were created in such a way, that the higher the probability of being in a class, the more saturated the colour of the post code polygon. The colours were chosen in a way to present the effect most clearly. The chosen colours (red, yellow, green, blue) should in no way indicate positive or negative values attached to the modes presented.

In a next step, maps were created that show which class of travellers is most represented in a specific area. In these maps, the most common travel class per post code was depicted. If clear regional trends could be observed, this would support the hypothesis that geographical factors play more of a role for people's travel choices than their personal factors do and vice versa. This map was obtained by first listing all OD IDs per postcode and the class that they were most likely to be in according to their sociodemographic characteristics. The actual probability of their class membership did not matter at that point. In these maps, the colour of each polygon represents a specific mode choice rather than a higher probability of being in a class.

2.5. Focus group workshops

The last step of this research was aimed at interpreting the results and assessing them together with experts. Hence, expert workshops and presentations were held throughout the research process to get guiding input. Specifically, 3 presentations with experts and researchers present throughout the research process were held and one final in-depth focus group workshop was conducted to discuss the findings and policy implications. The first presentations were aimed at benefitting from the general input regarding analysis steps and relevance for policy and were held in the months 6, 7, and 8 of the research process. Between 5-15 people were present at each of the presentations. While in the first presentation, only fellow researchers from TU Delft were present, the second and third presentations were directed towards policy makers and researchers from the PBL Netherlands Environmental Assessment Agency in order to relate the abstract, data-based findings to the practice of policy making. The last focus group workshop was thus specifically aimed at in-depth feedback about the usability and policy recommendations and was held in month 10 with seven researchers from the traffic and mobility research team (V&M) at the Netherlands Environmental Assessment Agency (PBL).
During the focus group workshop, it was planned that the researchers would discuss the findings freely, upon being re-introduced to the methodology and research. In a previous workshop, the experts were presented the research in-depth, so that in the following focus group workshop this did not have to be done again. The researchers were confronted with 3 main findings from the research and asked to comment and interpret. In case that they would not discuss freely by themselves, they were asked to discuss along the lines of the following questions:

- What do you see?
- What do you think is relevant/interesting?
- What did you expect/what is surprising?
- How useful do you think the findings are? For you as researchers? For policy makers?
- What is missing from the analysis/what would you want to know more about?

The idea of a focus group interview is generally to observe expert interactions and benefit from letting a discussion flow (Adler and Clark, 2014). Focus group workshops were chosen as a method because generally they are a good way of generating data from experts to benefit from practical knowledge and possibly guide to new angles of analysis.They are also an easy way of producing data as one can also benefit from the interactions happening during group discussions (Adler and Clark, 2014; Fontana and Frey, 1994). Due to the group setting, it is also thought that focus group discussions can yield more critical output than bilateral interviews. This is especially useful when consulting more experienced researchers and experts to benefit the policy applicability of this research. Lastly, focus group interviews can also be used to validate the findings and provide a deeper understanding than mere data analysis

can. In a focus group setting, confronting multiple experts with difficult-to-grasp information will also result in less comments due to mere lack of understanding, as the experts can discuss and analyse the presented information together (Adler and Clark, 2014). As the focus group consisted of a team of experts who work together on a day-to-day basis, it was expected that they would not intimidate each other and that everyone felt invited to speak their mind and help interpret the findings. They also disagreed a few times throughout the course of the focus group session which is considered to generate very fruitful information.

In the next chapter, relevant academic literature with regards to travel behaviour, sociodemographics and mobility justice will be reviewed. The aim of this chapter is to identify relevant sociodemographics to be included in the LCA as well as which travel behaviour indicators should be used to quantify travel behaviour meaningfully to investigate the formulated research problem. Furthermore, the chapter will show why LCA is the necessary methodology to apply.

3

Literature Review

In this chapter the literature study is presented. The aim of the literature study is answering the first sub-question ”What relevant factors are known to influence travel behaviour?”. Answering this question has has two purposes. First, it is crucial to identify what general criteria factors to be included in the subsequent analyses should conform to. Thus, the first part of the literature study is aimed at identifying theories and concepts around the relevance of factors influencing travel behaviour to guide the identification process of factors. The literature found should give an indication as to what is relevant for (fair) policy making. Then, the literature study continues to identify relevant factors to be included in the subsequent analysis. Those factors should be in line with what is identified as relevant in the first part. Also, the analysis method itself is assessed.

3.1. Search strategy

The literature on the general input was found by searching for ”transport justice”, ”mobility justice”, ”transport poverty” and ”equity and accessibility” in the search engine Google Scholar. For the second part, the literature on relevant factors when assessing travel behaviour and sociodemographics in the context of accessibility was found by searching for ”sociodemographics and travel behaviour”, ”travel behaviour and accessibility” as well as ”sociodemographics and accessibility” in the search engine Google Scholar. Papers that were suggested by the search engine from these keywords were assessed based on their abstract and if deemed relevant, subsequently downloaded and reviewed. From the papers that were initially found, other relevant papers were identified in a snowball-like sampling strategy by reviewing those papers' references. The literature search was first performed in October 2022 and updated until June 2023 with relevant literature.

3.2. Policy relevance

The costs and benefits of transport policy measures as well as of the wider transport system are generally unequally distributed over (groups of) people (van Wee and Mouter, 2021). Nevertheless, put simply, the aim of the transport system and transport policy in particular should be to enable people to travel from where they are to where they want to be (Van Wee and Geurs, 2011; Miller, 2018; Martens and Bastiaanssen, 2019; van Wee and de Jong, 2023; Pot et al., 2023; Lucas, Mattioli, et al., 2016). In addition, there is academic consensus that a good transport system should work towards enabling travellers to reach their desired destination by environmentally friendly, healthy and affordable modes such as active modes or public transit (Kroesen, 2019a; Bastiaanssen and Breedijk, 2022; Lucas, Bates, et al., 2016; Schwanen et al., 2004; Maat et al., 2005;Molin et al., 2016; Kroesen, 2019a). Main reasons as to why a transport system should enable travel by those modes include the negative externalities associated with a growth in non-sustainable transport such as car (Pot et al., 2023; Molin et al., 2016). This includes negative safety impacts, environmental effects and health effects. Generally, car travel is also seen as morally questionable as the safety risks are higher for pedestrians and people travelling by bike, thus for those who did not actively consent to those risks (Pereira et al., 2017). Another reason for aiming at enabling everyone to travel are the detrimental effects social exclusion through transport poverty can have (Lucas, 2012). Being able to move around freely and participating in social

life is central to feel included in the wider society and contributes to people's wellbeing (Lucas et al., 2009; Martens and Bastiaanssen, 2019). Not only is being excluded problematic for people's happiness and livelihood opportunities. An inability to access job opportunities also leads to economically less productive people (and more welfare dependence) which can hurt economic prosperity. Additionally, inability to travel can lead to increased social isolation and, if this happens to people with a migrant background, might lead to further segregation and can hinder successful integration (Fransen and Farber, 2019; Martens and Bastiaanssen, 2019; Martens, 2012; Pot et al., 2023; Lucas, Mattioli, et al., 2016). Hence, transport policy should work towards a transport system that is available to all people and in fact, has been declared a policy goal for Dutch politics under the umbrella term of 'broad welfare' (Brede Welvaart, see e.g. Bastiaanssen and Breedijk, 2022). Specifically, broad welfare as an aim entails preserving everything that is considered as worthy by people. Besides material welfare this includes issues such as health, education, the environment and landscape, social cohesion, personal development and safety (Planbureau voor de Leefomgeving, 2022).

Accessibility differs from the concept of mobility, albeit related, in that mobility evolves around the ease and mass (i.e. frequency, distance) of travel. In contrast, accessibility does not mainly concern people's actually observed mobility but rather the options someone has from (or to) a certain location (Handy, 2020; Fransen and Farber, 2019; Martens, 2012; Miller, 2018; Martens and Bastiaanssen, 2019; Pereira et al., 2017; Pot et al., 2023). Thus, while policies aimed at building more roads might help people to travel further away, measuring only mobility indicators such as vehicle miles travelled does not give an indication about whether a person *had to* travel all those miles to get to a certain place or whether they just chose to do so. Additionally, this focus has traditionally prioritised car travel and thus led to improvements in car mobility rather than other sorts of mobility. Moreover, focusing on people's mobility levels will only ever show the data of those people that are already mobile and it will not include information about their motivation to travel as much or little as they do. However, focusing on accessibility, enables researchers to inform policy makers about regions that are deprived of certain options. Hence, when aiming at designing a good transport system that enables people to reach desired destinations by other modes than the car, focusing on spatial accessibility rather than mere mobility has been established to be more effective.

One of the most used definitions of accessibility referred to in policy making is that of spatial accessibility (see e.g. Bastiaanssen and Breedijk, 2022; Kapatsila et al., 2023). Roughly put, it measures accessibility as the number of destinations that can be reached from a specific location or area within a specific travel time and distance and with a specific budget (Bastiaanssen and Breedijk, 2022; Kapatsila et al., 2023). This definition is rather popular for policy making as it is easily understandable and measurable. Spatial accessibility is the result of the combination of the built environment (or land use) and transport systems (Van Wee and Geurs, 2011; Handy, 2020; Fransen and Farber, 2019; Martens et al., 2019; Martens, 2012; Miller, 2018; Van Eenoo et al., 2022; Pot et al., 2023). However, not only the spatial aspect of built environment influences it but also factors such as time constraints and individual circumstances (demand factors) influence one's ability to reach a desired destination (Fransen and Farber, 2019; Miller, 2018; Van Wee et al., 2013; Martens and Bastiaanssen, 2019; Pereira et al., 2017; Maria Kockelman, 1997). Going beyond the concept of mere spatial accessibility, the following section will outline in detail which other concepts can be used to understand one's ability to travel.

3.3. Active accessibility, person-based accessibility and motility

While spatial (also called place-based or location-based) accessibility generally analyses and understand traveller's options from a merely spatial perspective, the academic literature offers other, broader concepts to understand and reason a person's travel behaviour. While active place-based accessibility describes the number of places that can be reached by a certain location and is as such a very relevant indicator of the travel opportunities from a specific location (Simma and Axhausen, 2003; Handy, 2020; Fransen and Farber, 2019), it cannot take individual factors into account, and is thus merely based on spatial factors. Thus, it is falsely assumed that the accessibility levels for people living in the same area are all the same (Fransen and Farber, 2019; Cascetta et al., 2013). While spatial accessibility correctly depicts the upper limit of the travel options people have, there might be people living in an area with different or specific needs that even further restrict their choices than the concept of spatial

accessibility presents. To overcome this oversimplification of reality, another layer of information can be added by analysing correlations between spatial data and zonal characteristics, such as investigating the correlation between low income areas and low accessibility levels. Nevertheless, the problem of this approach is that the aggregate data misses out on further detail by e.g. using the average of percentages of certain groups and that this one factor is the only one influencing their constraints (and influencing everyone in this group equally strong) (Fransen and Farber, 2019). Hence, when the goal is to gain more in-depth information about travellers, a person-based indicator would be a better choice. Person-based indicators show accessibility at the individual level, for example by applying the concept of space-time geography (Van Wee et al., 2013; see Fransen and Farber, 2019 for a detailed account). Nevertheless, not only does this concept need a lot of data on the individual level but also is its visualisation and interpretation on the aggregate level and conclusion drawing for policy not possible due to its rather subjective nature (Fransen and Farber, 2019; Miller, 2018). Hence, it can mainly be used for detailed analyses of individuals (Fransen and Farber, 2019). A theoretical concept established in the social sciences that tries to connect the idea of spatial ability to move but also more fundamental capabilities and the general motivation around mobility is called *motility* (Bernier et al., 2019; De Witte et al., 2013). Conceptually, it joins the concept of spatial accessibility with potential mobility. It was coined by Kaufmann in 2002 as ”the capacity of entities to be mobile in social and geographic space, or as the way in which entities access and appropriate the capacity for socio-spatial mobility according to their circumstances” (Kaufmann et al., 2004:750). Elsewhere described as active accessibility, this concept tries to generalise travel needs and inhibitors for certain sociodemographic factors as well as spatial circumstances. In the next section, relevant factors that inhibit a person’s capacity to be mobile along the lines of motility will be outlined in depth.

3.4. Inhibitors of free movement - Axes of disadvantage

In general, differences in travel behaviour are especially relevant when they are due to arbitrary factors, and they are even more grave when it comes to arbitrary, non-changeable factors. Beyond spatial accessibility, the available academic literature describes broader concepts such as active accessibility or motility which also entail individual components on top of land-use effects, the transportation system or travel time. As such, these concepts describe how people’s travel behaviour is changed or inhibited by factors that are external to the traveller and as such are relevant for policy makers to take into account when assessing or wanting to change people’s travel behaviour. Individual components are made up of specific needs of a person which can depend on personal characteristics such as age, income, educational level, household situation; abilities (personal as well as in terms of mode availability) and opportunities (depending on income, budget, educational level). Van Wee and Geurs (2011) specifically state that the individual component might heavily influence the aggregate accessibility result. Elsewhere (see for example Miller, 2018; Pereira et al., 2017; Martens et al., 2019; Geurs and Van Wee, 2004; Van Wee et al., 2013) it is also stated that individual preferences and capabilities are crucial in determining personal accessibility levels. Building on the available academic literature, so-called axes or dimensions of disadvantage can be identified which are based on those individual components. The meaning of these axes will be further elaborated on in this section.

Martens and Bastiaanssen (2019) define two main axes of disadvantage in transport equity as spatial and mode choice related. Thus, depending on one’s place of residence, given the built environment of a certain area and the inherent differences of space, one might be disadvantaged more than someone having a different place of residence (e.g. someone living in the city centre is closer to the central municipality office than someone living in the outskirts of that same city)[1]. Furthermore, freedom of mode choice is another central disadvantaging factor according to Martens and Bastiaanssen (2019). This is due to the fact that in the past decades, cities have been modified increasingly to accommodate for cars and thus any other mode of transport is generally more disadvantaged in terms of travel time. Generally, the academic literature widely agrees that people with low income or without access to a car are thought to be the most disadvantaged in terms of general mobility equity (Martens et al., 2019; Bastiaanssen et al., 2020; Lucas, 2012). This is especially related to the spatial conceptions of

[1] While this section is mainly concerned with assessing axes of disadvantage beyond merely spatial circumstances, in general the spatial dimension has to be assessed together with sociodemographics (i.e someone with low income who lives in the city centre will be less disadvantaged than someone with low income who lives in a rural area).

accessibility. The next section presents different implications of spatial disadvantage.

3.4.1. Spatial accessibility - built environment

The exact role spatial circumstances play is still somewhat contested. Some studies find little to no effects between land use and travel behaviour (Maat et al., 2005). Rather, Maat et al. (2005) claim that travel behaviour changes depending on whether ”travel time is minimised, benefits maximised or activity patterns optimised” (Maat et al., 2005:1). Others (e.g. van de Coevering, 2021) find that land use and ease of travel determine the 'action space' of a person. Thus, while land use is not the only factor in determining how someone can travel, it does play a significant role. Again others (Pot et al., 2023) find that not only do actual spatial circumstances matter but perceived accessibility is actually what determines how someone travels. Thus, comparing measured spatial accessibility levels to perceived accessibility, Pot et al. (2023) found that low levels of accessibility do not actually translate equally to low levels of perceived accessibility. They found that some sort of adaptive preference mechanism in rural areas can be observed, which can partly be reasoned by residential self-selection (the active choice to move away from urban areas and with that away from higher levels of accessibility), partly by the fact that satisfaction of a status quo always depends to some extent on what someone's immediate peers have (i.e. regret-minimisation). Nevertheless, the study assessed accessibility plainly as the sum of options in a specific vicinity, irrespective of mode choice. The authors also stated that people living in urban environments have a high car-dependency which conflicts with policy aims of shifting to more sustainable modes of transport and also is not inclusive to people who do not (want to) own a car. Kroesen (2014) finds that built environment precedes residential preferences, thereby slightly contradicting the claim of residential self-selection. Most research (see e.g. Ewing and Cervero, 2010; Schwanen et al., 2004; Ewing and Cervero, 2010; Saeidizand et al., 2022; Van Wee et al., 2019; Lucas et al., 2018), however, shows that built environment characteristics such as density of an area does indeed have an impact on mode choice. Urban density is generally thought to be the strongest factor of the built environment in influencing mode choice. Less dense environments are associated with higher levels of car use. However, much of the literature examining the effect of built environment on travel behaviour poses that to some extent the effect is spurious, and without examining relevant sociodemographic factors, or attitudinal factors, one cannot draw robust conclusions from the findings (Schwanen et al., 2004; Saeidizand et al., 2022; Van Wee et al., 2019).

Most studies, as also reviewed in Ewing and Cervero (2010), while analysing for correlation between built environment and travel behaviour, do not control for differences in travel groups other than income. The variable that is indeed controlled for is socioeconomic circumstance, as defined by income levels. Ewing and Cervero (2010) conclude themselves that some differences in their outcomes might be due to the different samples. Thus, it seems relevant and especially taking issues of justice and equity into account, crucial to analyse those relationships for different travel groups.

3.4.2. Sociodemographic characteristics

Beyond mere spatial accessibility, other, mostly intangible factors also impact an individual's ability to travel and reach a certain destination. Apart from spatial and mode-related disadvantages, other axes of disadvantage include arbitrary non-chosen personal characteristics such as age, gender and ethnicity as well as possible impairments or special needs and other morally arbitrary factors such as income (Martens et al., 2019; Bastiaanssen et al., 2020 Van Wee and Geurs, 2011; Bersch and Osswald, 2021; Simma and Axhausen, 2003; Durmus, 2022; Fransen and Farber, 2019; Chowdhury and Van Wee, 2020; Lucas, 2012; Lucas et al., 2018 Kroesen, 2014; Lucas, Bates, et al., 2016). Some of those categories coincide with the other axes (such as low income and car ownership) whereas others can worsen the ability to fully make use of the transport system (see e.g. Chowdhury and Van Wee, 2020; Lucas, Bates, et al., 2016 or Lynch and Atkins, 1988).

A prominent factor of which findings in the literature are rather conflicting is that of gender. Basically every study reviewed here at least controls for gender as a sociodemographic variable. While there should not be any TB differences qua biological differences between males and females, there are social and learned behavioural differences associated with the idea of gender. According to a recent study by the research body Innovate UK, women's travel realities are heavily impacted by concerns over

safety. Moreover, travelling with children changes one's travel behaviour significantly, especially with regards to public transit use. While this is not an inherently female activity, travelling with young children remains a gendered activity to this day (Cain et al., 2022; Kern, 2021; **)**. Another important finding is that certain area's 'sketchy' or grim character inhibit women from travelling there, thereby restraining their access to these places. While this would not traditionally fall under the term of accessibility it can be argued that this does in fact restrict one's ability to travel and should thus be taken seriously in the debate around accessibility and mobility justice. Other research (Kroesen, 2019a) has found that being a (high-income) woman is associated with a more active lifestyle and thus also more active travel choices. While that seems positive in and of itself, assessing the reasons behind this choice for active travel is necessary. It could be a conscious choice to be more active. It could also be due the fact that traditionally more women give up their jobs to take over the task of the household or that if there is a car in the household, it is used by the man. As Schwanen et al. (2004) state "the women in such [young, two-earner] households in particular rely on the private car for commuting to ease the combination of paid labour with household maintenance activities" (Schwanen et al., 2004:587f). Hence, while some women enjoy the access to a car which they apparently have to use to also take care of (apparently) *their* household maintenance activities, other women might not have this privilege and thus ironically fall under the category of living a healthy lifestyle. Again other (similarly dated) research by Simma and Axhausen (2003) shows that being male is associated highly with car use and increased distance travelled. It is crucial to assess the role of gender in-depth in connection with other sociodemographic variables to understand realities and reasons for certain behaviour in light of rather conflicting research.

Again, while it is not an inherent female activity to be a a parent, travelling with children and already merely having them is shown to impact travel behaviour (see e.g. Martens et al., 2019; Lucas, Bates, et al., 2016; Simma and Axhausen, 2003; Cain et al., 2022; Kern, 2021). Especially travelling with young children is often used as an argument against prohibitive car policies in cities (along the lines of 'but what about the single mother with three children, should she do all her groceries by public transit'), but while it seems established that someone who travels with a stroller, for example, will have a different travel behaviour, it is interesting to see what that looks like. Some research around the travel behaviour of parents shows increased trip frequency and decreased trip distance (Lucas, Bates, et al., 2016; Martens et al., 2019).

Regarding income-related mobility inequality, there is a significant body of literature (see for example Bastiaanssen et al., 2020; Lucas, 2012; Barbosa et al., 2021; Lucas, Bates, et al., 2016; Lucas et al., 2018; Martens et al., 2019). It is generally agreed that income is a significant factor limiting people's travel choices and possibly leading to a downward spiral in terms of general social inclusion as well as job opportunities (Lucas, 2012; Bastiaanssen et al., 2020). Lucas, Bates, et al. (2016) argue that while researchers are aware of this, the actual effects are not included in any transport models and thus often not recognised in predictions and hence also disregarded in policy-making.

Similarly, the effect of car ownership is widely established in the academic literature (Lucas, Bates, et al., 2016; Bastiaanssen et al., 2020; Bastiaanssen and Breedijk, 2022; Handy, Weston, et al., 2005; Simma and Axhausen, 2003; Molin et al., 2016). This highlights that having a car leads to further distances travelled and increased trip frequency. A rather recent study of an assessment of car ownership effects on individual employment probabilities by Bastiaanssen et al. (2020) shows that car ownership is significantly associated with higher employment probabilities but also higher sensitivity to longer travel times for youth when it comes to commuting times. It also showed that certain groups of people without access to private transport have severely constrained employment chances if their public transport access is low (Bastiaanssen et al., 2020). Although interesting, this study does not give a general overview over also non-work related travel.

Moreover, the effect of ethnic background has not been studied extensively, partly due to a lack of data (Martens et al., 2019). Nonetheless, there is the general academic understanding that ethnic background indeed has an effect on TB. Partly fuelled by safety and harassment considerations, in other cases by mere cultural habit or basic language barriers (see e.g. Chowdhury and Van Wee, 2020; Lucas, Bates, et al., 2016; Martens et al., 2019). Generally, it seems to be an inhibitor rather than an enabler to mobility.

Another interesting point in this regard is that age, representing multiple other factors such as health (Durmus, 2022) or life stages (Kroesen, 2014; Martens et al., 2019). Age has also been shown to be a predictor of travel behaviour. However, while Durmus (2022) found that age is not necessarily per se a good proxy for health, Kroesen (2019a) find that higher age is associated with less active travel. Other studies (e.g. Molin et al., 2016) find that age has an effect on TB in that younger age is associated with more sustainable and more multimodal travel, but that attitudes towards public transit, for example, are rather low.

Level of education is a factor that is also included frequently in studies that assess or control for sociodemographics. Molin et al. (2016) find that high education is associated with multimodal travel. Other studies also find that high education is associated with active travel through an active lifestyle (Kroesen, 2019a).

Generally, the academic literature overwhelmingly agrees that low-income households and people who cannot drive or do not have access to a car are most likely to experience disadvantage; ”within this, children, young people, and the elderly, single parent households,low-skilled workers, ethnic minority groups, people with physical or mental impairments, are usually identified as often most poorly served. Women are also likely to be more disadvantaged than men within each of these social groups” (Martens et al., 2019:24)

Concluding this section, it has been presented that while the general research on accessibility has increased in the past years, relatively little research has actually evolved around mobility realities for different travel groups (Lucas, Bates, et al., 2016). Although there is a significant body of literature regarding income-related accessibility inequality (see for example Bastiaanssen et al., 2020; Lucas, 2012; Barbosa et al., 2021; Lucas, Bates, et al., 2016), research on other personal characteristics such as gender is either merely qualitative or rather limited, or only used as control variables (see e.g. Cain et al., 2022; Joshi and Bailey, 2023; Durmus, 2022; Lucas, Bates, et al., 2016) and almost entirely lacking in the Netherlands (Durmus, 2022 being a notable exception). Although there is general agreement in the academic literature that specific personal characteristics (such as gender, ethnic background, age) (can) have a strong impact on the travel options that someone has in a similar manner as the built environment (see e.g. (Van Wee and Geurs, 2011; Bersch and Osswald, 2021; Kawgan-Kagan, 2015; Crass, 2020; Lynch and Atkins, 1988; Cascetta et al., 2013; Saeidizand et al., 2022), sociodemographics are not widely recognised as factors that restrict mobility so much that they could be called to limit accessibility. Contrary to that wide belief, recent studies, e.g. a study on travel barriers perceived by women and girls by InnovateUK (Cain et al., 2022), and a study on the differences in socio-economic characteristics of people in transport poverty (Fransen et al., 2022) conclude that while some physical barriers to transport are present for everyone, travel behaviour differs substantially based on personal circumstances and inherent characteristics. For some groups, while their spatial accessibility may be sufficient, certain personal characteristics inhibit travel decisions further. Most studies conclude that it is necessary to investigate travel behaviour in a differentiated manner in order to be able to direct policies towards the necessary groups (Lucas, Bates, et al., 2016). It needs to be established to what extent certain sociodemographics influence travel behaviour as if they were physical barriers. Assuming that everyone faces the same travel barriers may lead to overkill in policies for some groups and not having a sufficiently strong effect for others, thus helping no one. Especially in the policy context of broad welfare it is crucial to understand to what extent certain sociodemographic factors impact travel behaviour and also how, to be able to formulate fair and effective transport policy in the Netherlands (Chowdhury and Van Wee, 2020; Bersch and Osswald, 2021;Crass, 2020; Lynch and Atkins, 1988; Van Eenoo et al., 2022;Saeidizand et al., 2022).

3.5. Other factors that impact travel behaviour

In this section, other factors that influence travel behaviour are outlined. Other factors identified in the academic literature beyond the built environment and sociodemographics are attitudes as well as travel purpose. It is assumed that attitudes that are formed based on negative experiences and that are connected to e.g. safety or economic considerations can be inferred from the assessment of so-

ciodemographics (see e.g. Chowdhury and Van Wee, 2020; Cain et al., 2022; Molin et al., 2016). Other attitudes that have merely to do with e.g comfort considerations are not assessed separately either and are disregarded in this analysis as they are not necessarily relevant for policy making (Miller, 2018) and would be beyond the scope of this research to be assessed in addition.
Another factor that influences people's travel behaviour is that of the purpose for which they travel (Schwanen et al., 2004; Lucas, Bates, et al., 2016; Simma and Axhausen, 2003; Kroesen, 2014). When travelling for work, people have other kinds of considerations than when they travel for leisure (Bastiaanssen et al., 2020; Lucas, 2012; Lucas et al., 2009). For leisure, people might accept longer travel times as long as it is more affordable but for work there might be other considerations. Also, it is possible that leisure trips might not be made at all if the costs (monetarily or otherwise) are too high. Either way, it is considered crucial to differentiate between necessary travels (such as for work or education) and leisure travels as travels for both of these purposes are relevant to someone's life but might look very different. Studies have also shown different travel behaviour and effects of sociodemographics depending on the purpose of travel (Lucas, Bates, et al., 2016; Simma and Axhausen, 2003).

.

3.6. Travel behaviour assessment

In order to understand and analyse differences in travel behaviour and infer policy-relevant conclusions from it, it is important to identify indicators that meaningfully quantify travel behaviour. Regarding this choice, there are specific aspects to consider.

3.6.1. Travel behaviour indicators

One could be interested to investigate people's mobility levels in terms of trip frequency and distance in order to evaluate their general participation in life as done by Lucas, Bates, et al. (2016), for example. While this is generally agreed upon as a relevant indicator to measure issues such as transport poverty or transport related social exclusion, certain relevant sociodemographics that are considered to disadvantage a person in society (e.g. being a single parent) have been proven to increase trip frequency (Lucas, Bates, et al., 2016). Moreover, in light of the rather recent policy paradigm shift, mobility is considered as having some instrumental value to be able to access certain amenities instead of being intrinsically valuable. So while investigating to what extent people generally have a free choice in terms of their mode of transport whenever they want to reach a destination could be reasoned within the policy ideal of broad welfare, it can be debated as to what extent free choice for the sake of free choice is desirable. As research by Handy, Weston, et al. (2005) shows, higher mobility levels are not necessarily desirable in itself if they are realised by car.

As sustainability and the ability and capacity to travel freely by more sustainable modes are interesting for policy making, what should be focused on when choosing the indicators are those that show how sustainable travel is realised or where people seem to travel by car and for what reasons. The relevant debate to be had for transport policy making also includes matters of necessity and choice (see e.g. Dworkin, 1981; Scanlon, 1975; Cohen, 1989; Handy, Weston, et al., 2005), whereby it is unclear to what extent certain choices can be related to just mere preference (i.e. be a matter of free choice) or necessity. This is pivotal to understand which people are limited in their travel behaviour e.g. due to specific needs and also to understand who is not travelling by more desirable modes than car and for which reasons. Therefore, in the assessment of travel behaviour (i.e. mobility) in its function as an enabler to reach destinations by sustainable modes, it should rather be focused on conceptualising travel behaviour in a way that allows for comparison with accessibility measures.

Mode choice is a common and relevant transport behaviour indicator because in order to understand how people could be driven to use more sustainable modes, their current mode choice has to be evaluated. As mentioned previously, multiple studies (e.g. Schwanen et al., 2004; Van Wee et al., 2019; Molin et al., 2016) evaluate mode choice and infer that the correlation between car use and more rural areas is due to built environment characteristics such as lower level of urbanisation. While it seems a logical assumption that car use is associated with longer travels and motivated by the lack of other options, unless proven or assessed by data, it stays a mere assumption. Hence, investigating how these

trip characteristics interact possibly uncovers relevant information about travel behaviour of people and reasons for it.

Generally, trip distance is seen as a measure of both mobility as well as an 'implicit measure of accessibility' (Lucas, Mattioli, et al., 2016:357) as it shows the distances people had to overcome to reach their desired destinations. Distance also gives an idea of how mobile a person is and to what extent they get to (or have to) participate in life outside of their closest community. On top of distance, however, travel duration is considered a relevant factor as well. In assessing spatial form policy effectiveness on travel behaviour, Schwanen et al. (2004) assess the travel behaviour dimensions of mode choice, travel duration as well as travel distance separately. They reason this by stating that from a sustainability perspective, it is crucial to assess distance travelled and mode choice together but in order to understand travel behaviour, time as a critical element has to be included as well. They subsequently find that travel time does not have a proportional relation to level of urbanisation or mode choice. In order to understand in-depth how people's journeys for different purposes look like, given their specific sociodemographics, it is necessary to assess all the indicators jointly. This leads to the question of which methodology apply to meaningfully measure travel behaviour.

3.6.2. Travel behaviour analysis method

Most of the studies on this topic known to the researcher and reviewed in this literature study assessed either only a certain, isolated travel behaviour dimension, such as travel time or mode choice or focused only on one specific sociodemographic factor. For example, Pritchard, Tomasiello, et al. (2019) model the effect of a new mode introduction and hence changes in spatial accessibility on travel behaviour but they lack the dimension of personal characteristics when assessing the effects as they focus on spatial distribution. A notable exception of the assessment of impacts of personal characteristics and the spatial structure on travel behaviour, and especially mode choice is a study of Simma and Axhausen (2003) in Upper Austria. The study concluded that variables of car ownership, gender and work status showed to have key roles in travel behaviour. What is more, they showed that spatial accessibility has less explanatory power than personal characteristics. This study used structural equation modelling to incorporate all different factors. Nevertheless, its lack of actuality (it was based on data from 1992) and its focus on the Upper Austria region make it rather different from a rather recent dataset for the Netherlands.

Yet another strand of research in this area focuses mainly on the geographical aspect only without paying specific attention to personal characteristics beyond income and gender (Lucas, Bates, et al., 2016). Moreover, studies that indeed attempted to understand travellers' realities more holistically tended to be qualitative and hence difficult to generalise.

Moreover, none of the studies reviewed examined travel behaviour patterns as comprised of multiple dimensions together (i.e. mode choice and trip distance and duration) although in reality those are all factors that appear together in any trip made by a traveller. There are many studies assessing certain social disadvantage factors and different travel dimensions separately, assessing these factors separately keeps the researcher from being able to holistically interpret people's travel behaviours. When knowing that someone with a car travels longer distances, it is relevant to assess for what purpose they travel longer distances and what their other characteristics are. Policies are made for people, and assessing characteristics that people could have or could be part of without trying to understand their whole realities will miss out on central aspects of their travel decisions. A method that enables the researcher to interpret the data more holistically is Latent Class Analysis (LCA). The method allows for clustering of the data based on the aforementioned travel behaviour indicators mode choice, travel distance and travel time while including sociodemographics in the model to test their relation with the TB clusters. As for example outlined by Kroesen (2014), Latent class analysis is useful as a cluster method in transport domain as its probabilistic assignment reduces misclassification biases and the availability of statistical criteria to establish optimal cluster number allows for truly data-driven analyses. In that, it is superior to more traditional cluster methods, such as k-means deterministic clustering. Although it is a rather new technique, there are some studies that successfully applied LCA. For example, Kroesen (2014) built a latent transition model and thereby analyses to what extent there are travel

clusters present in the Dutch travel population and how they change over time. The analysis showed that besides age and residential environment, a life changing event such as moving house has an effect on one's transport profile, but that is to a certain extent dependent on prior preferences and prior behaviour. A similarly strong effect was observed with regards to changing jobs. Generally, a main conclusion is that life events make people re-evaluate their travel patterns. However, this study mainly focused on mode choice, it was also pointed out to focus on other aspects of travel behaviour, such as travel duration or travel distance to get an even better understanding of people's travel behaviour. Molin et al. (2016) apply a related method, namely latent class cluster analysis to analyse the association of sociodemographics and attitudes with multimodal travel. They, however, do not include spatial variables in their analysis, limiting the conclusions regarding reasons for people's negative attitudes or non-multi-modal travel behaviour.

A different approach was used by Barbosa et al. (2021) who used cell phone data to assess travel patterns in cities in the US and Brazil. What is more, they combine observed travel patterns, with socioeconomic information and spatial accessibility data and their used mobility metrics are average distance travelled as well as trip frequency and mode choice. Their study showed that out of the 100 cities studied, clusters of two groups can be formed, those cities where residents' movements are impacted by their income and those where it is independent. Interestingly, they mention public transport to be a feature mitigating the correlation between income and mobility levels, thus possibly equalizing mobility levels for the lower income groups. Nevertheless, due to privacy issues, the data they used for the travel pattern analyses was detached from personal information, which was only inferred from zonal residential location. Thus, the aforementioned limitations of merely working with zonal averages instead of individual data that is aggregated arise (see also Fransen and Farber, 2019). Moreover, results from American and Brazilian cities have limited relevance for Dutch policy making and transport justice in the Netherlands.

Concluding, in the academic literature, there is no clear general agreement on the actual impact of specific accessibility factors in combination with personal characteristics on general travel behaviour (Ewing and Cervero, 2010; Simma and Axhausen, 2003; Barbosa et al., 2021; Pritchard, Stępniak, et al., 2019; van de Coevering, 2021; Lucas et al., 2018). While the resulting travel pattern in a study by Barbosa et al. (2021) seems to be depending on the interplay between the built environment (and thus accessibility levels) and individual circumstances of the travellers, other studies such as by Maria Kockelman (1997) show that personal characteristics have little to no impact. Again another study by Simma and Axhausen (2003) shows personal characteristics to have the most explanatory value. Nevertheless, going into more detail and uncovering the specific types of journeys is needed to be able to give more specific policy incentives (such as aimed at by Pot et al., 2023). Especially when dealing with reasons to use unsustainable modes of transport such as car, it is important to understand that not all car trips are the same and that different users might have different motivations and reasons to use a specific mode. Hence, in this research it was decided to utilise Latent Class Analysis (LCA) to not only investigate traveller's isolated choices but be able to interpret different mobility styles more holistically. This should enable the researcher to draw more robust conclusions as to why certain groups have different travel behaviour profiles. The LCA is the most useful method in this regard as it is more straight forward than building a sophisticated land-use model but it can also analyse more data than qualitative methods could. The LCA is also advantageous because it can uncover the needs of different travel groups, thus being a great fit for a policy-related analysis. It offers the context for the understanding as well as being rather simple to interpret.

3.7. Transport Equity

The last part of the literature review concerns the reviewing of relevant ethical theories around the issue of choice and necessity and how to evaluate it. This review adds to the research by presenting theories of equity that show to what extent mobility inequalities are relevant irrespective of the political aims at hand. This information will be used at a later stage to evaluate the findings from an ethical perspective, irrespective of political goals or policy aims. As was outlined previously, the general stance taken by recent Dutch politics in connection to the ideal of broad welfare is that equity in transport is a goal, thus that people being deprived of easy access to basic amenities or jobs should get that access. Nonethe-

less, evaluating actual travel behaviour, it becomes more difficult to establish whether a person was deprived of other options or whether they had the free choice and just chose this specific mode or journey.

To begin, equity can generally be described as the concept of distributive fairness or justice (Van Wee and Geurs, 2011; Pereira et al., 2017). As one single overarching definition for equity is still lacking, different scholars focus on different aspects (Pereira et al., 2017). One central concern of equity can be intergroup differences (Fransen and Farber, 2019) while other scholars (see e.g. Martens, 2012; Martens and Bastiaanssen, 2019, Pereira et al., 2017) consider the question of sufficiency a central concern to equity. There is considerable consensus in the academic literature that equity in transport includes access to key destinations, so called basic services or basic amenities like health care facilities, education and employment (Martens and Bastiaanssen, 2019; Lucas et al., 2009; Bastiaanssen et al., 2020) but as it is a matter of distribution in a spatial or economic sense this makes assessing actual levels of equity rather complex (van Wee and Mouter, 2021) . What further complicates assessing equity in transport especially in the policy context is that whether a transport policy actually triggers and changes the behaviour of the people it is targeted at is not always clear (Van Wee and Geurs, 2011;Martens and Bastiaanssen, 2019; Lucas et al., 2009).

When it comes to evaluating the equity of a transport system or a transport policy, the situation at hand needs to be assessed based on an ideal situation, an ideal distribution. Deciding what is an equitable distribution and what is not is a difficult task as it involves a moral judgement on behalf of how a substantial part of society should be organised (Van Wee et al., 2013; Van Wee and Geurs, 2011; Mouter et al., 2017; Pereira et al., 2017). For that to be rational and acceptable, a fitting theory of equity is needed to base the moral judgement on (Pereira et al., 2017). Theories of distributive justice are generally concerned with the question of what it is that is measured (i.e. what is being distributed). In terms of mobility justice, the relevant factors are mode choice, travel time, travel costs to reach basic amenities. Further, a theory of justice would guide how something should be distributed. The most commonly known distributive principles is equality and is often mistaken to mean the same as equity, but it actually refers to everyone having exactly the same of some resource, no matter their individual needs and realities (Pereira et al., 2017). However, in transport equality is seldom reachable due to its inherently spatial nature (Martens et al., 2019). Another common distributive principle is proportionality which does not require perfect equality but that benefits are distributed over the population in proportion to group sizes (Martens et al., 2019). Other principles are the minimax principle brought forward by Rawls (Rawls, 2004) or sufficientarianism which argues for a minimum level that should be available to all (Martens, 2012). While generally, the concept of sufficientarianism has received substantial agreement in the transport justice literature, authors such as Pereira et al. (2017) suggest a broader framework, building on the work of not only Rawls but also Sen and Nussbaum (see e.g Rawls, 2004; Sen, 2005 and Nussbaum, 2009) towards a combined capabilities approach. Overall, deciding in detail how the transport system should benefit citizens and how to classify differences in transport behaviour is the task of politics and policy makers. Nevertheless, there is a general agreement that once arbitrary factors constrain choices, that would not be ideal from both a moral as well as a political standpoint.

Based on this brief review it can hence be synthesised that under the declared aim of broad welfare (see Planbureau voor de Leefomgeving, 2022), and following the theories surrounding Rawls (2004), Dworkin (1981) and Scanlon (1975), people should have minimum access to certain crucial amenities, to which social events should also count (Lucas, 2012) according to their preferred circumstances as long as their needs can be classified as necessary rather than preferential. Hence, someone wanting to travel somewhere safely should be able to do so while someone wanting to travel somewhere extraordinarily comfortable does not have to be enabled to do so.

3.8. Conceptualisation

The factors relevant for transport policy that influence travel behaviour are summarized in a conceptual framework. This conceptual framework is based on the literature study performed in this chapter. The factors presented in the framework are based on this literature study as well as on the availability of the dataset (see chapter 4). Hence, this framework does not give an overview of all possible factors (it

e.g. neglects the effect of attitudes) but it presents those included in the model.
As can be seen from the reviewed academic literature on sociodemographics and travel behaviour, this research will contribute to closing gaps in the literature by uncovering the effect of sociodemographics on a large scale, namely the entirety of the Netherlands. So far, rather little research on the broad scale has been carried out in the Netherlands especially not by making use of Latent Class Analysis (Bauman and Bull, 2007; Handy, 2020; Bastiaanssen et al., 2020). This has both moral, equity-related relevance for policy as well as practical relevance in the light of shifting towards more sustainable travels.
Additionally, comparing different travel purposes will help uncover differences in travels that cannot be avoided and travels made that could be avoided but which therefore could lead to social exclusion. Hence, the model presented in figure 3.1 is build for travel purposes of necessary travels (i.e. work and education as well as work only) and leisure purposes.

Figure 3.1 shows the conceptualisation of this study, that resulted from this literature review. The Latent Variable in this conceptualisation is the idea of travel behaviour in general. The logic behind LCA is outlined in more detail in chapter 2. Generally speaking, the latent variable is thought to be not-measurable directly, which is why it is conceptualised as the combination of the observed variables, or indicators (i.e. mode choice, travel distance and travel time).

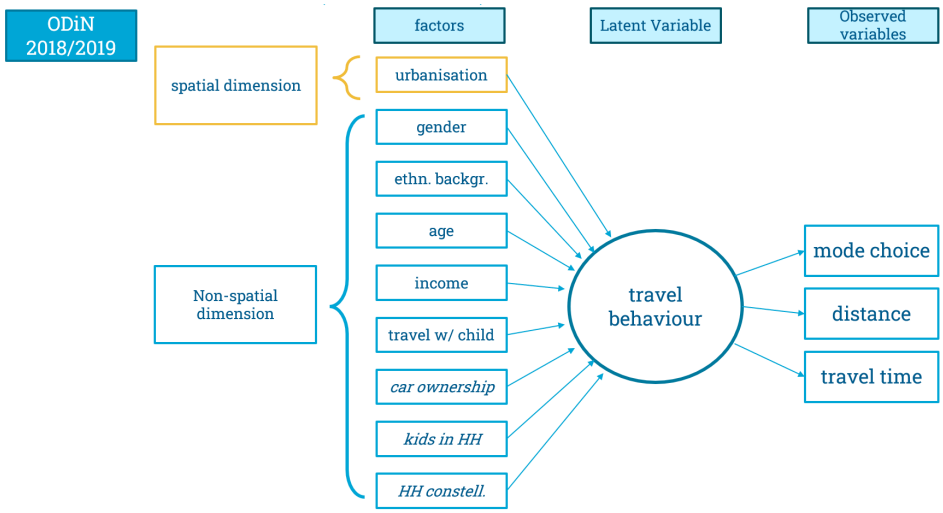


Figure 3.1: Conceptualisation

3.9. Conclusion

Summary

- transport policy should be concerned with sociodemographic factors if they arbitrarily restrict motility
- sociodemographic factors that are relevant to be taken into account are those that are arbitrary (i.e. non-chosen) and/or cannot be changed
- research on the role of the built environment and spatial circumstances leads to conflicting output, a possible reason could be that different travel groups deal with different spatial circumstances in diverse ways
- analysing different travel purposes uncovers information about topics of social exclusion, work abilities as well as general differences between those travel types
- Latent Class Analysis seems a very fitting method to assess differences in travel profiles based on sociodemographics and get a contextualised understanding of those profiles

This literature study showed that transport policy should be concerned with sociodemographic factors in addition to spatial factors as they play an important role in restricting mobility. As policy making is mainly focused on spatial accessibility, it is important to evaluate to what extent realised mobility of people matches with what would be expected by spatial accessibility. In general, assessing for which travel groups factors of sociodemographics are more relevant can be very useful for more efficient policy making. Especially combinations of so called arbitrary disadvantaging factors are interesting to investigate as they may or may not have a further worsening impact on accessibility levels especially from an equity perspective. As it is necessary for this analysis to understand the travel behaviour of people in a given context, it was chosen to make use of Latent Class Analysis as a method.

In the next chapter, the data used in the analysis is outlined more in depth. As certain choices are informed by this literature study, it is placed after this chapter.

4

Data

Data from the Dutch National Travel survey (Onderweg in Nederland, ODiN) from the years 2018 and 2019 was used to inspect the relationship between sociodemogographics and travel behaviour profiles. The data was obtained from the Data Archiving and Networked Services (DANS) and analysed within the TU Delft virtual Citrix environment, thereby complying to all necessary data safety regulations. Part of data were obtained from the PBL Netherlands Environmental Assessment Agency and these parts were also analysed within the PBL virtual environment to comply with all necessary regulations. The ODiN dataset is representative for the inhabitants of the Netherlands. It is thus sampled and based on representing the inhabitants of the Netherlands accurately.

4.1. ODiN2019 and 2018

The dataset entails information about daily mobility of residents of the Netherlands aged 6 or older, excluding that of people living in closed health facilities or institutions (Centraal Bureau voor de Statistiek, 2018; Centraal Bureau voor de Statistiek, 2020 translated by author). Daily mobility means regular mobility including mobility due to tourism and excluding work related trip chains and excluding mobility with heavy freight vehicles and aviation. Work-related trip chains are trip chains that solely entail work-related movements, such as if a handyman has to travel to 8 clients in a day. Up to three destinations are included as normal trip chains (Centraal Bureau voor de Statistiek, 2018; Centraal Bureau voor de Statistiek, 2020). All Dutch registered inhabitants are included in the study population excluding those living in closed institutions because they are possibly inhibited in their travel behaviour.

The dataset is generated by a survey that is sent to a pool of residents of the Netherlands. The sampling is done in such a way that respondents' answers are randomly chosen based on certain characteristics. The dataset is built by sampling according to a set of combinations of different characteristics so that in the end the dataset is representative for the residents of the Netherlands, given those characteristics. The sample is drawn according to a two-step stratified model. In the first stage, (sub)municipalities were systematically selected for each postcode area with probabilities proportional to their population numbers, whereby the number of people to be recruited is also determined for each selected (sub)municipal area. The second stage is a simple random sample of persons in the selected (sub)municipalities, with the sizes per sub-municipality as determined in the first stage. Attention is specifically paid to groups that tend to have low response rates in the survey. They are divided into five strata based characteristics of age, ethnic background and income which leads to 20 sub-groups. It is made sure that these groups are firstly over-sampled and subsequently represented in proportion to the Dutch residents in the final dataset. For the 2018 dataset, after reworking the data and having made some adjustments, 57260 responses were usable. The 2019 dataset resulted in 53380 responses (Centraal Bureau voor de Statistiek, 2018; Centraal Bureau voor de Statistiek, 2020).

The respondents are asked to fill in their mobility choices for one specific day of the year. They are asked where they travelled, what the purpose of their travel was, what mode they used and how long it took them to get there. Also, they are asked about specific (relevant) aspects such as whether they

own an electrical bike, which mode of transport they use most often and person-related questions such as level of occupation and socio-demographic factors. Other aspects are automatically retrieved from official registers such as whether they have a drivers license.
In the questionnaire in 2019, the ethnic background 'Western or Dutch' was split in two different categories, whereas it was treated as one in the 2018 dataset (Centraal Bureau voor de Statistiek, 2020). Hence, while it will be reported on all three categories (Dutch, Western, non-Western), it has to be noted that only the non-Western category is truly correct, as the Dutch and Western categories are slightly skewed.

4.1.1. Weighing

The data includes three different factors to make the sample representative for the population: One factor is for persons, one for trips and another one for households. By weighing the data and combining different characteristics, it becomes representative of the entire population. The weighing factors, especially those used to increase the numbers of certain groups are created by taking into account different aspects, such as age and place of residence. Some of those aspects are also included as variables in the dataset. However, they might be skewed when looking at the continuous data as the classes are used to do the weighing (Centraal Bureau voor de Statistiek, 2018; Centraal Bureau voor de Statistiek, 2020).

4.1.2. Travel purpose

The dataset includes different travel purposes. They are defined on the journey level and not on the trip level and represent the general purpose of travel instead of the purpose of each individual trip travelled. For example, if one were to drop off their child on the way to work, the travel purpose of both of these trips would be 'work'. In the survey, there are 13 different travel purposes participants can choose from.

1. from or to work
2. business visit during work time
3. business travel
4. pick up/drop off persons
5. pick up /drop off goods
6. education/ following courses
7. shopping/groceries
8. visit/stay with friends or family
9. touring/hiking
10. sport/hobby
11. other leisure activities
12. services/personal care
13. other

[1]

As established in chapter 3, trips that must be made (such as work related ones) show a different behaviour than leisure travels. Therefore, trip purposes such as work-/education-related (1,2,3,6), leisure (8,9,10,11) and service-related/needs travel (4,5,7,12) can be grouped. Regarding service and needs related travels a distinction between necessary and leisurely journeys is rather difficult as it does not become clear from the given motives (e.g. pick up/drop off persons could be related to dropping off one's child at the daily care or dropping off a friend who could have also taken another means of transport). It also does not make clear if someone would have dropped off another person, had they had

[1] translated by author

the means for it. Thus, as any conclusions drawn from this travel purpose would be rather speculative, this group of purposes will be left out of the analysis. Hence, albeit it would have been relevant and interesting for this research, it is not possible to evaluate necessary travels to amenities such as health facilities.

4.2. Socio-demographic groups

While most research identifies disadvantaged groups ex ante based on assumptions, common sense or qualitative research (Durmus, 2022 focused on the elderly, while e.g. Bastiaanssen et al., 2020 focused on unemployed), in this research it is crucial to identify significantly differing travel behaviour that is due to any socio-demographic characteristics and combinations thereof. That is the case because the aim of this research is to investigate the general effect of sociodemographics. It is hence crucial for the validity of this research to be as objective as possible and let analysis firstly be guided by data and then secondly followed by logical choices. Hence, the method of Latent Class Analysis (see chapter 2) was chosen.

The final choice of sociodemographic factors to assess in terms of their impacts on travel behaviour was based on a synthesis of the literature (see the section on axes of disadvantage in chapter 3) as well as based on which indicators were available in the ODiN dataset. Because inherent and/or unchangeable factors are especially relevant since they are arbitrary and cannot be influenced by the person who has them, those factors are most relevant for policy making. Inherent factors that cannot be changed are deemed most relevant, which are

- gender/sex [2]
- ethnic background
- age

Unfortunately, there is no information about special needs or health impairments.
Another group of sociodemographics are those that might change over a lifetime but are generally expected to stay permanent:

- role in household
- household constellation
- occupation hours
- occupation status
- income [3]
- occupation status (detailed)
- education level
- dependent kids in the household [4]
- level of urbanisation of place of residence

Factors that have to do with sociodemographic cirumstances:

- travelling with a child younger than 6 years old
- car ownership

[2] The questionnaire only asked for the Dutch word 'Geslacht' which can be translated as either gender or sex as there is no Dutch word for the term gender which means the socially constructed concept as coined by Simone de Beauvoir and Judith Butler. Hence, in this research the terms gender and sex will be used interchangeably to mean the Dutch word 'Geslacht'. In 7 possible effects of the lack of depth in this question are evaluated in detail.

[3] In 10% groups

[4] children younger than 12 live in the house or not

The listed sociodemographics are all deemed to be relevant for transport policy and travel behaviour in some sense. Nevertheless, it would have been beyond the scope of this research to include all factors as well as all interactions. As for the inherent factors age, gender and ethnic background, they and their interactions were included as they are the most relevant. Age was included in this category, since albeit one's age changes, there is no active influence to be had on this process. Once someone is older than a certain age and thus at higher risk of health deterioration, they cannot change that. Those factors that are partly interrelated or can logically be inferred to only have an indirect effect via another factor which is listed were not included in the final analysis. This was the case for the factor of income and occupation hours as well as occupation status. While both occupation hours and occupation status (as well as occupation status (detailed)) can be imagined to have an effect on travel behaviour, ultimately the level of income is the relevant factor in influencing TB.

Similarly, role in household, household constellation and whether or not a dependent child lives in the household will either have an effect on (household) income or on the variable of whether or not someone travels with a child younger than six years old. Moreover, it cannot clearly be established what household constellation (single, couple, other) or whether one lives with a child or not can be considered to be disadvantaged according to the factors listed in chapter 3. However, the interaction effect of household constellation and whether or not a child lives in the household might have a specific, relevant impact. Therefore, those variables were included in the interaction term LCA but only household income and whether or not someone travels with a child younger than six were included in estimating the initial latent class models. As for car ownership, the presence of access to a car is established in the academic literature as a relevant factor impacting travel behaviour but its causal direction is not clear. Hence, the variable is not included as an active covariate in the LCA but together with household constellation and the presence of a under 12 year old child in the household these variables are included as inactive covariates. As for the level of urbanisation and level of education, the effects of both have been empirically established by other scholars and their interaction effects with other sociodemographic variables might be substantial. Therefore, the final list of sociodemographic indicators to be included is the following:

- age
- gender
- ethnic background
- income
- travelling with a child
- level of urbanisation
- level of education
- (household constellation)
- (dependent child)
- (car ownership)

4.3. Travel modes

The ODiN datset has 18 modes to choose from. Modes used include car as passenger, car as driver, scooter, bike, e-bike, bus-tram-metro, train.

4.4. Data Preparations

In order to be able to conduct the aforementioned analyses with the ODiN dataset, several data preparation steps had to be taken. First, the 2018 and 2019 datasets were combined to be able to benefit from a wider pool of data.
After merging, the datasets were divided in three datasets that were filtered on travel purposes work/education,

work and leisure to be able to conduct the same analyses on different travel purposes. This was done as travel behaviour for leisure travel is hypothesized to differ significantly from necessary travels (see chapter 3). However, as many education-attending travellers are not old enough to drive yet it is also clear that travel behaviour of the working population only will differ fundamentally from education travels as well. Hence, the dataset for work only related travels is analysed in addition, in order to control for the possibly skewed choice set of young students. Nevertheless, the dataset of work and education is kept after all because how the younger travellers travel is relevant for possible future travel choices (see e.g. Kroesen, 2014).
Moreover, other changes to the dataset include the deletion of the class 'unknown' in the ethnic background variable as that was not meaningful for interpretation. Similarly, the class 'unknown' for car ownership was also deleted.

After merging, the data was cross-checked with a similar dataset with regards to significant differences that would hamper with the validity of the analysis. For that, different variables, such as frequency of migration background, number of cars in household and household constellation were cross-checked. There were no significant differences found and the dataset was declared fit to be used for analysis. Next, in order for the subsequent descriptive analysis as well as the LCA to show meaningful results, the variables chosen to be analysed were aggregated to bigger groups as the level of detail for each of them was too granular to be able to meaningfully interpret them in the LCA. Thus, the variables of travel purpose (see above), urbanisation level, age, education level, income, car ownership, and household constellation were summarised in fewer groups (see below).

The new variables worked with were thus:

- Urbanisation level; 1: 1-3 (urban), 2: 5-4 (rural)
- Age: categories, 1: 6-29 years old, 2:30-64 years old, 3: 65+ years old
- Education level: categories, 1: no or basic education, 2: low or medium education, 3: high education or finished professional training, 4: unknown, other, or respondent was younger than 15 at the time of the questionnaire
- Income: categories, 1: income percentiles 0-30%, 2: 30-70%, 3:70-100%
- Car ownership; 0 cars, 1 car, 2 cars, 3 or more cars
- Household constellation; alone, with a partner, other (all other household constellations)

Regarding travel indicators, initially there were 18 different mode categories which were reduced to four: car (includes passenger and driver), public transit, active (includes electric bike) and other. As for travel distance and travel time, the categories were defined according to how researchers at the PBL generally divide those. Hence, regarding the travel time, the overall division is 0-5 minutes, 5-15 minutes, 15-30 minutes and longer than 30 minutes. Similarly, regarding travel distance, categories are 0-1.5 kilometres, 1.5-7.5 kilometres, 7.5-20 kilometres as well as 20 kilometres or more.

4.5. Data makeup

In this section, the overall makeup of the data is presented. This is done to get an overview of what the general population in the Netherlands looks like and will help contextualise findings once all analysis steps in this research are finalised. Generally, the merged dataset is representative for a number of 31.98 million people, which is twice the Dutch population and hence makes sense given that the datasets for two years are merged. When weighted for trips, the dataset results in about 88 Million daily trips, which amounts to 2.75 trips per day per person which is also in line with expectations.

	Sample (%)
Urbanisation	
Urban	70.4
Rural	29.6
Gender	
Male	49.6
Female	50.4
Ethnic background	
Dutch	76.6
Western	10.3
Non-Western	13.1
Age	
6-29	30.6
30-64	49.4
65+	19.9
Income	
0-30%	17.1
30-70%	38.4
70-100%	42.5
Education level	
in education/unknown	13.3
low education	7.3
medium education	46.4
high education	32.7
Travel with child younger than 6	
No	92.4
Yes	7.6
Inactive covariates	
Car ownership	
0	18.2
1	45.4
2	27.6
3+	8.3
Children aged 12 and younger in household	
No	74.7
Yes	25.3
Household constellation	
Single	25.8
Couple	73.7
Other	0.5

Table 4.1: Sample characteristics

Table 4.1 shows the distribution of sociodemographics across the overall dataset. As outlined previously, most of the indicators were aggregated to a higher level in order to ease interpretability of the LCA. It can be seen that more than two thirds of the Dutch inhabitants live in urban environments, namely 70.4%. Regarding gender division, the dataset entails a nearly equal division of males and females. As for the ethnic background of the respondents, three quarters are Dutch, and 10 and 13 percent respectively are from Western and non-Western ethnic backgrounds. The share of respondents with an unknown ethnic background amounted to 0%, or 1738 cases in the merged dataset and was thus disregarded. As for age, it can be seen that the class of people aged 30-64 is biggest, with 49.4%. In general, they can be labelled 'young' (age 6-29), 'working age' (age 30-64) and 'seniors' (age 65+). As for income, the dataset shows income percentiles and it can be observed that income group 3 is the largest. Regarding levels of education, it can be seen in table 4.1 that a third of the population has higher education in terms of a university education or a professional training while a half

has received medium education or training. Another substantial group has unknown education or they are younger than 15. Cross-evaluating educational level with age showed that about 80% of people in that class are actually younger than 15 and thus still in education. Only about 7% of people have no or low education level. Moreover, most people living in the Netherlands do not travel with children aged 6 or younger, as only about 7.6% do that. Regarding car ownership, almost half of the residents of the Netherlands have one car in their households, while about a third has two. Roughly 18% do not own a car and less than 10% have more than three cars in the household. Two thirds of Dutch residents live with children aged 12 or younger and also about two thirds live with their partner (and potentially a child). One third lives alone and only 0.5% live in other constellations.

4.6. Data limitations

Since an available dataset was used for this research and no separate data was collected, certain limitations arise.
To begin, as outlined above, the motives had to be grouped in work (work/education) and leisure, and no specific group for 'necessary travels' that are not work could be formed. This was due to a lack of clarity in the dataset. Hence, the research will not be able to make any statements about travels that are not work or education related but still necessary travels such as medical appointments.
Moreover, as ODiN is merely a cross-sectional study, conclusions drawn to the wider population are subject to a certain degree of uncertainty.
The minimum number of observations for a specific characteristic is 50, so that people who are part of marginal groups of less than 50 people are not represented. Moreover, the ODIN description says that totals for public transport are more reliable from the public transport authorities as those are not cross-sectional data but actual data. Hence, the public transit data needs to be treated with caution. In addition, as the ODiN data does not include any information on travel costs, the subsequent analysis will have to be conducted without taking monetary factors into account. It will merely be worked with travel time, distance and mode choice.

The next chapter outlines the Latent Class Analysis conducted with the data described here and will start with a short descriptive analysis of the travel behaviour indicators and sociodemographics.

5

Latent Class Analysis

In this chapter, the latent class models are presented. Latent Class Analysis (LCA) is used to uncover underlying classes in a dataset, in this case classes of TB. In other words, it shows associations between different aspects of behaviour and groups them in classes. In this analysis, the LCA was conducted for the TB indicators, mode, travel distance as well as travel time and the effect of the covariates urbanisation level, gender, ethnic background, age, income, level of education and whether or not someone travels with a child were evaluated. The factors of car ownership, household constellation and living with a child younger than 12 were assessed as inactive covariates as explained in chapter 4. The goal of this chapter is to show differences in travel behaviour and assess to what extent sociodemographic profiles explain these differences. The LCA was performed on the dataset of the Dutch National Travel Survey (ODiN) of work and education related travels, work related travels as well as on the dataset for leisure travel. In this section, first basic descriptive statistics for the TB indicators and sociodemographics are presented. Then, all classes for the different travel purposes will briefly be outlined, followed by an in-depth analysis of those classes that have similar journey characteristics (travel time and travel distance), yet different mode choices. The results of the LCA will be presented together with the maps that are created from matching the predicted class memberships based on sociodemographics with the post code information. The maps are presented in two forms. First, a map with the class membership probability as its highest layer is visible. In this map, no administrative borders or cities within the Netherlands are depicted. The second map (on the right) then entails the same information, however, the layer with administrative borders and city names is highest, thereby allowing for an analysis of the connection between specific areas and travel behaviour. The maps fulfill two roles. First, the travel behaviour in terms of class membership is presented. Second, and similarly interesting, the social makeup of an area is shown. This is because the map creation happens on the basis of the probability of class membership given the sociodemographic make-up of a postcode area. Next, it will be evaluated whether the observed TB is spatially bound and to what extent mobility of certain people is restricted (spatially or by sociodemographic factors) to the extent that it limits their active accessibility. Lastly, latent class models with interaction terms along the lines of the most socially disadvantaged are created and briefly analysed. Thus, in this chapter the research question ”In what way are existing TB patterns related to sociodemographics?”is answered by assessing the sub-subquestions, ”Are specific sociodemographic profiles associated with certain mode choice?”, ”What makes people choose different modes when facing similar journey characteristics?” and ”How do combinations of sociodemographics influence TB patterns?”.

5.1. Descriptive statistics as preparation for LCA

In this section, statistic descriptive analyses that were conducted in preparation for the latent class analysis will be presented. The aim of this pre-analysis was to get a general overview and understanding of correlations between sociodemographics and the different travel behaviour dimensions separately. As for the mode choice, the most used mode for all trips in the dataset is car, followed by active modes. Public transit and other are placed third and forth respectively. This ranking is the same order if filtered on work/education and work only related travel purpose while for leisure related travel active is the most

used (49.9%), with car placed second (43.8%) followed by public transit (3.8%) and other (2.5%).

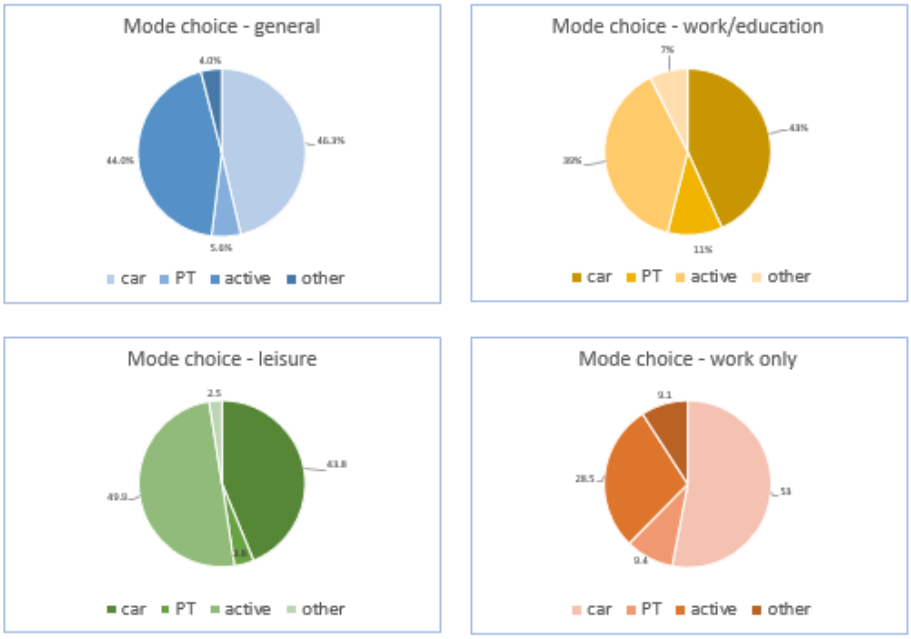


Figure 5.1: Mode choice by travel purpose

Regarding travel time, the majority of travels generally falls within 5-15 minutes, namely 36.9%. The other travel time categories all take up roughly a fifth of trips, namely 22.4% 15-30 minutes, 21.8% longer than 30 minutes and finally 18.9% up to minutes. When travelling for work or education, also most people travel 5-15 minutes (31.2%), followed by travelling longer than 30 minutes (29%). Next is 15-30 minutes (27.4%) and only 12.3% travel up to 5 minutes to work or education. Leisure travel is ranked similarly to work/education travel, as it also mostly takes between 5 and 15 minutes (34.3%), followed by 30+ minutes (28.5%) and 15-30 minutes (22.8%). Only 14.4% of leisure travel lasts up to 5 minutes. However, people travelling for work only travel longer than 30 minutes most often (31.8%), followed by 16-30 mins (30%) and 5-15 minutes (29%). Only 9.2% travel up to 5 minutes for work.

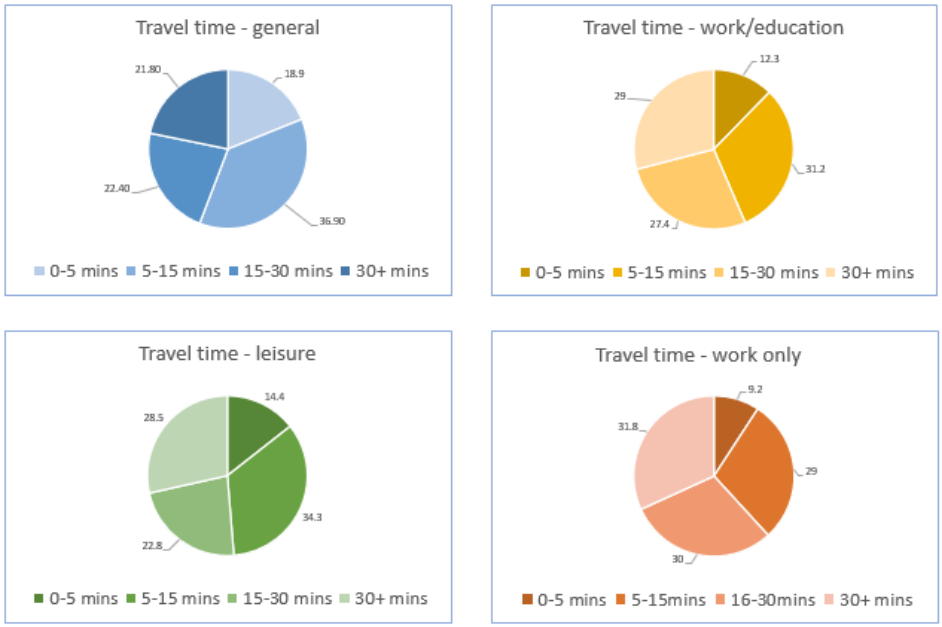


Figure 5.2: Travel time by travel purpose

As for the travel distance both leisure travel and the overall dataset have similar travel distance distributions. For all motives except work only, the most travelled distance is 1.5-7.5 kilometres (38.1% general, 32% work/education, 41.6% leisure travel). For work, the most travelled distance is 20+ kilometres (32.1%). While for leisure and the general dataset, the second most travelled distance is up to 1.5 kilometres (27.3% of the general dataset, 23.7% of the leisure dataset), the second most travelled distance for work or education related travels is 20 or more kilometres (26.8%) while it is 1.5-7.5 kilometres for work (30.1%). All motives travel 7.5-20 kilometres the third most. Least travelled for general and leisure is 20 ore more (16.7% general, 16.6% leisure) while it is up to 1.5 kilometres for work or education related travels (18.4%) and work only (12%).

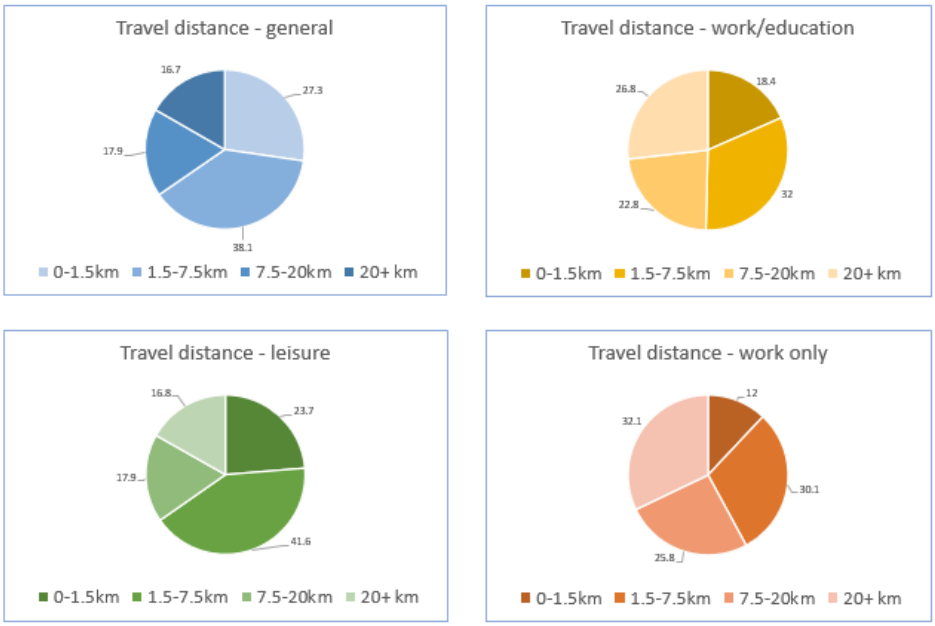


Figure 5.3: Travel distance by travel purpose

The above analysis shows that leisure travel differs to a significant extent from work and education related travels and from work related travels in terms of mode choice. With regards to travel duration, work and education is more like leisure travels whereas work only related travels tend to take longer. Also regarding distance travelled, work only falls in between the values of leisure and work and education in that the largest share of distance travelled is that of 20 kilometres and more while work and education travels tend to cover a little less distance and leisure travels have a tendency to be much shorter in distance.

5.1.1. Sociodemographic descriptive statistics

Assessing the composition of the samples filtered for each of the analysed travel purposes as shown in the last column of table 5.4, table 5.5, and table 5.6, it becomes apparent that the general composition of the sample to begin with looks different per travel purpose. While all three purposes have a similar split between rural and urban travellers, the gender split already looks different for work than it does for the general, non-filtered ODiN dataset (see chapter 4). For both work and education as well as for work related travel purpose, there are almost 60% males. The leisure data entails mere 47.6% males. Therefore, conclusions about the wider makeup of the workforce can already be drawn. Regarding ethnic background, there seem not to be any major differences, in all travel purposes there are around 80% of travellers with a Dutch ethnic background and around 10% of Western and non-Western travellers. In the leisure travel purpose dataset, however, there are slightly fewer non-Western travellers, with only 8.7%. The age composition of the datasets varies quite a bit. While the leisure dataset resembles the overall ODiN composition, the work only dataset entails more than two thirds of people in the working age group (aged 30-64) and only 5.4% older than 65. The work and education dataset overrepresents the younger travellers, with 42% in the young group, 54% in the working age and merely 4% in the 65 or older group. The education level composition in the leisure dataset is similar to that of the entire ODiN dataset, with a slightly higher ratio of people in education. As for work and education, the composition is similar to leisure and for the work only travel purpose, the education level is very skewed, with 50% having medium education levels and 44% high education levels, leaving 2.4% in education and 3.5% with low education levels. As for the ratios of travelling with children, ratios are much lower with regards to work only travel, as there are 98.9% of trips done without children, while it is 92.2% of leisure trips (which is roughly the non-filtered travels' ratio). Work and education falls in between, with 96.8% of trips done without children younger than 6. Car ownership is roughly similar across all purposes, and also meet the general composition of the ODiN data. Lastly, the leisure dataset and the work dataset differ slightly in the amount of people living with a dependent child (i.e. a child that is younger than 12), reflecting the amount of people who have children but do not work. While 77.7% of the work dataset live without children, it is 71% of the leisure dataset. The work and education dataset shows an even different picture, with 69.4% while the ODiN composition is at 75.4% who live without children. Regarding household constellation, all datasets roughly resemble the general ODiN composition of 3/4 of people living with their partner.

5.2. Latent Class Analysis - Number of Classes

The latent class analysis was performed with the indicators and covariates shown in tables 5.4, 5.6 and 5.5. For each of the travel purposes, a separate latent class model was built with identical indicators and covariates and each model was estimated with up to 10 classes as can be seen in table 5.1. The optimal number of classes was determined using multiple criteria. First, the BIC-values were consulted as it penalises increasing model complexity (Vermunt and Magidson, 2013). Furthermore, it was checked which models had classes smaller than 5%, as that would be too small to be interpreted meaningfully. Lastly, it was checked whether the class profiles are logical and contribute to the interpretation of the model. The model fit statistics for the LCA models for the work and education travel purpose as estimated for 1-10 classes is shown in table 5.1. It can be seen that the BIC values are lowest for the 10th model, however, the class sizes drop below 5% after the model with 8 classes. Hence, regarding work and education as well as work travels, the model with 8 classes fits best, while for leisure a model with 6 would be best. Nevertheless, in a model with only 6 classes, there would be no class with a public transit-dominant mode choice. Hence, it was decided to continue working with the model with 7 classes for leisure travels, although the 7th class, the public transit dominant class, entails only 3.16% of the sample size. The model statistics for the work and leisure travel purposes are

# of clusters	Log-Likelihood	BIC(LL)	# of parameters	Max. BVR
1-Cluster	-37129139575	74258279356	9	7357785744
2-Cluster	-31122254755	62244510131	27	767055170
3-Cluster	-29505315063	59010631160	45	127422000
4-Cluster	-28581489689	57162980827	63	198606566
5-Cluster	-27859966534	55719934929	81	87174912
6-Cluster	-27500899367	55001801010	99	82864691
7-Cluster	-27198483047	54396968784	117	63679960
8-Cluster	-27042513608	54085030319	135	34546879
9-Cluster	-26965750326	53931504169	153	12513427
10-Cluster	-26913158049	53826320029	171	17595774

Table 5.1: Number of class estimation for work and education travel purpose

shown in appendix C. What also becomes apparent from table 5.1, is that there is still very extensive association between the covariates. This is captured by the BVR which stands for bivariate residuals. Thus, it needs to be noted that the model does not achieve full heterogeneity between the estimated classes.
For all classes, class composition in terms of active as well as inactive covariates will be reported. As outlined in chapter 2, the active covariates contribute to class formation while the inactive covariates do not define how classes are formed. In the next section, the estimated latent class models for each travel purpose will be presented and interpreted.

5.3. Estimation results

In all models, the sociodemographic covariates proved statistically significant in predicting class membership as all covariates had a sufficiently high Wald-test (see table 5.3 and appendix E for details). Table 5.3 shows the Wald test rankings of the sociodemographics for the three travel purpose models. All were significant at the 0.001 level and thus the here presented results can be said to be generalisable to the wider population. It can be seen in table 5.2 that level of education is the most relevant covariate in terms of statistical effect across all travel purposes. The second and third most relevant covariate are age and level of urbanisation respectively, while this is the other way around for work. Gender comes fourth for necessary travels but it is the least impactful for leisure travel purposes. Instead, income comes fourth for leisure. Fifth most important for leisure is travelling with a child, while this is the least relevant for necessary travels. For necessary travel purposes, the two least relevant covariates are ethnic background and travel with a child, while it is ethnic background and gender for leisure.

covariate	Work/education	Work	Leisure
Level of education	1	1	1
Age	2	3	2
Urbanisation level	3	2	3
Gender	4	4	7
Income	5	5	4
Ethnic background	6	6	6
Travel with child	7	7	5

Table 5.2: Covariate Ranking according to Wald-test magnitude of different travel purposes

5.4. Latent Class model - Work and education

The work and education related travel LCA results in 8 clusters with clear travel patterns which are larger than 5% of the sample size. The reported parameters for the model are all significant and show that the clusters as as well as the covariates are relevant to the model estimation. As can be seen in table 5.4, the first two largest classes are active modes, clusters 3-5 are car clusters and cluster 6 entails active travels for rather log distances as well as some public transit users. Finally, classes 7 and

covariate	Work/education	Work	Leisure
Level of education	798056767	**259484420**	156292732
Age	**439864237**	153633540	127237895
Urbanisation level	**180629282**	173147128	93074107
Gender	89142761	**123691202**	29413036
Income	80209898	64215341	**84853427**
Ethnic background	**52839889**	38861630	48524013
Travel with child	46404392	3730400	**54951933**

Table 5.3: Wald tests (tests of impact of covariates) for different travel purposes, all significant at the p=0.001 level

8 are public transit and car & other classes respectively. Generally there are about two classes for each distance category, indicating that mode choice is what is really different in those TB pattern classes. What also becomes apparent is that for those groups that are minorities in the datasets (e.g. being of non-Western descent, travelling with a child), there never is a class that consist of a majority of people with these characteristics. Thus, the re-parametrised logit values will be assessed below, indicating the effect of having such a characteristic on class membership. In interpreting the classes, significant deviations from the average will also be considered. As for the spatial distribution of the classes, map 5.4 shows in which areas certain classes were most common. Green colour represents active modes while red and orange coloured areas indicate car classes to be the most common class. Blue indicates the public transit class to be the most common. It can be seen that for work and education related travels, the Randstad area seems to be a bit more likely to have an active-mode class as its most common class. However, it is not an entirely unambiguous spatial separation.What is also striking, is that there are very few areas with the public transit class as their most common one.

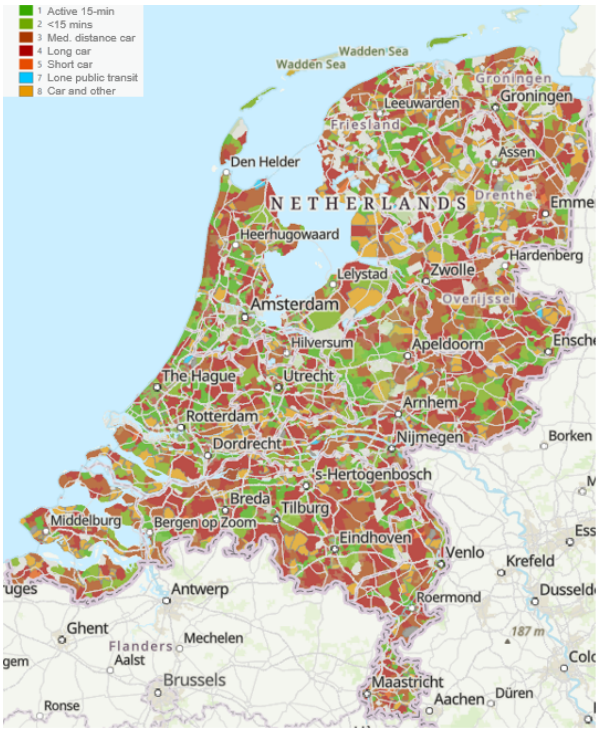


Figure 5.4: Distribution of most common classes, work/education travel purpose

Class 1: Young urban affordable active 15-minute travellers, 18.6%
The first class is characterised by being majority active travellers who take around 15 (6-30) minutes for 1.5-7.5 kilometres. This class consists of a majority of people from an urban environment who are female, younger travellers. Albeit not the majority, travellers in this class are above average non-Dutch, with slightly lower income who tend to have a lower education level or are still in education. Travellers

in this class seem to appreciate proximity to their work place or education and they travel by affordable, environmentally friendly modes. As for the inactive covariates, this class sees above-average travellers who do not have a car in their household. This class is 39% education related travels and consists of an above-average number of travellers who live by themselves.

Class 2: Young Work/study around the corner, 17.5% (<15 minute travels)
Class 2 is made up of active travellers as well, but this class travels only up to 15 minutes and up to 1.5 kilometres. It is irrespective of urbanisation level and characterised by more females and Dutch travellers. Overall, this is the youngest cluster with the highest ratio of travellers that are in education and the highest ratio of travellers that travel with children younger than 6 although that is still only 8%. More than half of the trips in this class are education related and also more than half of travellers in this class live with children younger than 12 in their households.

Class 3: Suburban breadwinner (medium distance car travel), 14.97%
The third class entails travellers that mainly travel by car and travel distances of up to 20 kilometres for which they take around 15 minutes (6-30). Travellers in this class come from a more rural environment and are Dutch, in the working age (30-64) and have medium education level or a high education level. In this class, 92% are work related travels without children and people tend to own at least one car. In 76% are these children-free households and people live with their partner.

Class 4: Well situated long car travellers, 14.96%
Class four, similarly sized as class three, entails long distance car travellers. Journeys last at least 30 minutes and cover more than 20 kilometres. This class is also characterised by travellers who are mainly males and in their working age (29-64). Furthermore, this class is the one with the highest ratio of travellers with a Dutch ethnic background, (medium to) high income, and (medium to) high education level and who do not travel with children younger than 6. Beyond, travellers in this class own at least 2 cars and 95% of these trips are work related. Moreover, 74% of trips are done by people who do not live with children. As this class is mainly consisting of work-related trips, it needs no in-depth assessment at this point, as it will probably come up in a similar manner in the work only related LCA.

Class 5: Short car trips, 11.08%
More than a tenth of the trips fall in the short car trip class which can be described as trips done with the car that last up to 15 minutes and cover in between 1.5 and 7.5 kilometres. As already the case with the previous two car-dominant classes, travellers in this class tend to be Dutch, with a medium education level but in this class they tend to travel with children significantly above average (6%). What's more, this is the oldest class, with most travellers aged 30-64, but also an above-average number of travellers aged 65 and older. 83% of these travels are work related and travellers own at least one car.

Class 6: Dedicated active, affordable travellers, 8.39%
Members of the the dedicated active travellers are characterised by being above average of non-Western descent, 6-29 years old and with a low education level (or being in education). People in this class do not own a car, do not live with or travel with children and 62% are work related travels.

Class 7: Educated lone public transit users, 8.3%
Similar sized to the dedicated active travellers is the only public transit-dominant class. Membership to this class is predicted by several sociodemographics. First, travellers tend to live in an urban environment, are above average female as well as young (6-29 years old), with slightly above average low income. This class also has the lowest ratio of travellers with a Dutch ethnic background. Furthermore, travellers in this class do not travel with a child and have a high educational level. As for the inactive covariates, this class is the one with the highest ratio of people who do not own a car, as well as who live without children (83%) and of single households.

Class 8: Long distance skilled worker trips (car and other), 6.3%
The last class comprises mainly work related travels. 93% of travellers in this class are male and 95% of trips are work related. This class has the highest ratio of travellers living in a rural environment, it is characterised mainly by Dutch travellers in their working age (30-64) with medium income and medium education level. People in this class do not travel with children younger than 6. What's more, this class has the lowest ratio of travellers who own no car.

Discussion
What is interesting about the aforementioned classes for work and education related travel purposes is that while some classes show a clear separation for either work or education related travels (e.g. class 3 'medium distance car travel' and class 4 'long distance car travel' are both >90% work related), other classes are more mixed (class 1, active 15 minute class, class 2, active <15 minute class both show a nearly 50/50 split). It also shows that in those classes that seem more mixed, certain sub-groups can be expected that were now still hidden due to the mass of the data. For example class 2, the active <15 minute class is both the highest of travellers who are in education as well as the highest in terms of travellers who travel with children. It can thus be assumed that while some of the travellers in this class are in education, there is another group of travellers in this class who travel to work and take their children. For cases like this, it is useful to be able to assess the work-only latent class model, which is presented below.

Axes of disadvantage
In this section, the impact of the previously identified axes of disadvantage are reviewed. For this review, the re-parameterised logit model of the latent class model was assessed. The parameters of the covariates show to what extent they contribute to being in a specific class. Thus, a negative parameter of high magnitude means that being in this category of this covariate contributes very negatively to being in a specific class. All detailed parameters can be found in appendix E.
Generally, the magnitude of the impact of the sociodemographics (i.e. covariates) range from 0.0018 to +2.34. The largest impact of all covariates is the impact of the highest level of education on being in cluster 4 (long car travel; +2.34). If one has basic or low education, there is a strong negative effect (-1.9) while having middle or high education has a strong positive effect (1.3). On the contrary, ethnic background seems to have the lowest overall impacts, with the lowest magnitude of 0.0018 being observed with regards to having a non-Western ethnic background and being in cluster 1 ('active 15-minute-city'). The other two levels of this variable, Dutch and Western have impacts of -0.0436 and 0.0418 respectively.
The largest impact of the covariate of urbanisation level is observed with regards to cluster one (young urban affordable active 15-minute travellers), where living in a rural environment has a -0.403 association with being in that cluster. A similar relationship can be observed with regards to cluster 7 (lone PT users), where the association is -0.27. Being in cluster 3 (medium distance car travel) is positively impacted by rural environments (0.22) as is being in cluster 4 (long car travel) (0.18). Cluster 8 (car and other long travel) is also positively associated with living in a rural environment (0.16). The other associations are below 0.1 and will thus only be reported on in the appendix.
As for gender, the largest association is observed with cluster 8 (long distance skilled worker trips), where being a male is strongly associated with being in this cluster (1.04). The active mode clusters (1,2 and 6) are all negatively associated with being a male (-0.27, 0.28 and -0.16 respectively) as is also being in the lone public transit cluster (-0.18).
Ethnic background has rather little associations with travel behaviour clusters with regards to work and education related travels. The largest associations are present with regards to cluster 7 (lone PT users), where Dutch ethnicity is associated negatively (-0.28), and non-Western ethnicity is associated positively (0.21). Western ethnicity is almost without impact (0.063). A similar relationship can be observed with cluster 6 (dedicated active travellers), with -0.18 for Dutch ethnicity and 0.13 for non-Western (Western ethnicity is associated with 0.05). Overall, Western ethnicity has no impact in comparison to Dutch or non-Western, as no coefficient is of higher magnitude than 0.1. Dutch ethnicity is associated with being in cluster 2 (active 15 minute city) and cluster 5 (short car trips) with 0.15 each.
Regarding age, the largest impact is present with regards to public transit use (class 7), where being young is positively associated (1.08) and the working age group as well as the older group are negatively associated (-0.16 and -0.92 respectively). Being of older age (65 years +) is associated most strongly with the short car travel class (0.53) or the short active class (0.46).
As for income, a general positive relationship between low income and the sustainable travel classes across all distances and travel times (active or public transit) can be observed, whereas there is a positive relationship between higher income and car travel (also across all distance and time categories). For instance, cluster one (young urban affordable 15-minute travel) has a 0.31 association with low income and a -0.11 and -0.2 association with medium and high household income respectively. Cluster 2 (active 15 minute city) also has a 0.21 association with low income and a -0.08 and -0.13 associa-

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Sample
Cluster size	19%	17%	15%	15%	11%	8%	8%	6%	
Indicators									
Mode choice	active	active	car	car	car	active	public transit	car	
travel distance									
0-1.5 km	5%	100%	0%	0%	0%	0%	0%	0%	
1.5-7.5km	95%	0%	7%	0%	100%	25%	0%	0%	
7.5-20km	0%	0%	92%	5%	0%	75%	17%	10%	
20+ km	0%	0%	1%	95%	0%	0%	83%	90%	
Mean	1.95	1.00	2.94	3.95	2.00	2.76	3.83	3.90	
travel time									
0-5 min	0%	61%	0%	0%	15%	0%	0%	0%	
6-15 min	56%	39%	32%	0%	82%	0%	0%	0%	
15-30 min	43%	0%	66%	28%	3%	37%	2%	27%	
30+ min	0%	0%	2%	71%	0%	63%	98%	73%	
Mean	2.44	1.39	2.69	3.71	1.87	3.63	3.98	3.73	
Active Covariates									
Urbanisation									
Urban	84%	67%	60%	65%	65%	70%	82%	60%	69.7%
Rural	16%	33%	40%	35%	35%	30%	18%	40%	30.3%
Ethnic background									
Dutch	75%	81%	83%	85%	84%	74%	70%	83%	79%
Western	10%	7%	8%	8%	7%	10%	11%	8%	9%
non-Western	15%	12%	9%	7%	9%	16%	18%	9%	12.1%
Gender									
Male	49%	48%	57%	61%	59%	54%	52%	93%	56.2%
Female	51%	52%	43%	39%	41%	46%	48%	7%	43.8%
Age									
6-29	58%	64%	23%	22%	28%	52%	55%	12%	42%
30-64	38%	31%	72%	74%	63%	45%	43%	85%	54%
65+	4%	6%	5%	4%	8%	3%	1%	3%	4%
Income									
0-30%	17%	12%	10%	8%	9%	14%	17%	8%	12%
30-70%	34%	35%	37%	28%	38%	34%	35%	45%	35%
70-100%	48%	53%	53%	64%	53%	52%	49%	47%	53.1%
Education level									
in educ./unknown	24%	47%	4%	0%	13%	19%	3%	6%	17%
low education	10%	6%	3%	0%	4%	13%	3%	6%	5.5%
medium education	35%	30%	57%	33%	56%	37%	43%	76%	42.5%
high education	31%	17%	36%	67%	28%	32%	51%	12%	35%
Travel with child younger than 6									
No	98%	92%	98%	99%	94%	99%	99%	99%	96.8%
Yes	2.2%	8.5%	1.6%	0.8%	5.5%	1.4%	1.3%	1.3%	3.2%
Inactive covariates									
Motive									
Work	60%	48%	92%	95%	83%	63%	69%	95%	73.3%
Education	40%	52%	8%	5%	17%	38%	31%	5%	26.7%
Car ownership									
0	23%	14%	5%	3%	7%	23%	28%	6%	14.2%
1	44%	45%	41%	35%	44%	44%	42%	43%	41.8%
2	26%	31%	39%	47%	35%	26%	22%	38%	32.9%
3+	7%	9%	16%	16%	15%	8%	7%	12%	11.1%
Children aged <12 in household									
No	71%	47%	76%	74%	70%	75%	83%	73%	69.4%
Yes	29%	53%	24%	26%	30%	25%	17%	27%	30.6%
Household constellation									
Single	27%	19%	22%	20%	20%	26%	29%	20%	23.1%
Couple	72%	80%	77%	79%	80%	74%	69%	80%	76.3%
Other	1%	0%	0%	0%	0%	1%	1%	1%	0.6%

Table 5.4: Latent Class Proportions; work and education travel purpose

tion with medium and high income respectively. While the effect with regards to medium car travel is negligible, for long distance car travels a -0.24 association between low income and cluster 4 can be observed, a -0.03 association of medium income with this cluster and a 0.27 association of high income and this cluster is present.
Travelling with a child has a rather substantial impact on the short car trips class, which is associated by 0.51 with this class. When travelling with a child, long active travels are less likely, as is shown by the negative association of -0.4 with cluster 6 (dedicated active travellers) and -0.27 coefficient with cluster 1 (young affordable active 15-minute travels). Short active travel (possibly walking), however, is positively associated with travelling with a child younger than 6 (0.21).
As this analysis will focus on the policy-relevant topic of what factors contribute to choosing car instead of more sustainable options, and the initial analysis showed that the 8th work and education related and work only related class consists mostly of work-modes, (so called 'white-Van-class') it will be omitted from most of the following analysis steps.

5.4.1. Latent class model - Work purpose

Correcting for the school and university related traffic, the work only model also resulted in 8 classes larger than 5%. It can be stated that travelling by car is a more common way of transport than in the work and education motive travel as well as in leisure travel. The car clusters in only work travel make up 55.6% while it is 47.3% in work and education travels. Moreover, the active clusters amount to only 36.5% in only work travel, while it is 44.4% in work and education trips. The public transit user class is 8% of size which is similar to work and education. However, the lone public transit user cluster has a larger portion of car travellers in only work related travels than they do in work and education related travels, namely 18.5%. As also becomes apparent from map 5.5, the effect of the Randstad area is slightly stronger than it is with work and education. Especially the lesser presence of active modes classes is striking. Moreover, it seems impossible to find a postcode area on the map in which the public transit class is most common.

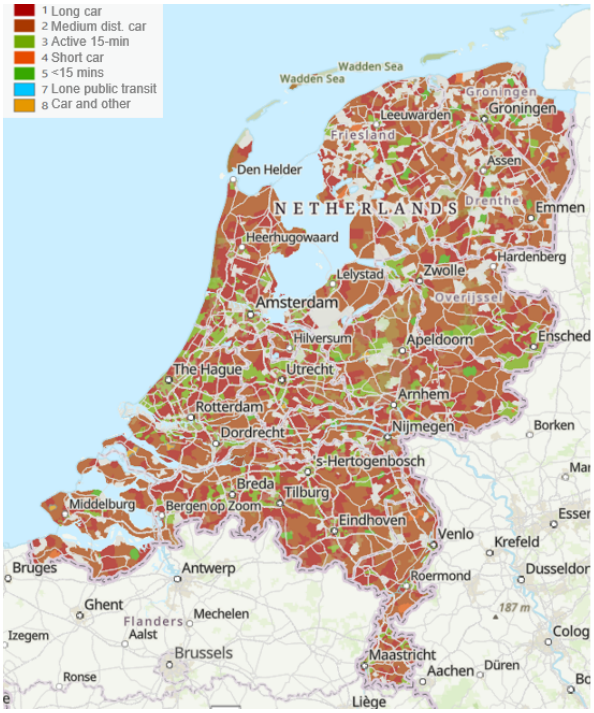


Figure 5.5: Distribution of most common classes, work travel purpose

Class 1: Well situated long car travellers, 21.39%
More than a fifth of trips made for work only purposes last longer than 30 minutes and cover more than 20 kilometres by car. This class is dominated by Dutch males who are in the working age (30-64), have a high educational level and high income (in fact, this is the cluster with the highest income).

Travellers in this class do not travel with children and tend to live in rural environments. Regarding the inactive covariates, this is the class with the highest ratio of 2 and 3 or more cars and the lowest ratio of people without a car. Moreover, travellers live with their partner and with children younger than 12 above average.

Class 2: Suburban worker (medium distance car travel), 17.46%
The second class is similar to the first in terms of the sociodemographic makeup, but it differs in terms of the distance and travel time in so far as distances in between 7.5 and 20 kilometres are covered in 15-30 minutes. Similarly to class one, travellers in this class are also Dutch and are in between 30 and 64 years old. Travellers in this class tend to live in rural environments and have medium or high household income and a medium level of education. They also do not travel with children. As for the inactive covariates, they tend to have 2 or more cars. Interestingly, the gender divide is less extreme than in the well-situated-long-car-travellers' class, with 42% females in this class.

Class 3: Young urban new workforce/Low earner (Active 15 minute traveller), 17.12%
Class three is characterised by travellers who mainly use active modes (74%) and cover 1.5-7.5 kilometres in about 15 minutes (ranging from 6-30). It is the class with the second-highest ratio of female travellers and non-Western travellers and the class with the highest ratio of the lowest income group and above average medium-level income. Travellers in this class tend to have everything but a medium education level above average and they tend to be younger than 30 and live in an urban environment. Travellers in this class have up to one car only, 81% do not live with children and it is the class with the highest ratio of people living alone. Interpreting this class, what seems obvious that in this class there are people who are just starting out in the workforce, they are young, have high education levels or are still in education and could be interpreted to be saving for a car or are still working in their sidejob. On the other hand, in this class we also see the second highest ratio of people who have no or low levels of education but are not in education anymore and who can thus be assumed to be more 'stuck' in their life situation and need to live in an urban environment for employment reasons.

Class 4: Comfortable car travellers (Short car trips), 11.53%
Travellers in the short car trip group mostly travel by car and cover 1.5-7.5 kilometres in 6-15 minutes. People in this class tend to be of Dutch ethnic descent, are older, have medium or high income and medium education level. Moreover, it is the class with the highest ratio of travellers who travel with children and travellers in this class tend to live in more rural environments. People tend to have at least two cars and live with their partner.

Class 5: Work where they live travellers (<15 mins active modes), 11.2%
In this active travel class, people cover up to 1.5 kilometres in up to 5 minutes (and in 35% up to 15 minutes). This class is defined by an above-average amount of travellers living in rural environments, they are majority females of Dutch descent. Travellers are either younger than 30 or older than 65 as this class has the lowest working age ratio. Travellers tend to travel with a child younger than 6 years old above average (1.4%) and also tend to have low and medium education levels and own up to one car per household. This class has the highest ratio of people with low education levels. The income levels are slightly lower than average but not alarmingly. This class can be interpreted as people who seem to work where they live, these people possibly even walk to where they work.

Class 6: Dedicated active travellers without alternative, 8.29%
Class six is also majority active-travels, although it also sees 26% of travellers going by public transit and 14% travelling by car. Generally, in this class trips take 16-30 minutes and cover distances of 7.5-20 kilometres. Travellers in this class live in urban environments, are above average females, non-Dutch and have lower income. They have everything but medium education levels and tend to travel with a child younger than 6.

Class 7: Lone public transit users, 7.96%
Travellers in class 7 use public transit in 79% of their trips (18.5% use car) and cover more than 20 kilometres while taking more than 20 minutes for it. This is the class with the highest ratio of urban dwellers, non-Dutch travellers, it has the highest ratio of people younger than 30 but also with high education level. Travellers in this class tend to have lower income. People in this class have no car, and live alone.

Class 8: Skilled working class (Car and other work related travels), 5.17%
Similar to the education and work related travel purpose LCA, class 8 is work related travel by using car and other modes. Trips in this class cover more than 20 kilometres and more than 30 minutes. 96% of travellers in this class are male. Moreover, this class is defined by being Dutch, aged 30-64, with medium income, low or medium education level and people do not travel with a child. Also, travellers in this class tend to live in rural environments and own at least one car. Also, travellers in this class live with their partners.

Discussion
Interestingly, the work only classes largely overlap with the work and education related ones. As for the classes that had the highest education related purpose trips, they have a similar sociodemographic makeup for work only related travel purpose apart from the fact that the <15 minute active travel class is much smaller and pertains to travellers living in a rural environment above average. It seems that in the cities, it is less common that people live so close to work that they can take up to only 5 minutes. Rather, this is something more common for education related travels or for people living in rural environments. In that class, the age composition is also different from work and education as the active below 15 minute class is the one with the lowest overall working age ratio. Moreover, education level is higher in the work travel purpose model. What seems puzzling is the class of the dedicated active travellers for work travel purpose. While their profile overlaps with the previously presented class of work and education of being non-Dutch, have a lower income and do not own a car, what's more, in this latent class model they have low and high levels of education (as well as still being in education), they also travel with a child and they are above average females and do not live with a partner. Moreover, this class is more common in urban environments. What is also striking is that the long distance active travellers as well as the public transit users overlap in that they are above-average non-Dutch, have lower income levels, no car and live in urban environments. The public transit users, however, have the highest ratio of high education while the active travellers have rather low or medium levels. The active travellers also tend to travel with children and are not above-average young (as are the public transit travellers) which hints at the fact that the dedicated active travellers might be in a different life stage than the public transit users.

Axes of disadvantage
Regarding trips made for work only purposes, the largest general impact (in terms of the Wald-test) on class membership is by the covariate of level of education, followed by level of urbanisation whereas travelling with a child or not has the smallest impact on class membership (see table 5.3). Specifcally, the biggest covariate impact is that of gender on being in the work and other class (namely +1.3 for being male). Leaving this class aside, the largest impact is that of a high education level on being in class 7 (lone public transit users, +0.94) and the smallest impact is that of of Western descent on class 3 (active 15-minute city/young urban new workforce/low earner, +0.0005).
As for urbanisation level, living in a rural environment has the largest impact on class 7 (public transit class), namely -0.53. A similar effect (-0.38) can be observed with regards to class 3 (active 15-minute city/young urban new workforce/low earner). People living in rural environments are the most likely to be in class two, the suburban worker class (+0.28). Regarding the effect of gender, it is almost completely absent for classes 1 (well situated long car travellers) and 4 (comfortable car travellers (short car trips). Women are more likely, however, to be in all sustainable modes classes across all travel distances and time categories. Namely, the Active 15 minute/Young urban new workforce/Low earner class (+0.35), the Work where they live travellers (<15 minutes active modes) (+0.39), dedicated active travellers without alternative (+0.2) and the Lone public transit users class (+0.18). The magnitude of the effect of ethnic background on class membership also differs a lot per class. For classes 1-3 it is almost entirely irrelevant (all effects <0.1), while class 4, 5 and 8 see a stronger effect of being Dutch (+0.15, +0.12 and +0.2 respectively). Classes 6 and 7 (dedicated active travellers and public transit users) however, are very negatively associated with being Dutch (-0.23 and -0.33) and are much more strongly associated with being of Western or non-Western ethnic background. Age has the largest effect on membership of class 7 (public transit users) whereas the youngest group is much more likely (+0.7) to be part of that group and the oldest much less likely (-0.76). However, being in the oldest age group is strongly associated with being in class 4 (comfortable car travellers (short car trips) or 5 (work where they live (<15 minute active trips)) (0.44 and 0.56 respectively), indicating that older age

is more strongly associated with shorter distances and travel times. The effect of income is strongest on class 1 (well situated long car travellers), 8 (skilled working class) and 4 (comfortable car travellers (short car trips)) where low income is very negatively associated with these classes (-0.25, -0.21 and -0.2 respectively). However, class 1 is most strongly associated with high income (+ 0.27) whereas class 8 is most associated with medium income (+0.16). Similarly, classes 5 (work where they live), 6 (dedicated active), and 7 (lone public transit users) are all associated with low income (+0.16, +0.19 and +0.18 respectively), showing a clear effect of lower income and more affordable options, yet covering all distances. As for education level, the effects on most classes are rather substantial. The largest effect is present for class 8 where high educational level is very negatively associated with class membership (-1.13), and a low and medium education level are very positively associated with it (+0.79 and +0.31 respectively). This effect is reverse for class 1 (well situated long car travellers). The impact of having low education level on being in this class is -1 while it is +0.89 for high education. Similar to class 1, class 7 (lone public transit users) is also strongly associated with the highest education level (+0.94) and strongly negatively associated with the low but also the medium education level. The low education level is most associated with being in class 8 (skilled workers class) (0.79) and class 5 (work where they live (<15 minutes active modes)) (0.53). There are also strong associations with class 3 (Young urban new workforce/Low earner)(0.31) and class 4 (comfortable car travellers) (0.23).
Lastly, travelling with a child has a substantial negative effect on class 1 (well situated long car travels)(-0.26), and a strong positive effect on class 4 (comfortable car travellers (short car trips)) (+0.19), indicating an association of travelling shorter distances with a child, irrespective of mode. Apart from these two, however, the effects are very small (<0.1).

5.4.2. Latent Class model - Leisure purpose

Regarding travel for leisure reasons, 7 clusters were found. All relevant statistical tests are large enough and significant. Nevertheless, as previously mentioned, the 7th cluster is just below 4% of the sample size which is normally regarded too low to be relevant. As otherwise there would not have been a cluster with public transit as a main mode, it was decided to keep the 7th cluster. Overall, leisure travels tend to be more active, with 51.3% of the trips falling within active clusters. Car clusters amount to 45.6% of all trips and public transit was used in only 3.2%. Map 5.6 shows that the effect of living in an urban environment, and specifically the randstad is much less apparent. It also shows that active travel is much more common across the entire country. As can be seen from the lack of blue colour in the legend, in the leisure model no area would use public transit most often. This makes sense given that the public transit dominant class is barely 3% in size.

Class 1: Urban active 15-minute travellers, 20.3%
The largest class for leisure travel purposes is that of the active 15 minute travellers and it comprises trips of up to 7.5 kilometres and around 15 minutes (6-30 minutes). Travellers in this class tend to live in an urban environment, they are below-average non-Western but above average young, have low income and are in education or have a low level of education. People in this class do not travel with children, in fact, this is the class with the highest ratio of people not travelling with children. Regarding the inactive covariates, travellers of the active 15-minute class tend not to own a car and live alone.

Class 2: Nearby activities (<15 minute active trips), 18.4%
The second largest class with 18.4% is also an active-travel class, but it comprises distances of up to 1.5 kilometres only and shorter travel times, namely a maximum of 5 minutes in 64% and in between 6 and 15 minutes in 36%. People in this class live in rural environments above average and are above average females. They are younger, Dutch, have a high household income and are in education. In fact, this is the class with the highest in-education ratio of all leisure classes. Furthermore, 35% of travellers live with children in the household.

Class 3: Comfortable convenient short car trips, 15.82%
The third largest class for leisure purpose travel is that of short car trips. Trips in this class last in between 6 and 15 minutes and cover distances of 1.5-7.5 kilometres. Travellers in this class are Dutch, 30-64 years old and have medium education level. It is the class with the highest household income and travellers also tend to travel with children. As for the inactive covariates, this class is the one with the highest ratio of people owning 2 and 3 or more cars and the lowest ratio of people who own no

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class8	Sample
Cluster size	21%	17%	17%	12%	11%	8%	8%	5%	
Indicators (mean)									
Mode choice	car	car	active	car	active	active	public transit	other	
travel distance									
0-1.5km	0%	0%	5%	0%	100%	0%	0%	0%	
1.5-7.5km	0%	1%	95%	100%	0%	24%	0%	0%	
7.5-20km	3%	98%	0%	0%	0%	76%	15%	12%	
20+ km	97%	1%	0%	0%	0%	0%	85%	88%	
mean	3.97	3.00	1.95	2.00	1.00	2.76	3.85	3.88	
travel time									
0-5 min	0%	0%	0%	17%	65%	0%	0%	0%	
6-15 min	0%	33%	57%	81%	35%	0%	0%	0%	
16-30 min	30%	65%	42%	2%	0%	42%	2%	24%	
30+ mins	70%	1%	0%	0%	0%	57%	98%	76%	
mean	3.70	2.68	2.42	1.84	1.35	3.57	3.98	3.76	
Active Covariates									
Urbanisation									
Urban	64%	58%	85%	61%	63%	79%	90%	57%	69.4%
Rural	36%	42%	15%	39%	37%	21%	10%	43%	30.6%
Gender									
Male	66%	58%	48%	62%	47%	55%	54%	96%	58.6%
Female	34%	42%	52%	38%	53%	45%	46%	4%	41.4%
Ethnic background									
Dutch	85%	84%	77%	86%	84%	73%	69%	86%	80.4%
Western	8%	8%	10%	7%	7%	11%	14%	6%	9.2%
Non-Western	8%	8%	13%	7%	8%	15%	18%	7%	10.4%
Age									
6-29	18%	19%	30%	20%	28%	26%	35%	14%	23.6%
30-64	79%	76%	64%	72%	61%	69%	63%	83%	71%
65+	4%	4%	6%	9%	11%	5%	2%	3%	5.4%
Income									
0-30%	7%	9%	19%	9%	15%	16%	18%	9%	12.2%
30-70%	30%	37%	37%	39%	37%	36%	35%	44%	35.5%
70-100%	63%	54%	44%	52%	48%	48%	47%	46%	51.7%
Education level									
in edu/unknown	1%	2%	3%	2%	3%	4%	2%	2%	2.4%
low education	1%	2%	5%	4%	7%	4%	1%	7%	3.5%
medium education	39%	59%	46%	65%	57%	44%	27%	78%	49.9%
high education	59%	37%	46%	29%	33%	48%	69%	13%	44.2%
Travel with child younger than 6									
No	99%	99%	99%	98%	99%	99%	99%	99%	98.9%
Yes	0.7%	1.0%	1.0%	1.6%	1.4%	1.5%	1.1%	0.8%	1.1%
Inactive covariates									
Car ownership									
0	3%	5%	24%	7%	18%	25%	30%	8%	13.6%
1	35%	41%	47%	44%	48%	46%	45%	47%	42.5%
2	47%	39%	22%	34%	25%	22%	20%	34%	32.3%
3+	16%	16%	7%	16%	10%	7%	6%	11%	11.6%
Children aged 12 and younger in household									
No	73%	77%	81%	78%	80%	80%	81%	75%	77.7%
Yes	27%	23%	19%	22%	20%	20%	19%	25%	22.3%
Household constellation									
Single	20%	22%	29%	20%	25%	28%	31%	20%	24.4%
Couple	80%	77%	70%	80%	75%	71%	68%	80%	75%
Other	0%	0%	1%	0%	0%	1%	1%	1%	0.6%

Table 5.5: Latent Class Proportions; work travel purpose

Figure 5.6: Distribution of most common classes, leisure

car. Additionally, it is the class with the highest ratio of couple-households and 33% of travellers in this class have children aged 12 or younger.

Class 4: Medium distance car travel, 15.42%
Travellers in the fourth class tend to travel around 15-30 minutes and in between 7.5-20 kilometres by car. The travel time specifically is not very clear-cut, as 30% of trips are 6-15 minutes long while 10% are longer than 30%. However, 56% of trips in this class last 16-30 minutes. Travellers in this class tend to live in the rural areas of the Netherlands, as this is the class with the highest percentage of people living in a rural environment. Generally, this class is very similar to the short car travellers in terms of sociodemographic makeup. Travellers are in the working age or older, they have high income, medium education level and tend to travel with a child that is younger than 6. Moreover, travellers in this class have around 2 cars in the household and almost a third live with children younger than 12.

Class 5: Long car travel, 14.35%
The fifth leisure-purpose travel class are long car journeys and it is defined by being the class with the highest ratio of males, Dutch people and people who travel without children. Travellers in this class tend to live in rural environments, are older and have medium and high household income as well as medium and high education levels. As for the inactive covariates, this class sees 77% of travellers with no children in their household, travellers own at least one car and the majority lives with their partner.

Class 6: Dedicated active travellers, 12.54%
Similar to the other travel purposes, there is a class of active travellers who travel rather long (up to 20 kilometres) for leisure. These travellers take more than 30 minutes and are above average non-Dutch (both of Western and non-Western descent), are 30 years or older (this is the class with the highest ratio of travellers older than 65) and tend to have medium or high income (this is the class with the highest ratio of medium income). Regarding education level, travellers in this class have all but high education levels and tend to travel with a child younger than 6. Also, travellers in this class tend to have maximum one car.

Class 7: Lone public transit users, 3.16%
The smallest class, with only 3.16% is that of public transit users. Trips in this class take longer than 30 minutes and cover distances of more than 20 kilometres. This class has the highest ratio of travellers living in an urban environment, who are female, non-Dutch as well has have a low income and are not travelling with a child. Moreover, it also has the highest ratio of travellers with a high educational level. Additionally, this class also has the highest ratio of people with no car, and who live alone. Also, 89% do not live with children.

Discussion
Regarding leisure, the effect of gender overall is much smaller than it is for the travel purpose of work and work and education, while the effect of income and travelling with a child or not is more significant. As for the general composition of the classes, it seem like the same, or rather similar profiles apply as in the other travel purposes. Interestingly, all car classes are associated with travelling with a child, which is one of the only differences from the work classes.

Effect of axes of disadvantage
Regarding the covariates for leisure travel, it can be stated that overall they have less severe impacts as the magnitude of the covariate coefficients ranges from 0.0015 effect of income on being in the nearby activities class) to -1.0123 (effect of being in education on being in the public transit class). Excluding the class of public transit, the largest effect shrinks to 0.492 (effect of being in education on being in the nearby activities class). This indicates that generally, sociodemographics are less relevant in predicting leisure travel behaviour than it is in predicting needs travels. The covariate with the largest impact is again educational level (see table 5.2 and table 5.3) while gender is the covariate with barely any relevant coefficients as the coefficients for all clusters are smaller than 0.1. As it was decided to include the 7th class although it is smaller than 5%, the effects of covariates on this class are higher. Thus, in analysing the effect of the covariates and specifically the covariates that represent the axes of disadvantage, the largest impact without the public transit class also has to be listed.
Similar to education and work related travels, urbanisation level has the largest association with the urban active 15-minute class (class 1). Living in a rural environment is associated with this class with -0.175. Similarly, the 'lone PT user' cluster (cluster 7) is also negatively associated with rural environments, namely by -0.32. Nevertheless, very short active trips (nearby activities) and medium car trips are positively associated by living in a rural environment (0.14 and 0.15 respectively). This indicates that people living in rural environments decide their mode choice partly based on the distance that is to be covered.
Regarding ethnic background, similar to education and work related travels, having a Western (but non-Dutch) ethnic background has little to no effect in comparison to Dutch or non-Western ethnic background. Only regarding cluster one (urban affordable 15-minute travels), a slight effect of 0.11 of being Western non-Dutch can be observed, while a non-Western ethnic background has a negative effect of -0.19. Dutch ethnic background is associated by 0.08 with cluster one. Larger effects of ethnic background with regards to leisure travel can be observed in relation to cluster 6 (dedicated active travellers) and 7 (lone PT users). These are similar effects as observed in education and work related travels. Having a Dutch ethnic background is negatively associated with clusters 6 and 7, (-0.17 and -0.27 respectively) while having a non-Western background is positively associated with these clusters (0.16 and 0.27 respectively). The Western background effects are rather negligible.
As for age, the largest effects are observed with regards to cluster 6 and 7. Regarding the dedicated active travellers cluster (cluster 6), the older one gets, the higher the chance of being in this cluster. Regarding cluster 7, 'lone PT users', this is negatively affected by being middle aged (recall, this is the working age group) by -0.36, while being in the younger age group is both positively associated (0.6).
Regarding income, there is a positive association between higher income and being in the car clusters (clusters 3-5). The opposite is true for the lone PT users cluster (cluster 7) and the active travel clusters. Notably, especially the effect on the car clusters is larger on average than in the work/education and work related travel clusters.
As for the effect of educational level, there are some effects of size. First, the largest effect apart from that on being in the public transit class is the effect of being in education on being in the nearby activities class (0.492). All other education levels are negatively associated with being in this class. Moreover, having low levels of education is most strongly associated with being in class one, the affordable active

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Sample
Cluster size	20%	18%	16%	15%	14%	13%	3%	
Indicators								
Mode choice (majority)	active	active	car	car	car	active	public transit	
travel distance								
0-1.5km	26%	100%	0%	0%	0%	0%	0%	
1.5-7.5km	74%	0%	100%	18%	0%	66%	0%	
7.5-20km	0%	0%	0%	82%	0%	34%	22%	
20+km	0%	0%	0%	0%	100%	0%	78%	
mean	1.74	1.00	2.00	2.82	4.00	2.34	3.78	
travel time								
0-5min	0%	64%	16%	0%	0%	0%	0%	
6-15min	48%	36%	81%	33%	1%	0%	0%	
16-30min	46%	0%	3%	56%	20%	11%	4%	
30+	5%	0%	0%	11%	79%	89%	96%	
mean	2.56	1.36	1.87	2.78	3.79	3.89	3.96	
Active Covariates								
Urbanisation								
Urban	78%	64%	67%	64%	66%	70%	86%	69.3%
Rural	22%	36%	33%	36%	34%	30%	14%	30.7%
Gender								
Male	46%	45%	47%	47%	53%	49%	43%	47.6%
Female	54%	55%	53%	53%	47%	51%	57%	52.4%
Ethnic background								
Dutch	82%	85%	85%	83%	86%	78%	73%	82%
Western	10%	8%	8%	8%	7%	10%	11%	9%
Non-Western	8%	7%	7%	8%	7%	12%	16%	8.7%
Age								
6-29	39%	41%	35%	31%	25%	27%	49%	34.6%
30-64	44%	43%	49%	49%	53%	48%	36%	47%
65+	16%	16%	16%	20%	22%	25%	15%	18.4%
Income								
0-30%	19%	14%	11%	12%	11%	18%	28%	14.9%
30-70%	36%	37%	37%	38%	39%	42%	35%	37.7%
70-100%	45%	49%	53%	50%	49%	40%	37%	47.4%
Education level								
in education/unknown	17%	25%	17%	14%	10%	16%	5%	16.5%
low education	7%	5%	4%	5%	4%	6%	5%	5.2%
medium education	41%	40%	46%	46%	46%	45%	39%	43.3%
high education	35%	30%	32%	36%	40%	33%	50%	35%
Travel with child younger than 6								
No	95%	93%	91%	90%	90%	91%	97%	92.2%
Yes	4.6%	6.9%	9.5%	9.6%	9.7%	8.7%	2.8%	7.8%
Inactive covariates								
Car ownership								
0	22%	15%	7%	8%	8%	20%	40%	15%
1	45%	46%	45%	47%	49%	48%	40%	45.9%
2	26%	30%	36%	34%	33%	26%	15%	30%
3+	7%	8%	12%	11%	11%	7%	5%	9.1%
Children aged 12 and younger in household								
No	75%	65%	67%	72%	77%	75%	89%	72%
Yes	25%	35%	33%	28%	23%	25%	11%	28%
Household constellation								
Single	28%	24%	20%	22%	21%	25%	40%	24.6%
Couple	71%	75%	80%	77%	78%	74%	58%	75%
Other	1%	0%	0%	0%	0%	0%	2%	0.4%

Table 5.6: Latent Class Proportions; leisure travel purpose

15-minute class. The effect of level of education on cluster 7 (lone PT users) is that it is negatively associated with still being in education (-0.8) and gradually increases with level of education until about 0.52 in the highest level of education. The reverse is true for cluster 7 (dedicated active travellers), albeit of smaller magnitude. Generally the active travel clusters are positively associated with lower educational level while the reverse is true for long distance car trips.
Travelling with a child has the largest effect on cluster 7 (lone PT users), where it is negatively associated with this cluster by -0.4. A similar association can be observed with regards to cluster 1 (affordable urban 15-minute travels), (-0.22), while the reverse holds for car-related clusters. Interestingly, the effect of this covariate on cluster membership overall is larger than when investigating needs travels (see also table 5.2 and table 5.3).

5.5. Assessment of reasons for specific travel behaviour choices

Having reviewed the composition of the classes, the next step is to analyse to what extent certain TB patterns can be attributed to specific sociodemographic profiles. This is relevant in order to infer how people's travel behaviour could be influenced by policy and to understand why people travel a certain way. First, in this section classes with similar mode choice are analysed in terms of their similarities or differences of sociodemographics. As the academic literature indicated, certain sociodemographics are associated with specific mode choice, irrespective of the other journey characteristics. This will be assessed. Next, classes with similar travel times and distances, yet different mode choices are analysed regarding their sociodemographic composition and spatial extension. Thus, it will be analysed to what extent sociodemographic factors seem to contribute to the specific mode choice or rather spatial circumstances.

5.5.1. Mode choice

In this section it will be assessed to what extent specific sociodemographic profiles for the specific mode choice clusters can be identified. This is relevant in order to understand if there are specific types of people with specific needs that might cause a certain mode to be chosen. For the assessment the mode choices will be divided along the lines of what modes would be desirable from a policy perspective, as discussed in chapter 3. Thus, active modes and public transit are seen as desirable while the car is seen as less desirable.

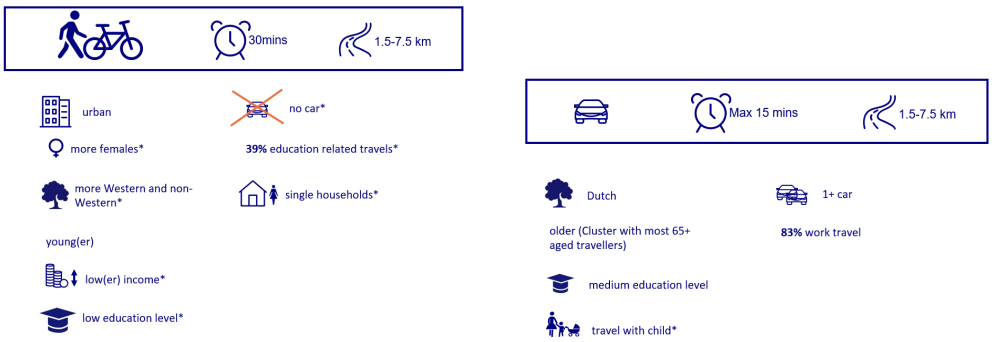
Sustainable modes
Assessing the sustainable mode classes for work and education related travels, it becomes apparent that all classes share certain characteristics. While all active classes entail younger people, the 15-minute city, below 15 minute city as well as the dedicated active travellers classes are above average female. All active classes share that people have low levels of education or are in education, whereas the 15-minute class, the dedicated active travellers and the lone public transit users are all characterised by non-Dutch people with low income and with no car. Nevertheless, both the 15 minute city cluster and the public transit one also have an above average ratio of single households which could explain low household income.
Regarding work only, a similar profile can be identified. All active modes see above average ratios of females, all active classes and the public transit class are characterised by people that own 0 or max. 1 car. The very short active class has the same make-up in both work and education as well as education. For work only, however, urbanisation level is much more relevant. All sustainable clusters apart from the very short active class are defined by people living in urban environments.
As for the leisure motive, the profiles are not as similar as are the work and work/education travel purpose profiles, but extensive overlap in terms of sociodemographics becomes apparent. While the very short active modes cluster is characterised by people with high income, Dutch and younger people in rural environments, the long distance active class is characterised by non-Dutch, working age and older, medium or low income travellers who are in all but in the high education class. Contrastingly, the public transit class is characterised by female, urban, non-Dutch, young, low income but single household highly educated travellers with no car and no children. Overall, it can be stated that it can not be generalised in terms of which sociodemographics predict sustainable mode choice in leisure travels.

Car
As for the less sustainable mode choice of car for work and education related travels, some sociodemographics become apparent that are correlated to car use, namely being Dutch, in the working age or older, having medium education levels and owning at least one car. While the very short car class is characterised by travelling with children, the longer car travel one and the class in conjunction with other modes are not. Regarding the motive work only, class compositions seem very similar and will thus not be analysed in further detail.
Regarding trips made for leisure reasons, a more clear-cut profile than for the leisure sustainable modes can be identified. Travellers of all three classes are aged 30 or older, have higher income and medium education level. Moreover, all travel with children above average and two out of three classes have an above average number of people living with children and with a partner. All classes see travellers with at least two cars.

Conclusion mode comparison
From this comparison it can be concluded that although there are some differences in the classes that have similar mode choice, a general tendency for sustainable modes to be chosen by young travellers, females and lower income groups can be observed. Interestingly, ethnic background also plays a role across all motives when looking at medium to long distance sustainable mode travels. However, the impact of ethnic background is very low, statistically speaking. Walking distances of up to 15 minutes as well as car use in general are associated with being of Dutch ethnic descent for all travel purposes. On the contrary, active travels of longer distances and public transit use is associated with not being Dutch. For car use clear profiles for both work (and education) and leisure could be identified. For leisure, this is an indication that while there is no clear trigger to use sustainable modes (as is income, ethnic background, gender for work), there seems to be a clear car-use profile. Car use seems to be a luxury that is reserved for the privileged. This can be seen from the clear association of it with working age, high income and medium education level. Although these sociodemographics cannot necessarily be said to trigger the need to travel by car, travelling with a child is. The fact that ownership of at least 1-2 cars is associated with car use especially for shorter distances, leads to the question as to whether one uses a car because one needs to or because one just has a car. It becomes a chicken-egg debate as to whether having a car causes people to use it or if they need it to fulfill their travel needs because any other mode is not feasible.

5.5.2. Journey types
The following section assesses the classes in which journey types (defined as similar travel duration and travel distance) are similar, yet the mode choice is different. The academic literature generally associates specific modes with certain journey types (i.e. car choice with longer and farther journeys), but the findings of this research suggest otherwise. Surprisingly, it does not seem like specific modes are necessarily only associated with specific spatial circumstances either. In order to guide the reader, figures are created that summarise the sociodemographic characteristic of each class. A characteristic will be listed if it is statistically positively associated with class membership. Thus, if travelling with a child is associated with being in a class this will be depicted in the figure, although this does not mean that the majority of people in this class have the characteristic. Moreover, maps are created to show the spatial concentration of a class with regards to the Netherlands. Each class is presented on two maps, one in which the colouring is the highest layer, the other (on the right, next to it), with the information on cities as the highest layer. This is done to relate findings more accurately to specific regions.

Short journeys
The first journey type to be analysed is the short one. Specifically, this type is characterised by a journey distance of 1.5-7.5 kilometres and travel times around 15 minutes. For the motive of work and education, classes 1 (active 15-minute city) and 5 (short car trips) are relevant.
Regarding sociodemographic characteristics, the classes have very little in common. While the active travellers tend to be confined to a more urban setting, have above-average ratios of women and non-Dutch travellers, tend to be younger and have lower education levels, the car class is characterised by above average Dutch travellers, medium income levels and is the cluster with the highest ratio of travellers aged 65 and up. Furthermore, the active travel class is characterised by people owning no car, while travellers own at least 1 car in the car cluster. Whereas income does not seem to play a

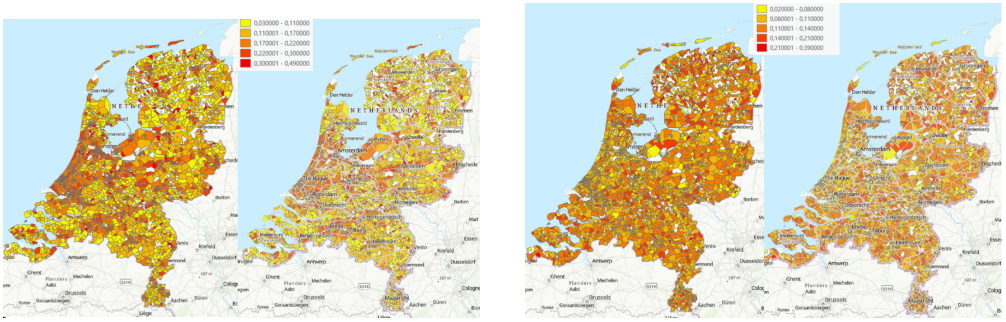


(a) Young urban affordable active 15-minute travellers, 18.6%

(b) Short car trips, 11.08%

Figure 5.7: Short journey classes

significant role for membership in the short car travel class, the active travellers' class is characterised by low(er) income. Nevertheless, this class also sees above average number of people living in single households. It can thus be assumed that their disposable income is not necessarily much lower than that of people in the car cluster. What is more, travellers in the car cluster tend to travel with children aged 6 or younger.
One- rather unsurprising - result from this is that younger people and potentially children travelling to school use more sustainable modes of transport and older people travelling to work tend to go by car more often.
From a spatial perspective, it becomes obvious that the active 15-minute travellers are more present around the randstad area. Nevertheless, there is no such effect for the short car trip travellers. Those seem to be present all over the Netherlands.



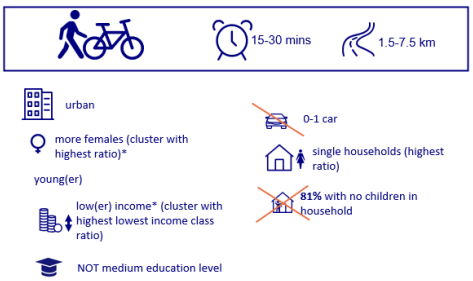
(a) Young urban affordable active 15-minute travellers, 18.6%

(b) Short car trips, 11.08%

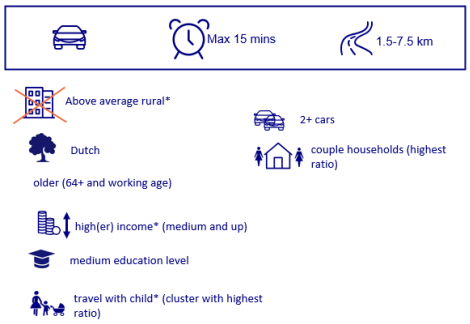
Figure 5.8: Work and education: Short journey classes only

Correcting the figures for the school children and assessing the work-only motive, a similar relationship becomes apparent. However, the short car trips class is also characterised by above-average rural travellers, whereas the active travellers are very clearly predominantly urban dwellers. Similar to the work and education motive, the active travellers are above average females and belong to the younger age groups while the car travel class is characterised by older travellers. The active travellers are also those with the lowest income across all classes while in the work only car class, the car travellers have a higher income. Overall, the active travellers also have the highest ratio of people living in single households with 0-1 car and no children. Contrarily, short car trip travellers have 2 or more cars, have the highest ratio of people living in with their partners and travelling with children. What's more, a spatial contrast between the Randstad and the more rural areas of the Netherlands becomes apparent. However, it can also be seen from both the statistics as well as the maps, that the effect of rurality/non-urban environments on whether or not someone travels by active modes is larger than that of living in an urban environment is on short car trips. Statistically, the effect of urbanisation level is more than twice as high for active travels than it is for car travels. Thus, while rurality seems a deterrent to active

travels, urbanity is not as much for short car trips.

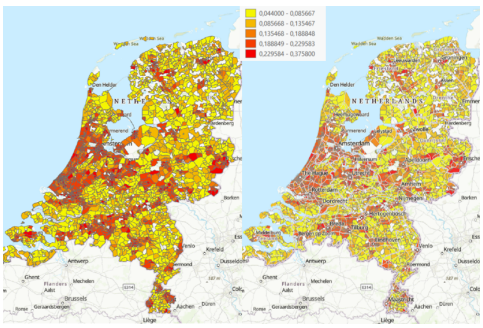


(a) Young urban new workforce/low earner(active 15-minute traveller), 17.12%

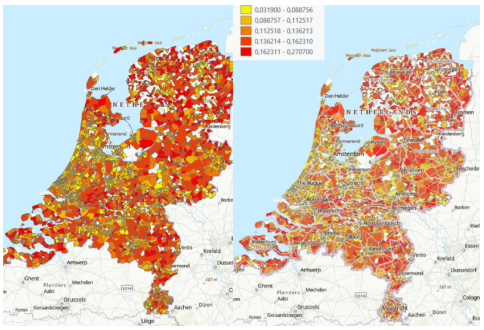


(b) Comfortable car travellers (short car trips), 11.53%

Figure 5.9: Short journey classes work only



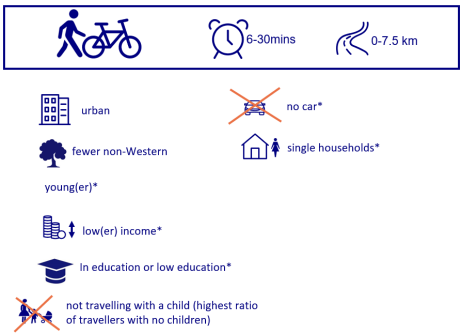
(a) Young urban new workforce/low earner(active 15-minute traveller)



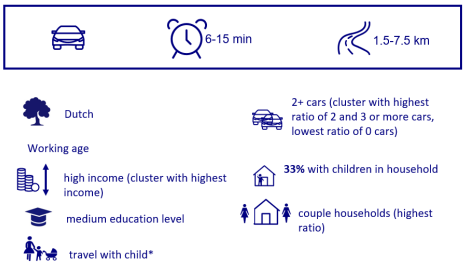
(b) Comfortable car travellers (short car trips), 11.53%

Figure 5.10: Short journey classes work only

Regarding short journeys for leisure, similarly to work only the active 15-minute cluster seems to be good fit as a possible substitution cluster. Similarly to work and education trips, travellers in the active travel cluster are more confined to the urban environment of the randstad area while short car trip travellers are not so much to be found only in rural environments. Also similar to the other motives, active travellers tend to be younger while car travellers are in the second age group (29-64). Again, active travellers have lower incomes than car travellers, however, they also tend to live alone, whereas short car trip travellers have the highest ratio of people living with their partners (which can also increase household income). Nevertheless, the active travellers also tend to have a lower education level than the car travellers. The latter also have the highest ratio of 2 and 3 or more cars as well as the lowest ratio of travellers owning 0 cars. In line with expectations, the leisure active travellers have the highest ratio of people not travelling witch children whereas that is the exact opposite for short car trip travellers. Overall, it seems like the short journey classes have similar characteristics for all of the purposes. Moreover, While a connection between factors cannot be assumed without doubt, it seems like these findings can be categorised in groups of life stages. Whereas it seems that being 'further in life' (i.e. older age, living with a partner, higher household income, higher education levels, having children) is associated with short distance car travel, 'earlier life stages' (i.e. younger, lower income, living alone, not owning a car, in education or low education) are associated with active travels. This trend is consistent over all travel purposes and can be assumed to be connected to people's need for comfort and convenience. Nevertheless, the spatial aspect of the travel choice is very interesting. As noted for both work and education and leisure travels, short car trips are present in all areas of the Netherlands. For the work travel purpose, the effect of urbanisation level is less strong for car than for active modes. This effect indicates that for work short car travels, spatial circumstances are less relevant than sociodemographic ones.



(a) Urban active 15-minute travellers, 20.3%%



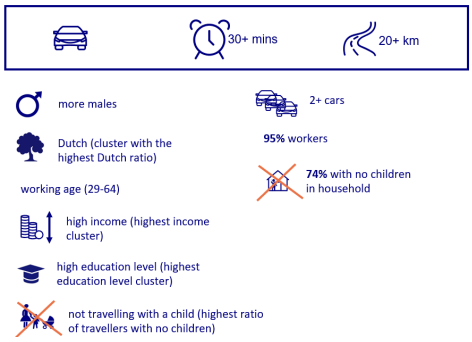
(b) Comfortable, convenient short car trips, 15.82%

Figure 5.11: Leisure: Short journey classes

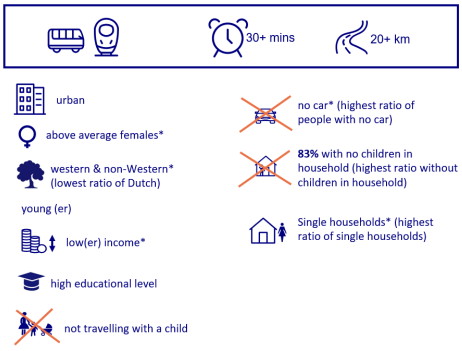
Long distance travel

On the other end of the journey-characteristic-spectrum are the long travel times (30+ mins) and long distance (20+km) journeys. As for the work and education motive, 2 modes could be substituted in this journey type, namely car and public transit. The long car travel class is the fourth largest for work and education travels and it entails 14.96% of the trips. The public transit group, cluster 7, is 8.3% of the trips. The long car travel cluster is characterised by consisting mostly of males and people who are in the working age group (29-64). It is the cluster with the highest ratio of Dutch people, and of people who have both high income as well as high levels of education. While it is the cluster with the highest ratio of people fulfilling these characteristics, it is also the highest ratio of people not travelling with children and most of those travellers also do not live with children. This cluster is neither confined to a specific geographic area in the Netherlands, nor to a specific level of urbanisation.

On the contrary, the public transit cluster consists mainly of travellers from the urban areas. They almost perfectly mirror the medium distance car class as they are above average female, non-Dutch, younger and have rather low income (again, this can be due to the fact that they have a very high ratio of travellers living in single households). While the car cluster travellers own at least 2 cars, the public transit class is the one with the highest ratio of people who do not own a car. Both the car and the public transit cluster have travellers with a high educational level and both classes do not travel with children.



(a) Well situated long car travellers, 14.97%

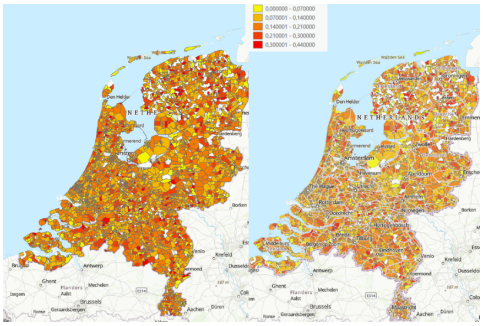


(b) Educated lone public transit users 8.3%

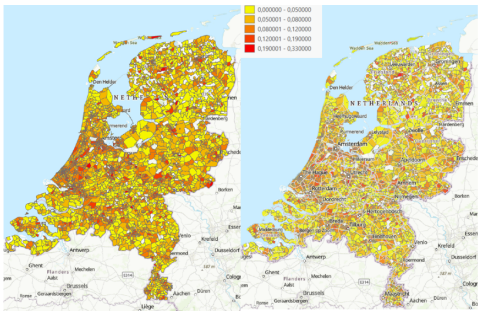
Figure 5.12: Work and education: Long journey classes

As for the work only motive, the characteristics of travellers in the long car travel class as well as in the public transit class are the same as for those in the work-edu motive.

Regarding leisure travel, the long car travel and public transit clusters look similar to the ones in the work motive ones, with a few differences. While it seems to be a lot more rare in general to travel long distances and long times for leisure (as the clusters are overall much smaller than in the work-related motives), the compositions are diametrical opposites. Whereas the long car trip class is characterised by more rural travellers, it is the class with the highest ratio of males, of Dutch people and with the



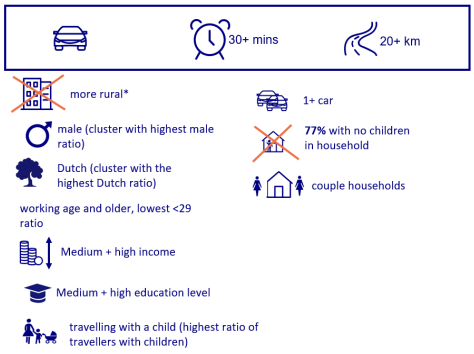
(a) Well situated long car travellers, 14.97%



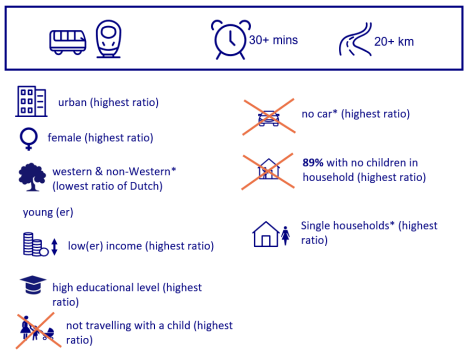
(b) Educated lone public transit users 8.3%

Figure 5.13: Work and education: Long journey classes

lowest ratio of people younger than 29. On the contrary, the public transit class sees the highest ratio of urban dwellers, females and non-Dutch travellers. It consists of rather young travellers and has the highest ratio of single as well as low income households, while also entailing the highest ratio of travellers with high educational level and of people with no car and no children. On the contrary, the car cluster is characterised by people with medium or high income who live with their partners and have at least one car. Whereas the car class has the highest ratio of people travelling with children, the public transit class has the highest ratio of people travelling without children. Spatially, in line with the level of urbanisation trend apparent in the different classes, it becomes obvious that people living in the randstad area have a higher chance of belonging to the long public transit class instead of the long car class. The contrast, however, is less clear than with the aforementioned short trip classes.

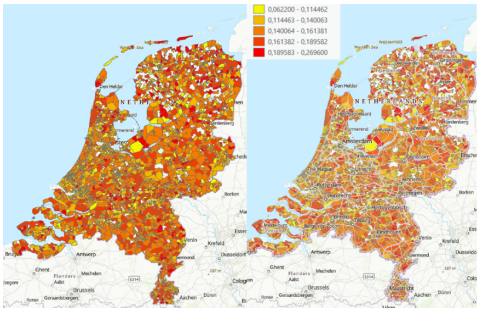


(a) Long car travel, 14.35%

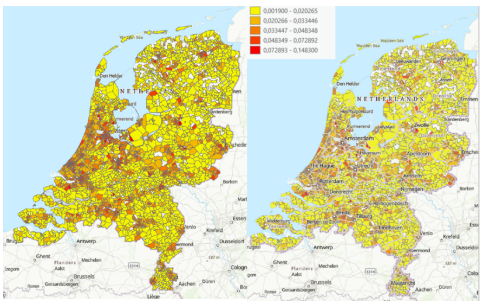


(b) Lone public transit users, 3.16%

Figure 5.14: Leisure: Long journey classes



(a) Long car travel, 14.35%



(b) Lone public transit users, 3.16%

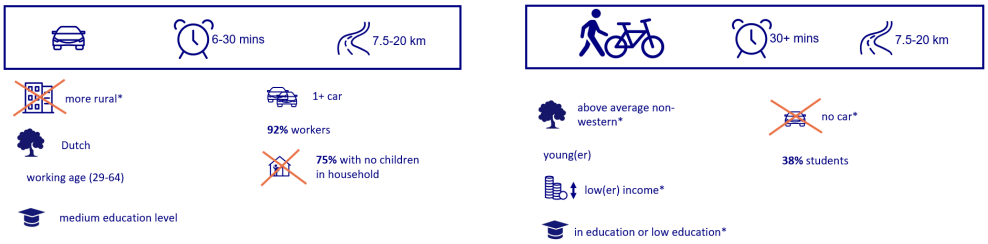
Figure 5.15: Leisure: Long journey classes

Overall it becomes apparent that while urbanisation level and especially whether or not one lives in a city is a positive driver for public transit use, this relationship is less strong for urbanisation level and car

use, especially when it comes to work and education travels. Apart from that, similar sociodemographic trends in the different classes can be observed to the short journey type. Age seems to be a very important driver in travel behaviour, along with gender and also ethnic background. While the effect of educational level seems to be associated with long journeys rather than mode choice specifically, it is high for all long journey classes independent of travel purpose. It seems like high income and favourable sociodemographic characteristics enable (or at least are associated with) car travel for long distances. A similar effect is observed for travelling with children younger than 6 which is a logical finding. As for the sociodemographics' effect, while the effect of income and age might vary over someone's lifetime, given that those classes are also associated with being Dutch and being male, one wonders what about the travellers who are non-Dutch, or those who are women. The above-average representation of males and higher-age and higher-income travellers makes it seem like the high-age, women and high-age non-Dutch travellers do not have a class that really represents them. It could be that these travellers travel less or that their behaviour differs, so that class membership for these travellers is scattered over multiple classes. Either way, this warrants further research.

Medium distance trips

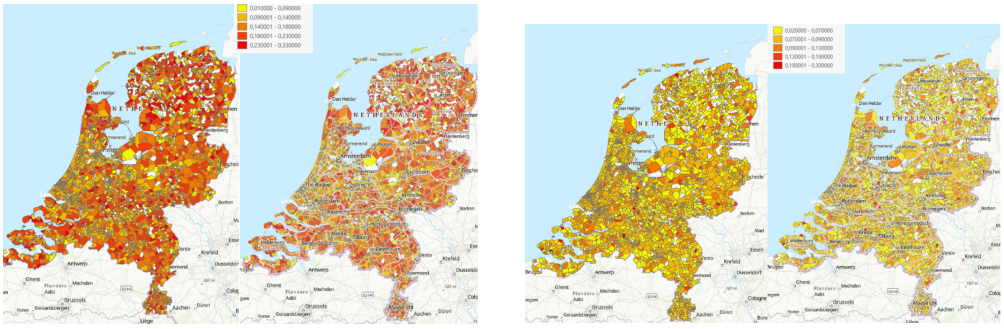
The medium distance trips are characterised by lasting up to 30 minutes and covering up to 20 kilometres journey distance. Regarding the work and education motive, two classes fall into the medium-distance category, namely medium distance car travels (class 3, 14.97%) and the dedicated active travellers (class 6, 8.39%). The former class is characterised by a rather rural traveller environment, it is mostly Dutch people aged 29-64 with medium educational level. People in this class own at least one car and the majority does not have children. The active travellers contrasts with this quite a bit. They are above-average non-Dutch, younger and have lower income and lower educational levels or are still in education. This class has an above-average ratio of people who do not own a car and it is about 40% students. Geographically, this class is present across the country, with a slight increase in the randstad area.



(a) Suburban breadwinner (medium distance car travel), 14.97%

(b) Dedicated active affordable travellers, 8.39%

Figure 5.16: Work and education: Medium distance classes



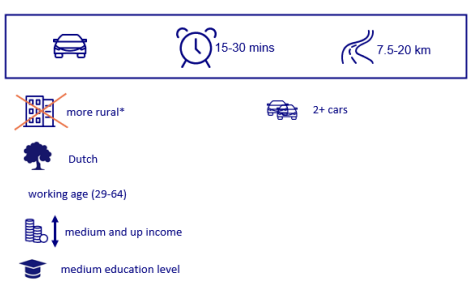
(a) Suburban breadwinner (medium distance car travel), 14.97%

(b) Dedicated active affordable travellers, 8.39%

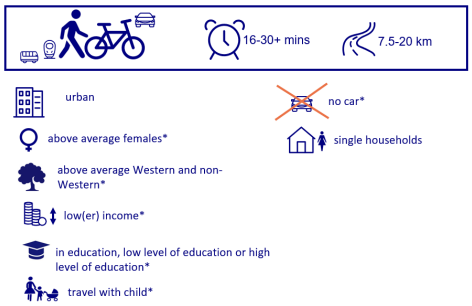
Figure 5.17: Work and education: Medium distance classes

Correcting for the education travels, the work only motive also has the medium distance car travel class as well as the dedicated active travellers. Nonetheless, while the medium car trip class' characteristics

look the same the dedicated active travellers class looks a bit different. The largest difference is that the mode choice is much less clear cut. Whereas the other classes show a rather high (>80%) ratio of people choosing one specific mode, in the work only dedicated active travellers class, the division is 57% active modes, 26% public transit and 14% car. This class is still characterised by a high number of travellers with a non-Dutch ethnic background and travellers with lower income but in the work-only class not only people with a low level of education but also those with a high level of education are present. Travellers in this class also have lower income levels (yet again, they also tend to live in single households) and they are above-average female. Interestingly, they also travel with a child above average. Spatially, while for the work and education dedicated active travellers, there was no effect of urbanisation or geographic location, the work only dedicated active travellers are confined to the urban randstad areas. Also the effect of geographic location seems to be more extreme for work only medium distance car travel (see figure 5.19a).

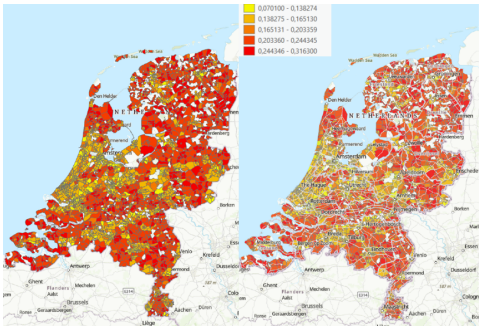


(a) Suburban breadwinner (medium distance car travel), 21.39%

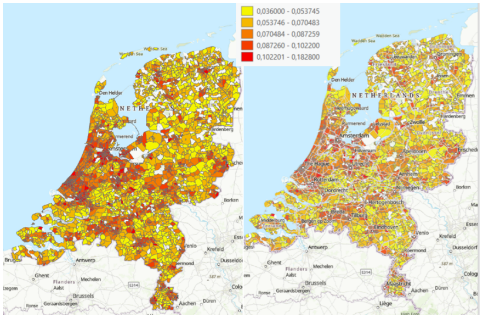


(b) Dedicated active travellers (without alternative), 8.29%

Figure 5.18: Work: Medium distance classes



(a) Work: Suburban breadwinner (medium distance car travel), 21.39%



(b) Dedicated active travellers (without alternative), 8.29%

Figure 5.19: Work: medium distance classes

5.6. Latent Class model with interaction effects

In order to evaluate the effect of combining certain sociodemographics and thus assessing the intersetionality of the different sociodemographic factors, interaction terms for all levels of all sociodemographic variables were created. This was done as all socioeconomic covariates seemed to have had significant influences on the travel behaviour patterns. This resulted in 275 interaction variables. As it would not be meaningful to estimate all interaction effects' impact as covariates on the latent classes, specific, qualitatively motivated interaction terms were included. They were chosen along the previously established axes of disadvantage (see chapter 3):

- gender (female)
- income (low)
- ethnic background (non-Dutch, i.e. Western and non-Western)

- urbanisation level (rural)
- age (old)
- education (low)
- children (yes, travelling with them)
- car (no)

By choosing only combinations that are assumed to result in the most disadvantage, and the most restricted choice behaviour, it is avoided to create and run a model with 275 interaction covariates. The covariate of household constellation was included in the forms of couple and single in combination with income, as that gives most information about the individuals' financial situation. Combinations resulted in 37 interaction terms that were subsequently included in the analysis.

sociodemographics		**resulting interaction term**
education	urbanisation level	low education & rural
education	gender	low education & female
education	ethnic background	low education & Western
education	ethnic background	low education & non-Western
education	income	low education & low income
education	child	low education & travel with child
education	age	low education & old
age	urbanisation level	old & rural
age	gender	old & female
age	ethnic background	old & Western
age	ethnic background	old & non-Western
age	income	old & low income
age	child	old & travel with child
urbanisation level	gender	rural & female
urbanisation level	ethnic background	rural & Western
urbanisation level	ethnic background	rural & non-Western
urbanisation level	income	rural & low income
urbanisation level	child	rural & travel with child
urbanisation level	children in HH	rural & lives with children younger than 12
urbanisation	car	rural & no car in HH
gender	ethnic background	female & Western
gender	ethnic background	female & non-Western
gender	income	female & low income
gender	child	female & travel with child
ethnic background	income	Western & low income
ethnic background	income	non-Western & low income
ethnic background	child	Western & travel with child
ethnic background	child	non-Western & travel with child
income	HH constellation	low income & single
income	HH constellation	low income & couple
income	HH constellation	low income & other
income	children in HH	low income & lives with children younger than 12
income	car	low income & no car
HH constellation	child	single & travel with child
HH constellation	children in HH	single & children in HH
child	car	travel with child & no car
children in HH	car	lives with children younger than 12 & no car

Table 5.7: Interaction terms

The choices for these interaction terms were partly based on similar effects in past analyses, partly on academic literature (see e.g.Lucas, Bates, et al., 2016). Assessing the relevance of the interaction-term covariates, it becomes clear that while some interaction terms are very important for travel be-

haviour choices, namely even more impactful than the base model's covariates, some have a rather low impact. The effect of interaction terms on class membership could be estimated based on the Wald-test. This gives a general overview of the impact the specific covariate has on class membership in that model.Table 5.8 shows the ranking of all covariates, but only the first 20 will be evaluated here. All model details can be found in appendix C.

Covariates, incl. Interactions	**work/edu**	**work**	**leisure**
level of education	1	1	4
age	2	2	5
low income + no car	3	3	6
gender	4	4	12
urbanisation level	5	5	7
income	6	6	1
travel with child	7	37	8
ethnic background	8	11	10
rural + kids in HH	9	17	9
no car + kids in HH	10	10	13
low income + single HH	11	7	2
rural + low education	12	15	32
rural + female	13	13	44
old +rural	14	36	27
no car + rural	15	9	15
rural + travel with child	16	41	41
single + kids in HH	17	18	18
non-western + travel with child	18	33	17
low income + kids in HH	19	19	14
low income + couple HH	20	8	3
low income + travel with child	21	26	**21**
low education + old age	22	23	**20**
female + travel with child	23	40	28
low education + low income	24	21	38
single + travel with child	25	32	**19**
western + old	26	35	29
female + low income	27	**16**	24
low education + female	28	**14**	40
low education + non-Western	29	12	42
female + non-Western	30	27	25
western + low income	31	22	43
rural + western	32	38	22
old_female	33	25	**16**
low education + Western	34	20	30
rural + low income	35	28	39
non-Western + low income	36	30	34
female + Western	37	24	35
travel with child + old	38	29	33
western + travel with child	49	34	36
rural + non-Western	40	42	23
low education + travel with child	41	31	31
no car + travel with child	42	43	26
old + low income	43	44	**11**
old + non-Western	44	39	37

Table 5.8: Ranking of all covariates, incl. interactions

Regarding the interaction terms for work and education related travels, while age and education level are still the most impactful covariates for necessary travels, in the interaction-included latent class

model, income is the most important covariate for leisure related travels. Necessary travels see the interaction term of low income and no car third, while gender, urbanisation level and income are 4-6 most impactful. Second and third most important for leisure travel purposes is the interaction term of low income and a single household as well as low income and a couple household. 4-6 are level of education, age and the interaction term of low income and no car. 7th most relevant for work/education is travelling with a child, whereas it is low income and single household interaction for work and urbanisation level for leisure. Interestingly, when including the interaction terms, travel with child becomes the 37th placed covariate for work, while it is 8th for leisure. Ethnic background is placed 8th for work/education, 11th for work and 10th for leisure. It becomes obvious that the most impactful interaction co-term for work/education travel purposes is level of urbanisation, as six out of 20 covariate terms have rural environment as the co-term. Moreover, income has a large impact as well, seemingly especially in combination with household constellation.
Taking a look at ranks 10-20 for the work only travel purpose interaction terms, it becomes obvious that the interaction terms are mainly made up of indicating rural environment, low income, low education level or female gender.
As for leisure related travels, the ranking of covariates including interaction terms ranked 10-20 looks much different from necessary travels. What becomes apparent is that the impact of income, both as an individual covariate but also as a factor in an interaction is quite influential in TB pattern formation for leisure as low income is present in 6 out of the 20 covariates. What is more, while gender has dropped to the 12th place, travelling with children and living with children is present 6 times in interaction terms.

Overall, the brief interaction analysis highlights interesting points about what an intersectional analysis can add to a quantitative model as well as the limits of the method of LCA. It shows that income dominates as a co-term for leisure, while this is the case for urbanisation level for necessary travels. The individually powerful covariates of age and level of education, do not seem to play a substantial role as co-interaction terms.

5.7. Effect of spatial accessibility vs impact of sociodemographic profiles

In this section, the findings will be compared with the accessibility maps estimated by Bastiaanssen and Breedijk (2022). As the previous section has dealt with evaluating the maps generally, this section will only concern the general statements that can be made regarding spatial accessibility. What becomes apparent from certain classes, e.g. the short car class for work and education as well as leisure, the dedicated active classes for work and education as well as leisure and the long car travel one for all motives is that spatial circumstances do not entirely predict how people can travel. Although the spatial accessibility in the randstad area for all motives (education, work and leisure) was estimated rather good (see Bastiaanssen and Breedijk, 2022), short car trips as well as long car trips were present. The model details regarding short car trips for the work only motive also showed that urbanisation level does not have as strong an effect as it does for the active modes. Nevertheless, what did become obvious is that regarding the active modes (except dedicated long distance) as well as the public transit classes, the observed behaviour resembles the maps estimated in Bastiaanssen and Breedijk (2022). In areas which are socially rather segregated, the maps would show clear location differences when they might actually stem from a specific social structure rather than travel behaviour at that location. Although this can be seen as a limitation of the maps, it also shows where the effect of spatial circumstance might be spurious due to specific sociodemograhic profiles that are over-represented and have specific travel behaviour patterns. Before assuming supremacy of either of the concepts, ore qualitative research into the motivations of these travellers is needed.

5.8. Conclusion

Summary

- both urbanisation factors as well as sociodemographics influence travel behaviour, magnitude of influence differs per group

- interaction effects show main sociodemographic influences per travel purpose, more data is needed for further analysis
- clear travel profiles for work related travels for car can be observed, more diverse picture for leisure present
- more disadvantaged groups seem to use sustainable modes more, travelling with children and higher age are factors contributing to car use
- substitution possibilities given for each travel purpose, car trips are present even when there is no spatial need for it, there, sociodemographics have more explanatory power
- overall, active modes and public transit match accessibility maps by Bastiaanssen and Breedijk, 2022, however, car use in good accessibility areas indicates other important factor

---

Overall, the analysis shows that both sociodemographic factors as well as location factors play a role in determining travel behaviour. Some sociodemographics, namely income level as well as education level showed consistent travel behaviour impacts, while other sociodemographics, such as gender differed in effect, depending to the other sociodemographics appeared with. While for the sustainable-mode classes it becomes apparent that urbanisation level and whether or not one lives in a city/urban environment significantly impact travel mode choices, the car options are not that much associated with geographic location. A notable exception is the work only motive for medium distance classes and the dedicated active travellers for leisure. For the former, geographic location matters for both modes (i.e. active travels are associated with urban areas/randstad and vice versa for car travel) whereas the latter is present across the Netherlands. This, however, means that when assessing how to influence travel behaviour, more attention needs to be paid to specific needs because different factors seem to function as deterrents or as enablers.

In the following chapter, the findings are discussed with experts from the PBL Netherlands Environmental Assessment Agency. Especially classes that make little sense are discussed there and possible reasons for certain travel behaviour are brought forward.

6

Expert input and Policy relevance

The next step of this research required qualitative expert input and revisiting the literature on mobility justice outlined in chapter 3 in order to assess the policy relevance and wider societal relevance of the aforementioned findings. Moreover, the expertise was used to interpret classes meaningfully that seemed contradictory at first.

6.1. Focus group

In order to assess the policy relevance of the findings, experts were consulted to interpret and possibly categorise the findings as relevant in policy contexts. The implicit guiding principle for policy relevance would be if it is relevant for more sustainable transport within the broader setup of the broad welfare goals. The expert input was generated by holding three presentations and Q&A sessions with experts as well as one in-depth focus group workshop. First, the findings were presented to fellow researchers from TU Delft, then they were presented to a panel from the Amsterdam Transport Authority and TU Delft researchers. Subsequently, the findings were presented to the research team of V&M (traffic and mobility) at the PBL Netherlands Environmental Assessment Agency. Lastly, one focus group sessions with 7 researchers from the PBL V&M team was conducted. It will only be reported on the final focus group session as the other presentation and interaction moments mainly helped to guide analysis and research rather than give final expert input. To begin, the researchers were outlined the research problem and objective and were given a short presentation of the methodology applied.

6.1.1. Interpreting travel purpose differences

The first topic that was then discussed with the researchers was the general finding that leisure travel is more active than work related travels. This statement was accompanied by the maps showing the most common class for each of the motives per postcode area (see also chapter 5). The researchers reacted by stating that they were neither surprised by the general finding, nor by the specific regions that were indicated on the maps as car-dominant or active-mode-dominant. They stated that going to work is often associated with trip chaining and that that thus is more easily done by car which explains why the car is most common when it comes to work travels. They hypothesized that for most people that use the car for shorter distances, this is due to the need for trip chaining and ease of doing it by car. Specific reasons for trip chaining given by the researchers were dropping off children at daycare or doing groceries after work. This is arguably a very relevant reason for trip chaining and according to the broad welfare policy aims something people should not be forced to use a car for. Other reasons given for car which fall more under the comfort rather then the need claim is that people are in a hurry when they go to work. When travelling to work, people see the journey to go to work as already part of working, which is generally considered not a fun, leisurely or pleasurable activity. Thus, travellers on their way to work tend to choose the mode which will reduce travel time the most. The researchers also stated that going to sports, 'people are not in such a hurry' (Focus Group interview, researcher 4). While an interesting claim, it cannot be substantiated by literature. If people attend certain sports classes, their time of arrival is similarly fixed as someone's working hours. It seems rather that, people's perception of a leisure-related journey is generally different (Meng et al., 2018). Thus, while the trip to

work is already perceived as taking longer and being less pleasurable, the trip to a leisure activity is perceived as part of leisure.

Furthermore, they discussed that the bike is an important mode when it comes to shorter distances, thereby reciting the general findings in the wider academic field as well as in this research that car is generally mainly used for (i.e. associated with) longer distances. With regards to active modes being more common in leisure related journeys, the researchers state that it would be interesting to exclude 'hiking and touring' from the trip purpose as it was hypothesised that travellers do not drive to these travel purposes. Since the class of dedicated active travellers in leisure is merely 4 percentage points bigger than for the work and the work and education motives, it can be assumed that they do not skew the research result extensively.

Moreover, the researchers were surprised by how little areas have public transit as the most used mode. They stated that this might look different if mapped for destination post code. One researcher, however, pointed out that the findings make sense given that the overall modal split of Dutch travellers to their knowledge is 60% car, 30% active modes and 10% only public transit.

6.1.2. Role of sociodemographics in mode choice

The second topic of the discussion was that the sustainable clusters were mainly associated with sociodemographic factors that are generally thought to be more disadvantaging in society. In order to fuel the discussion, the research team was shown all clusters, grouped as car and sustainable modes with similar sociodemographics marked. The discussion first moved towards the fact that the work travel purpose overall has more clear-cut profiles than the leisure purpose. The researchers argued that this could be due to leisure travels being more diverse in general than work or work and education related travels. A possible reason for that was hypothesised to be routine, whereas with leisure travels one has more possibilities to also choose different modes. This hints at the fact that leisure travel is not as time constrained in terms of time of day. Thus, the researchers concluded that diversity in activities as well as in travel time (of day) possibly leads to higher active mode choices. It needs to be noted that although work related travels *in general* are less ambiguous in terms of their sociodemographic makeup, (see e.g. table D.2 and table D.1). When the latent class models are formed for the separate travel purposes, however, differences between travel purposes are irrelevant because there are three different models, one for each travel purpose. Thus, for example, seeing a more clear-cut profile for car travels with specific sociodemographics for work related travels has nothing to do with a less clear-cut profile for car travels for leisure related travels. The latent class models are formed based on deviations from the general average behaviour and sociodemographics for each travel purpose dataset. If every class had equal shares of a certain sociodemographic, this sociodemographic would not have any explanatory power in the model and it would not have been statistically significant. While it is true that work related travels are on average less diverse, this does not explain that the within-work groups are more clear-cut. If they were essentially all the same, there would not be 8 classes. Rather, it shows that when travelling for work, people are more bound to their routine. This is what one researcher also stated. Nevertheless, they also claimed that leisure travels are less of a routine which is not necessarily true. Many people do sports in clubs which take place at set times and to which one should not be late. Another possible reason put forward by the researchers for more diversity within the sustainable classes was that leisure travels are generally shorter than work related travels. Taking a look at the general distribution as shown in chapter 5, this is indeed true. What's more, another hypothesis brought forward by researcher 2 was that as the type of trip is more diverse with regards to leisure 'going to the sports club, going to meet friends, going to the cinema' (Focus group session, Researcher 2), the travel behaviour is different according to the diversity of types of purposes rather than types of people.

The researchers were puzzled by the class of very short sustainable modes for leisure (nearby activities). While generally sustainable modes for leisure show a more diverse image in terms of sociodemographic make-up, especially the young high income very short distance class confused them. To them, the combinations of sociodemographics that were present in this class did not entirely make sense. This class is characterised by travellers from rural environments, who are Dutch, aged 6-29 have high income but are above-average still in education. After some time, the researchers concluded that these

are probably students who still live at home. The researchers also found especially interesting that the very short sustainable travels group were present in rural areas. This is partly due to the general understanding that the rural environment is mainly associated with higher trip distance, rather than ultra-short ones. Overall, they saw an interesting connection that people living in rural areas tend to either make very short trips with active modes or longer trips by car. Intriguingly, the 6-30 minute active travel class is more often present in urban environments, meaning that in rural environments it is indeed either a within-village very short trip or a longer car ride. The researchers agreed that is was a very interesting and relevant finding especially for policy.

Next, when shown the car clusters for work, they found the clusters especially interesting in terms of policy making as it could be concluded that the parent who works closest to child care probably takes the child on their way to work. They concluded this from the fact that both the very short work car cluster as well as the very short leisure car cluster see an above average ratio of people travelling with children. They stated that it might simply be difficult for people to take children if they go for work and not travel by car. According to the researchers, a more in-depth investigation of what kind of trips are made with children and more research on what the main barriers for people travelling with children are is necessary. It can, however, be hypothesised and related from other research (see e.g. Cain et al., 2022; Kern, 2021) that physically high entrances, too narrow public transit vehicles, limited space during rush hour, possibly less safe and less child-friendly incidents and the likes are reasons for people travelling with car instead of public transit. These barriers are evidently to be considered on top of basic spatial accessibility. Regarding active modes, more thought has to be given to the different trip purposes that might be connected in a trip chain which keep someone from travelling by public transit, as well as the general distance. As in this case, the distances are up to 7.5 kilometres only, this aspect should not be what keeps someone from using a bike. Thus, a necessary policy step in the regard of travelling with children on one's way to work would be to facilitate child care facilities also in rural areas or to make it easier to travel with children by e.g. active modes and not take the car.

Concerning both work and work and education long trips, they stated that the findings are in line with expectations, for example that higher income is associated with longer car work travels. They stated that in line with prior research, three groups can be identified for which it makes sense to travel less by car because they are known to have less access to one. Those groups are people with low income for who it 'makes sense that they do not have a car' (Researcher 4), and these are 'young people, women and non-Westerners'. The researcher went on saying that it does not make sense for women to be but it is still the reality.Presumably they meant that young people might just be starting out in the workplace or still be in education, so it makes sense that they have little income and no car. For people with a migrant background, it 'makes sense' that they have lower income because they might face difficulties in the job market with language barriers, they might not have an established Dutch social network to support in questions around education or the job market or they might have come to the Netherlands for a job that just does not pay as much in comparison to other jobs. It needs to be stated that the researcher did not imply that it made sense for people having a non-Western background to have low income and that this was good but they presumably meant that it is established knowledge that there is a high correlation between people with a non-Western ethnic background and lower income levels. When stating that it 'does not make sense for women, but it is the reality', the researcher meant that apart from women historically having been disadvantaged in comparison to men, there are no logical reasons for them to have lower income levels and/or less access to a car. One researcher also stated that 'if we want more sustainable travels, we definitely need the females' (Researcher 2), alluding to the fact that females are over-represented in most of the more sustainable travel classes, that is they are above-average in both active work and work and education classes, as well as in the dedicated active travellers work related motive class and in all public transit classes. This is, however, not related to the fact that women tend to be more mindful and sustainable by nature but that they still take up roles in the household that put them in a position of being less mobile and travelling closer to home (see e.g. Schwanen et al., 2004). Taking a look at basic cross-tabulations of distances travelled by men and women for work, it becomes apparent that men travel much longer distances more often and women travel ultra-short and short distances more often (see Appendix A). Another researcher also stated that 'in the lower income households, if you can only have one car, statistically it is usually the man who takes the car'. Taking into account that these roles are slowly but steadily overcome in the

Netherlands, and given that those who have a free transport choice seem not to choose to travel short or medium distances by active modes or the long distances by public transit,it seems like the car will be used increasingly more.

6.1.3. Interpreting substitution opportunities

After discussing with the research team which sociodemographic relations with travel behaviour patterns they found most interesting, the third topic that was discussed was that of possible substitution opportunities, given by similar journey characteristics and yet different mode choice. The team was again shown the profiles of the travel behaviour groups in combination with the respective maps showing where these profiles are most common. This time, however, the team was presented the different profiles with similar journey types simultaneously. After a first glance, the team commented that income and car ownership are important predictors of car travel even for the same distance and travel times. They stated that although a car should not be a deterrent to using active modes, it seems that once someone owns a car, they intend to use it. This became apparent as one of the clear differences of these classes are that people in the car cluster own a car. thus, even for the shortest distance and travel time journeys across all travel purposes, the profile that used car had at least 1 but mostly 2 or more cars in the household. Researcher 2 described this as 'having a car is not a limitation on using active modes' but also stated that it looks as if that was the case.

Another clear factor connected to using car when alternatives could be available was travelling with a child. Researcher 2 reacted by stating that it should not be impossible to travel with a child and without a car. They also stated, however, that many people think it indeed is impossible to travel with children without a car and that having a car is necessary when having children. This is in line with previous research stating that people who do not use other modes than car generally overestimate these modes' travel times and effort (see e.g. Molin et al., 2016). Again, what seemed clear is that travelling with children without a car needs to be facilitated more.

Furthermore, another factor that was picked up by the researchers is the in-parts clear spatial pattern. They, however, also stated that it also alludes to the fact that the car-culture in rural areas is different from cities. They said that car use is still a very cultural issue.Thus, car use can be seen as more than just a mode but a 'way of life', leading people to use the car for other reasons than necessity or comfort but because that is just what you do. Not going by car might be seen as cheap or weird in certain areas. According to the researchers, this is generally in line with the fact that most people in these areas have medium education level which was also found in this research. Thus, the researchers concluded that the general finding of car use also when there does not seem to be a reason for it was due to strong car travel cultures present. According to the researchers, these different travel cultures can be said to be confined to specific areas (e.g. Randstad vs non-randstadt area) but also to broader cultural background, which can be inferred from car travels being associated with above-average ratios of people with a Dutch ethnic background.

As for substitution possibilities with regards to leisure travels, the researchers stated that the profiles are difficult to assess due to the diversity of leisure travels. They assume that the journeys in the car class differ substantially from the journeys in the active classes. In line with their expectations, however, they found that travellers with high income and medium education are rather car oriented while high income and high education travellers are less car oriented. Medium education travellers are assumed to be part of a specific social class, people that are more the 'hard working type' and also more confined to the suburban landscapes rather than the city centres. Interestingly, this is in line with findings from Schwanen et al. from roughly two decades ago (2004) who stated that a certain kind of people moved outside the cities and preferred travelling by car rather than live where they work. These findings in combination with these sociodemographics are a strong argument for residential self selection in these specific areas and for these specific travel behaviour profiles.

Regarding the medium distance trips, the researchers were puzzled by the effect of ethnicity which is persistent across all travel purposes for the dedicated active travellers class. They stated that from what they know and generally from what the academic literature offers on the topic, there is a correla-

tion between people with a non-Dutch ethnic background and low income and overall lower levels of mobility. Hence, it was rather surprising for the research team to see that the dedicated active travellers classes for necessary travels entail above average ratios of travellers who are non-Dutch and have low income levels and yet travel distances of more than 7.5 kilometres. This finding indeed goes against the general understanding that the radius of participation away from their home base for people with low income is much smaller than for people with higher income levels. Thus, against expectations this research shows that there are indeed a class of 8% of Dutch travellers for necessary travel who travel long distances by active modes. Revisiting the class composition for leisure travel, it becomes obvious that the dedicated active class is correlated with higher income for this travel purpose, thereby not fitting the type referred to by the researchers.

A last finding was that the research team found interesting is that in cases in which a household had more than one car, the effect of gender was lacking. Thus, the short and medium car classes across all analysed travel purposes, for example, are all characterised by more than 1 (for work and leisure even more than 2) car and an average distribution between the genders. This hints at the aforementioned fact that while females in certain situations are more constrained in their choices, they equally contribute to taking the car if they can.

Overall, the assessment of the classes together with the research team was very fruitful. Regarding usefulness for policy making and research, the team stated that for certain groups they would need more detailed information on what people were doing exactly, e.g. with regards to leisure travels or in cases in which subgroups can be assumed to exist. With regards to input for further research from the research team, this included to run the analyses again separately for only urban or only rural people. As this would result in twice the amount of models to be analysed, this would be beyond the scope of this study. Moreover, another input was to identify the areas where people were more homogeneous in terms of sociodemographic factors. Another point was to look at different levels of sociodemographic factors and how those are divided over the different travel groups. As these points were also beyond the scope of this research, they are taken up as interesting avenues for future research.

6.2. Policy relevance

Regarding the question to what extent the findings *should* be relevant to policy making from a general equity related standpoint, they need to be assessed with regards to the theories outlined in chapter 3. Generally, as was stated there, any limiting effect of arbitrary characteristics on one's behaviour is not reasoned rationally and should hence be regarded. Given this rather broad definition of what should count as relevant from an ethical perspective, any of the effects of those factors that were outlined as socially disadvantaged matter. What makes the findings so much more pertinent, however, are that the profiles are seldom showing only one of the factors that are considered as disadvantaging. For example, investigating the active 15 minute work class, which in itself is desirable from a policy point of view, one is confronted with above average low income, young, low education females who live in an urban environment and tend to live by themselves but also have only up to one car. While other subgroups can also be identified (i.e. the high income, high education people), this particular combination of disadvantaged sociodemographics is very relevant and should be alarming with regards to the established knowledge on transport related social exclusion, transport poverty and transport related issues with employment (see e.g. Bastiaanssen et al., 2020; Lucas et al., 2009; Chowdhury and Van Wee, 2020; Bersch and Osswald, 2021). Considering, that a majority of travellers in this class combine all the disadvantaging factors, it seems like these profiles are rather vulnerable. From a policy perspective, this is also relevant because it shows that in contrast with the people who choose not to travel by active modes, who show profiles of the more advantaged factors (i.e. high education, working age and up, above average Dutch, higher education) and who thus seem to have more economic freedom to choose how to travel, they choose not to travel by the more sustainable modes. Another dimension of this, however, is the factor of need within those advantaged people, as those people also travel above-average with a young child. During the focus group session with the experts, this seemed to be the most relevant finding in terms of policy relevance for them. Most of the other findings were either regarded as not surprising or as not necessarily concrete enough to formulate policy objectives.

6.3. Conclusion

To conclude, this chapter presented the results that were obtained from the focus group workshop as well as a subsequent analysis in terms of policy relevance. As the previous interaction moments with researchers and experts merely functioned to guide further analysis, they were not listed in this chapter. Main findings from the workshop include that according to the PBL V&M research team, the choice to travel by car is more associated with work related travels due to the routine and the specific time-association that comes with it. Further, it was stated that someone travelling to work could also further trip chain after work, thus already planning ahead and taking the car on the journey to work. Generally, it also became apparent that travelling with children is associated with car travel, as is high income and car ownership. Women seem to be less problematic in their car usage, but that is probably because they are the ones without access to a car, not because it is a conscious choice not to travel by car. Interestingly, medium education classes which are more present in the outskirts and more suburban parts of the Netherlands seem to be associated which car travels for cultural rather than 'needs' reasons, hence alluding to possible residential self-selection. Additionally, ethnicity had a clear effect on all motives with regards to medium distance travels, which puzzled the researchers. Although this effect is rather moderate in magnitude, it had a statistically significant effect. The discussion also did not lead to a conclusion on this finding. For many of the findings, however, a result was that the classes need to be assessed more in-depth to be able to draw more concrete conclusions from them for policy.

Summary

- car and work travels are associated possibly because of the routine and strict time it comes with
- policy making should enable people with children to take their children and drop them off at day-care without having the need to take a car
- women as well as people with a non-Western ethnic backgroustill belong to the group that traditionally does not have as easy access to a car and are thus 'overrepresented' in the sustainable modes classes
- income and car ownership are among the predictors for using car even though accessibility by other modes is also sufficient
- residential self-selection and a culture of car-driving are reasons for the medium-education people to be overrepresented in the medium-distance car class according to the experts

In the final section, the findings from the LCA as well as from the expert group sessions will be interpreted and related to the academic literature. Moreover, recommendations for policy as well as public transit operators will be formulated and avenues for future research are outlined.

7

Discussion and Conclusion

In this chapter, the findings from this research are interpreted, discussed and contextualised in light of the state of the art research. Moreover, limitations are outlined as well as recommendations for policy and ideas for further research are given. Finally, a general conclusion is presented.

7.1. Discussion

In this section the findings will be interpreted and related to the academic literature. Generally, the findings can be divided into two main strands - empirical findings regarding the effects of sociodemographics on TB and policy implications thereof and more methodological/conceptual findings regarding the methodology applied and its consequences thereof.

7.1.1. Empirical findings

As for the empirical findings, the initial hypothesis was that the socially disadvantaged (see chapter 3) would show different TB than less disadvantaged groups. Moreover, the expectation was that policy makers would find it relevant and alarming if TB was indeed found to be restricted by arbitrary sociodemographic factors. An initial question was also to what extent car travel can be said to be the result of mere ignorance (i.e. out of comfort) or need and how that can be dealt with from a policy side. Concerning the anticipated differences in TB, some sociodemographics (e.g. income, children, car availability) came with clear expectations as to how they would influence TB, while factors such as gender, age and ethnic background were less clear. To recall, some research stated that since women and men still take on different roles in society, and women tend to take care of children, their TB is different in that they use more active modes and have a smaller travel distance. In contrast, other research claimed that for the same reason, women use the car more as they have to combine household tasks with paid labour. Similarly, regarding age it was hypothesised that young people use active modes more while other research indicated the opposite. Clear expectations, as for example for the effect of income were that people with low income have a smaller travel radius, also connected to the fact that access to a car is limited. This section will relate relevant findings with regards to sociodemographics and specifically the axes of disadvantage to the statements from the academic literature.

The most interesting overall finding was that across all analysed travel purposes, specific, rather clear-cut TB patterns could be identified. Also, for each travel purpose, similar classes were identified. Interestingly, roughly for each travel distance there have been two classes, but with different modes and slightly different travel durations. Those classes were assessed in more detail in the substitution analysis as there was substantial overlap of journey types with the same travel distance and time. Generally, regarding specific mode choice patterns, while the classes for sustainable mode choice for leisure were less clear cut, the car classes showed rather similar compositions. Hence, the sociodemographic makeup of these allows for more in-depth understanding for the reasons behind certain TB patterns. Concerning car use, this thesis for example successfully shed light on the multiple different reasons and ways of car travel. Against expectations and reasons brought forward by scholars (Schwa-

nen et al., 2004; Molin et al., 2016; Handy, Cao, et al., 2005) the findings in this research showed that the car is not only used for longer distances and hence a reaction to low accessibility due to spatial disadvantages. Instead, the car is also used in areas with good accessibility by other modes. It is, however, used for different journey types and by specific people. This means that while in areas with low spatial accessibility by public transit or biking there is indeed high car dependency, in areas with high accessibility of other modes, the car is still used by people whose sociodemographics limit their capacity to use these modes (e.g. travelling with a child younger than six and thus possibly travelling with a stroller, being of old age and thus limited in your physical mobility) as well as by people who can afford to travel by car. The strong association of all car clusters with higher incomes leaves one to wonder how (and if) people travel who cannot use the car because they do not have access to one but are limited in their mobility (i.e. travel with a child).

Four mode choice profiles
Throughout all research steps and analyses, four mode choice profiles surfaced. First, those that seem to choose active modes because it is feasible (e.g. the ultra-short active mode class (nearby activities) that is also present in rural areas), second, those that choose active modes possibly for reasons of no other choice (e.g. low income groups, women, younger people (urban affordable active 15-minute travelers)) and third, those that choose the car because it is more convenient (e.g. high income, already own a car), and fourth, those that need to use the car because travels are otherwise hardly feasible (e.g. people travelling with young children).

Effect of axes of disadvantage
Regarding the axes of disadvantage, the previous assumption was that people with disadvantages on all of the axes show a substantially different TB than people who are merely disadvantaged on one or two of them (Bersch and Osswald, 2021; Cain et al., 2022; Kern, 2021; Martens et al., 2019; Martens and Bastiaanssen, 2019). This thesis confirms this expectation, especially in terms of mode choice. Specifically, the public transit class across all travel purposes had the same sociodemographic predictor factors and combined most disadvantaging factors identified previously (i.e. travellers are young, non-Dutch women with low income) which demonstrated that people who travel by public transit seem to do so not only for specific purposes. Similarly, the dedicated active travellers also ticked many of the disadvantage boxes (non-Dutch, young, lower education, tendency to rather low income), but they also tended to travel with a young child, at least for leisure related travels. As this class showed interesting sociodemographic compositions depending on the travel purpose, it will be assessed separately below.

As for the effect of gender, the literature study showed conflicting results in terms of gender, or rather in terms of how women travel. One the one hand, there was the qualitatively backed research that claimed that women and/or people with a non-Dutch ethnic background tend to prefer to travel by these modes less because these modes signify spaces of possible unpleasant encounters (Chowdhury and Van Wee, 2020; Cain et al., 2022; Joshi and Bailey, 2023; Kern, 2021). This would indicate that the need to travel somewhere is stronger than their preference not to travel by e.g. public transit which is contrary to what was expected. Other research (e.g. by Kroesen, 2019a) indicated that women do travel by active modes, which was partly confirmed in this research. However, what was significantly added and what is slightly contrary to the finding of Kroesen (2019a) is the context of who those women are. Positive association of female gender with active-travel class membership was almost always coupled with positive associations with low income, with low education levels, a migrant background and often with low levels of car ownership. As outlined above, these travellers are at higher risk of transport poverty. Contrary to this, the research by Schwanen et al. (2004) had indicated that women would have to travel by car more often if they do work and have access to a car because that is necessary to be able to combine paid labour with household tasks. The findings in this research confirmed that once women have access to a car (i.e. more than 1 car in household) they will use it in a similar manner as males (except for the long-distance car travel which seems to be a very male activity for all analysed travel purposes).

Education level showed to be the most influential covariate across the three estimated latent class models. With regards to necessary travels, high education levels are associated with long car travel

but also with long public transit travels. Low or basic education levels were strongly associated with shorter active travels but also with short car trips, hence indicating that higher education level is associated with longer travel distances and travel times for work. A similar picture becomes apparent for the work and education model, only the effect of people in education on the very short active travel is larger. Moreover, for both necessary travels classes, medium education is positively associated with medium distance car travel.For leisure travels, it is a similar picture, with high education levels being associated with the long travel classes, long car and lone public transit. It can therefore be concluded that high education levels are associated with longer travel but irrespective of mode choice, while low education levels seem to be bound to active, and specifically short trips. This indicates that the travel radius of someone with lower education levels is more limited than for someone with higher education levels. With regards to the effect of medium education, the experts in the focus group workshop helped shed light on the possible car-culture that is present in the suburban areas of the Netherlands.

Concerning the differences in mode choice when travel time and distance were overlapped substantially, the substitution analysis helped to shed light on TB of people with similar accessibility levels in terms of travel distance and time. It showed that there are indeed classes of people who travel further distances by sustainable modes. This was a rather unexpected finding that also surprised the experts in the focus group. Nevertheless, the classes that cover longer distances by other modes than car and are more represented by travellers with a more disadvantaged sociodemographic profile are also substantially smaller. More research would be needed on the satisfaction of people in the active modes class and whether their current destination is also the one they want to reach. Moreover, investigating both departure as well as destination of travels would give an indication as to whether those choices are restricted by spatial circumstances of the destination as was suggested by one of the experts consulted in the focus group.

In general, it is interesting to see that similar TB patterns can be identified for leisure and necessary travel purposes, yet the sociodemographics that contribute to the formation of these patterns have different ranking of importance. While for all travel purposes, education is the most relevant factor, for leisure travels income and travelling with a child is more relevant (especially in statistical terms) than for necessary travels, while gender is more important for work related travels. Ethnic background is least relevant, albeit still being statistically significant. This effect also became apparent in the brief interaction effect analysis. This showed that when it comes to leisure travel, income is very restrictive as it seems to limit people's ability to travel the way they want to. This puts low income groups at risk of social exclusion (see Lucas, 2012). Also, travelling with a child impacts how people can spend their leisure activities. It seems that the car is essential when travelling with a child for leisure. In the interaction effect analysis, travelling with a child was not a very prominent co-effect. It was present in the 'top 20' covariates only as a co-term with being a single parent and being non-Western (the 19th and 20th placed covariates) while travelling with a child was placed 8th most influential. It thus seems to be more important in and of itself, and not necessarily in combination with other terms.

Sociodemographic explanatory value above spatial circumstances

Yet, for other classes, spatial circumstances play a bigger role than their sociodemographics. These findings seem to indicate that spatial circumstances impact different travel groups differently. And that TB results from an interplay between sociodemographics, spatial circumstances and travel purpose. It can thus be concluded that for some people, spatial factors seem to be the first thing they consider when travelling somewhere, as there is not much else to consider for them. Other travellers, however, specifically travellers with lower income, lower levels of education, female travellers and people with a non-Dutch ethnic background have additional considerations when it comes to daily mobility. This was confirmed by the presence of multiple clusters across the Netherlands, irrespective of urbanisation level or with a comparatively slight effect only. This was the case for clusters of short car travel for work and education as well as leisure, dedicated active travel for work and education as well as leisure and long car travel for all groups. In those cases it seems obvious that it is not restricted spatial accessibility levels by public transit or active modes that cause this choice but rather the other sociodemographic factors. In other cases, however, such as for the public transit class, it becomes obvious that urbanisation and specifically living in the Randstad area plays a role in mode choice. Across all travel purposes,

the public transit TB profile was only present in the most urban regions. Regarding the other cases, namely the car trips that are present in those areas with assumed high spatial accessibility by public transit or active modes (specifically for the short distance ones), a more in-depth assessment is crucial. Apart from the fact that travellers tend to travel with a child above average in those car trips, the other sociodemographics of that profile indicate that the mode choice is motivated by convenience and comfort rather than need. As also stated by the experts in the focus group session and also in line with the academic literature, the presence of a car and the convenience of taking it seems to trigger the use of it. Moreover, their statements and the findings with regards to medium education non-urban car travellers strongly support the argument for residential self-selection. While according to some research into excess driving, driving due to convenience and 'culture' leads to longer distances being driven by car (Handy, Weston, et al., 2005), this research shows that the car will be used across all distances, as long as there are at least two cars in the household. Further research is needed to assess if there is a connection between trips made by people with a young child and the other trips made without a child. Specifically, it is interesting to investigate whether these are the same people, who then travel without a child or if these are two entirely different groups, i.e. comfort car travellers and couldn't-cope-without-a-car travellers. If the former were true, and people made the conscious choice to buy a car because they have children or enter a certain life stage, but then keep on using it because it is available, policy efforts must be undertaken to counter that development.

Life Stage Association

Associated with the above point is another interesting finding of a general possible association of certain live-stages with specific TB patterns. It seems that young people travel, for instance, to their jobs differently than people in the age of 30 and up do. This shift in especially mode choice may coincide with settling down, and making the decision to get a car. This theory is also underpinned by research by Kroesen (2014). Also linked to the aforementioned point, once that transition has happened, they will be more likely to use car even though they might not necessarily need it just because it is convenient. It would be interesting to investigate what exactly it is that triggers the decision to buy a car. Are reasons status and ability to afford one or rather the need due to starting a family. Likewise, the amount of leased cars from work that lead to this TB would also be relevant to know for policy. If the amount of cars that are leased via work is substantial and thus possibly causing excess driving behaviour, policy makers should try and interfere by for example introducing regulation that requires employers to offer deals for other modes of transport, beyond car travels. What's more, policy efforts could aim at subsidising other, more sustainable, modes. More recommendations will be outlined below. Regarding the general finding of life stage association with certain TB, research shows (e.g. Muromachi, 2017) that students are more likely to buy a car if they have experienced travels with other modes (especially public transit) negatively while they did not have a choice (i.e. while growing up). Coupling this information with results reviewed by Molin et al. (2016)in chapter 3 that young people with low income use public transit and yet have a negative attitude towards it, leads to the conclusion that these travellers will switch and become car travellers once they can.

Somewhat unexpected regarding the effect of age on TB was the finding that people in the oldest age group did not show substantially different TB than people in the working age group for leisure travels. Only with regards to necessary travels in the very short active classes and with regards to the very short car travel classes did the oldest age group stand out as most likely to be in this class. In the long car travel class for necessary travels, the oldest age group was least likely to be part of. This indicates that for people in the oldest age group who work, their TB patterns change with regards to distance and travel time rather than mode choice. For leisure, however, the oldest traveller group was least likely to be in the very short active travel group, while being in this group was (slightly) positively associated with both the youngest and the working age groups. Moreover, the very short car travel was negatively associated with older age and young age while it was positively associated with working age. This indicates that for leisure travels, again, travel time and distance are more relevant for older people. But the effect seems reverse to necessary travels, indicating that older people tend to travel longer for leisure purposes. This makes sense given that they have more time on their hands if they are in retirement and that they might not be bound to tight social schedules that necessitate planning leisure activities in a smaller radius. With regards to transport policy, it becomes apparent that the oldest

age group is most likely to be in the car medium distance, car long distance class as well as in the dedicated active travellers class. It thus seems irrelevant for this *age* group what mode to choose, but other sociodemographics (such as urbanisation level, income, whether or not they travel with a child) are more relevant for that decision.

Leisure purpose more active TB
Another one of the more expected findings was that for leisure travels the choice for more sustainable modes was more common. Although the overall distances and travel times for leisure are shorter, which makes the choice for active modes easier, the same journey classes (e.g. active 15-minute travels) are bigger in leisure than in any of the other travel purposes investigated. This is especially interesting, given that most sociodemographics had an overall smaller effect on leisure travels than on work or work and education related travels. This is generally in line with the literature (e.g. Schwanen et al., 2004). Possible reasons for these findings are the sheer diversity of leisure travels, the unboundedness with regards to time of travel and possibly also the generally more enjoyable reason to travel which was also a conclusion of the focus group sessions. Similarly, a findings is that leisure travels see a generally smaller impact of sociodemographics on class membership in terms of statistical magnitude. Also, some of the active modes classes have higher income shares for leisure travel purpose than for the work (and education) related travel purpose. This finding can be interpreted as meaning that the car cannot be said to be an entirely free choice for everyone but it seems to be something only a certain travel group needs and can afford.

Most unexpected class
The overall most interesting class was the class of dedicated active travellers. Across all travel purposes, the only sociodemographic factor they all share is that travellers are above-average non-Dutch. Also, the travel duration for all purposes is between 16-30 minutes and longer than 45 minutes while the distance covered is around 7.5-20 kilometres. The results of non-Dutch ethnicity being associated with longer distance active travel is not in line with the literature and went against the expectations of the experts in the focus group. To recall, in the work and education model, these travellers are present across all urbanisation levels, have an average gender divide, are younger than average, are present on average across all income classes, have a high number of travellers in education or with no or low education (the highest ratio of all work/education classes), do not travel with children, 63% of travels are for work purpose, a quarter of people in this class do not own a car and people tend not to live with children. From this sociodemographic makeup this class could be interpreted mainly as young people possibly with the time and physical ability to travel actively. There does not seem to be much more to this class than that. In the model for work travel purpose, these people live in urban environments, tend to have lower income levels, have the highest in-education ratio of all work-purpose classes (yet, it is only 4%, the majority has high education), do not have a car, and do not live with dependent children. For this class it can be interpreted again as people who choose to be active (given the high education level and the urban child-free context or people who are just starting out in their jobs and do not have (the need to have) a car yet. Nevertheless, it could also be people with low income and hence the inability to afford a car. As also criticised in the focus group, this class makes it seem like there are subgroups and that there is the need for more research to identify what exactly are the triggers for people to travel longer distances (7.5-20km) for work by active modes. In the leisure purpose travel class, however, the dedicated active travellers are older than 65 above average or in working age, are the only class where more people have a medium income than high income, have average education levels, average gender composition, average urbanisation composition, have a slightly above-average chance of travelling with a child as well as having fewer cars than average and do not live with children. This class' characteristics thus again make it seem like travelling actively for longer distances is a choice possibly due to the availability of more time. Or that it is triggered by not having a car available but with regards to this being a leisure travel class, it would be more likely then that people do not even make the journey and rather stay home. Thus, the findings of the leisure travel purpose indicate that the findings of the work as well as work and education classes of few cars are part of an active choice not to have a car and to travel by other modes instead. However, as this is all rather speculative, more in-depth research on this specific travel profile is needed to confirm or falsify these interpretations. Likewise, the focus group interpreted this class as including the practice of hiking. It is unclear to what extent this might skew these results, hence more research is necessary.

7.2. Can one speak of restricted/altered accessibility?

Evaluating the findings of this study with regards to ethical relevance in terms of accessibility is a challenging task. An observation was that those groups that would traditionally be considered disadvantaged in society (non-Dutch, women, low income, lower levels of education) travel by sustainable modes more frequently, and not necessarily out of free choice. This is inferred from the clear association of above average values of those categories that are considered advantaged (or privileged) in society (i.e. men, Dutch, working age, high education levels) with the car-clusters. The spatial dimension of urbanisation level showed the expected strong association of very urbanised areas with public transit and further-distance active travels. But a less strong association between car travels and rural areas was found.

The former finding underlines that income, low education and non-Dutch women do not necessarily freely choose to travel by active modes or public transit but do so because they have no or difficult access to a car, which signifies limited accessibility in terms of modal disadvantage. If coupled with spatial disadvantage, they might suffer from transport poverty. Generally, the connection of more disadvantaged groups using the more sustainable (and also more affordable) options is due to the fact that owning a car is more expensive. In addition, the disadvantaging factors of lower education levels but also of non-Dutch ethnicity are also strongly associated with lower income (see e.g. Bastiaanssen et al., 2020, Lucas, 2012). The changing effect of gender when household income is higher was explained during the focus group session. It was hypothesised that if there is only one car in the household which is the case in medium to low income households, this one car is usually used by the male of the house. Once there is more than one car available, which correlates with higher household income, the effect of gender is gone, and both genders make use of the car. Nevertheless,the effect of certain sociodemographics on specific mode choice especially for work related travels is convincing enough to speak of restricted choices rather than mere preference. This general finding of statistically significant associations of certain sociodemographics with specific modes is generally in line with the academic literature.

Referring to the theories of equity reviewed in chapter 3, while the choice of socially disadvantaged travellers to go by sustainable modes is desirable from a sustainable transport policy perspective, it is not from a transport justice perspective. As long as those travellers can reach their desired destinations it can be argued to be irrelevant that these travellers did not have the choice to go by car. What really is a problem from a transport justice perspective, however, is the people that choose the car for mere preferential reason (i.e because they get to have a choice due to good education, good income and/or the convenience to do so). These should be limited in their car use. Not only do they use it without the need to but also does it put non-car travellers at higher safety and environmental risks. As these non-car travellers potentially did not have the choice to go by another mode than foot/bike, there is a major source of injustice to be identified (see e.g. Pereira et al., 2017). Even though there might not be an accessibility issue for those people who cannot choose the car but happen to live in urban areas, the fact that they are exposed to the risks of car users without actively choosing to do so is problematic. Therefore, the aim of policy makers should be to redistribute travel options, e.g. by taxing specific, more advantaged groups. In order to confirm this interpretation, however, more in-depth research on the identified and possibly disadvantaged classes is necessary. Moreover, it would go beyond the scope of this research to make a definite claim about the ethical issue with people not having the choice to go by car who are nevertheless subsequently exposed to risks of other car drivers. Hence, an in-depth ethical assessment of this is necessary.

7.3. Methodological implications

Applying LCA on different datasets filtered on travel purposes of leisure, work and work and education and subsequently visualising these findings in the context of the Netherlands proved very useful in interpreting and understanding TB patterns more in-depth. Due to the emergent nature of the clusters, a true data-driven presentation of TB classes could be achieved. The rather explorative nature of the research, however, limits conclusions to be drawn about detailed sub-groups. As the maximum amount of classes to be estimated and meaningfully interpreted is 10, and it is common not to choose a model that includes classes sized smaller than 5% of the sample, only 8 (or in the case of leisure 7) classes were distinguished. In a more detailed analysis, it would be interesting to investigate more in-depth

what specific sub-groups' realities look like. Nonetheless, this research succeeded in showing that the spatial context as well as the sociodemographic context are differently relevant for different groups and travel purposes and that not one overarching general aspect can be said to be most influential to all people's TB. It should thus be concluded that, from a methodological point of view, the application of LCA has proven beneficial in that it allows for more holistic interpretation of people's TB and therefore enables drawing more concrete and directed policy recommendations. It thereby added on work done by Schwanen et al. (2004) and also filled gaps posited by Kroesen (2014) or Molin et al. (2016).

7.4. Limitations

In this section, it will be briefly reflected on the scientific limitations of this research. The limitations will regard internal validity, thereby assessing to what extent the measurement and model itself could be faulty as well as external validity. The latter concerns wider applicability of this research and to what extent the findings are limited in their generalisability beyond the scope of this research.

7.4.1. Internal Validity

As the course of this analysis required working with data from two different datasets which stem from same source (ODIN 2018 and ODIN 2019), there is the risk of labelling errors. As outlined in the section about data preparation, several comparative analyses were conducted to ensure internal validity of those analysis steps that require merging the two different datasets. As the data of ODIN 2018 and 2019 is cross-sectional data, limitations apply with regard to the comparison of age groups that were made. While it is logical to assume comparability of TB of currently younger age groups with currently older age groups, no linearity between those can be assumed with certainty. It could be that the currently younger age groups will all never transition to using the car for similar journeys, in the same way as those older age groups could also have been using the car already when they were still younger. Assumptions in how the age groups will develop hence need to be treated with caution.

7.4.2. External validity

Regarding the external validity of the conclusions drawn in this research, due to it being based on a national-scale dataset it aims at being generalisable to the general Dutch population. Due to the spatial as well as socio-cultural dimensions of TB, the findings only apply to other nationalities in a limited manner. Nevertheless, certain limitations also regarding conclusions for the Dutch population can be identified.

Sampling and weighing

Regarding the fact that this research is based on a sample, it can be stated that the weighing process diminishes the general external validity. Due to certain responses being multiplied, the extent to which analyses have a meaningful outcome for certain individual characteristics decreases. Also, the findings should be interpreted conceptually and specific statements are valid in relation to one another rather than taken out of context.

Dated sample

In order to avoid possible impact of Covid-19 on the used travel data, the combined sample from the pre-Covid years 2018 and 2019 was used in this analysis. Hence, the analysed data is at least 4 years old. Some of the changes in TB during Covid-19 might turn out as a constant change. Nevertheless, it was decided that the risk was too high that data from 2021 included temporarily changed TB and thus analysing this data would not have been representative of the general Dutch resident's TB.

Latent Class Analysis

It must be noted that the class formation in LCA is probabilistic rather than deterministic. While that is often praised as an advantage of the methodology, it can lead to misinterpretations of clusters. One thus needs to be cautious to interpret the different class characteristics as set or even as connected. It seems intuitive to e.g. interpret a class that entails people who travel with children and also entails people who live with children, as a class of people live *and* travel with children, however, that is not necessarily the case. The model groups travellers with similar characteristics, and if one group is represented in the class with 80% and another group is present in that class with 50% that could still

mean that only the overlap of 30% of travellers in this class actually have both characteristics. Hence, the LCA model output always has to be interpreted carefully, which is partly why experts were consulted to also get their opinion. Nevertheless, due to the vast amount of data, only a maximum of a 10-class model was evaluated, more in-depth analysis regarding the specific possible sub-groups per estimated class is necessary. Moreover, there is an interpretation limitation regarding the variable of household income. Due to the fact that people living alone but also couples with children are classified and treated as the same analysis unit (namely a household), people with actually little disposable income (because they might have to feed an entire family from it) and people with good-enough income (because they live alone) will be grouped together in the same household income class. Thus, assuming that classes with people in the lowest household income group and with people who live alone means that the individuals in this class actually do not have little money available, but are in the lowest income group *because* they live alone is logical, yet still only an assumption and should not be taken as factual. This, furthermore, also leads to possible subgroups that represent people who could afford a higher living standard live in the more affordable realities by choice while other people need to. People who elicit similar TB but for different reasons will be grouped together if their sociodemographics are alike enough.

Maps
When visualising the findings of the LCA onto the postcode areas of the Netherlands, it was actively chosen to show where the combinations of sociodemographics were present in people rather than in trips. While the LCA was weighted and based on trips and who made which trips, the visualisation contributed by showing where people who are in those specific travel pattern groups are present. This decision was made not to overly represent people's sociodemographics who make many trips because the frequency of trips themselves was not the relevant focus for the visualisation. However, this also led to showing where certain sociodemographics are present rather than where which TB patterns were more present. The scope of this research did not allow for the creation of multiple more maps based on datasets matched on the trip level, as the matching of datasets proved to be a very time-intensive activity. Nevertheless, future research could investigate this very mismatch on top of the spatial distribution, thereby also showing which people might conform to certain sociodemographics and how mobile they actually are in terms of trip frequency. The maps could be a powerful way of visualising actual TB rather than the location of people who travel a certain way.

Self-reported answers
Another limitation of working with the ODiN dataset is that the TB indicators are self-reported. While this does not limit the meaningfulness of mode choice or distances, travel times can differ a lot and can feel different depending on what purpose one travels and how one experienced the trip. Hence, they have to be taken with caution.

Lack of depth in questions
The ODiN dataset is gathered by sending a questionnaire to a sample of residents of the Netherlands as well as obtaining some information from the general statistical database (see chapter 4). Therefore, some information was gathered in ways that limit conclusions that can be drawn from this research to a certain extent. How that is the case is outlined briefly.

Gender/sex
Several issues regarding a certain lack of depth in some questions can be identified. Those include that the question of biological sex/gender only resembles the binary 'male/female' without even offering 'other/diverse'. The dataset also does not contain any entries of that question not being answered which means that even if one did not identify as either of the two and would hence be at more risk in terms of travel safety (which can be assumed to impact their TB, see e.g Kern, 2021), they could not have chosen not to answer and were forced to choose one of the two, thereby possibly falsely attributing certain TB characteristics to either male or female.[1].

[1] I do not aim at settling or assuming any metaphysical truth about the existence (or not) of gender, I merely note that there are people who do not identify as either of the two answer possibilities and yet have TB aspects that are analysed falsely in this research

Ethnic background
Another issue with regards to lack of depth is the indication of ethnic background of the respondents. While a detailed listing of countries of origin/migration could be regarded as too detailed, listing the ethnicities as Dutch/Western/Non-Western is considered rather problematic due to the many definitions of what is Western and what is not (political, geographic, economic, etc., see Dictionary, 2023). For example, one might assume political Westernness, geographical Westernness, or rather 'ethnic' Westernness, as in Caucasian when answering whether they are Western or not. Whether this possible mis-labelling of ethnicity is problematic, however, is also unclear what findings about ethnicity mean. In order to hypothesise which of the possible factors connected to ethnicity (political, geographic, ethnic, phenotypic, etc.) could be influencing TB, detailed information on how one comes to be labelled Western or non-Western would be necessary. Due to the lack of depth of the data regarding this issue, this research also will not be able to contribute to this body of literature.

Health
Next, in a recent research Durmus (2022) showed that health rather than age is a limiting factor. Thus, as elderly people tend to be of worse health, the latter is the factor impacting their TB. Thus, although difficult to include, it would be interesting to assess level of health that is relevant for mobility as an additional variable, rather than age itself. As such a variable is not present in the dataset, age as a good predictor of health is used instead. It has to be noted, however, that just because someone is in the highest age group and therefore the probability of their health being limited is higher, age does not equal worse health on an individual level.

7.5. Recommendations

In this section, the recommendations for policy as well as for further research will be outlined.
To begin, some practical recommendations can be formulated on the findings that leisure travels are more sustainable than work travels, even when covering the same distances, possibly due to their more flexible nature. Specifically, one of the recommendations that could be taken up by policy making as well as by employers would be to promote leisure-like work conditions for those people who work in occupations that can accommodate flexibility. Hence, promoting flexible working in terms of working from home or co-working spaces but also in terms of flexible working hours could be a way to enable choosing active modes over the car for work. Moreover, as also posited above, other modes to travel to work besides by car should be subsidised and offered to workers to avoid people travelling by car out of convenience. While it is understandable that the car might be necessary for some people to get to work, the behaviour of using the car similarly frequently in leisure when it might not be needed should be countered. Another related point is furthering the dialogue between employers and employees with regards to mode choice for work related travels. As previously mentioned, even if the same distances are covered, especially for work the choice for car is very dominant. While this might have to do with comfort, offering e-bikes for employees could be a good start to also facilitate a shift in thinking and culture. Likewise, work-provided cars that can be shared rather than have to be owned would be another useful step in the right direction.

Another recommendation concerns the life-stage finding, namely that the overall profile of people with similar journey types differs to the extent that they seem to be in different 'stages' of their lives. It shows that policy-making should not only intercept at the point where young people make the decision to rely on a car but already pay attention to how children travel once they get to the stages of 'necessary travels'. While this recommendation concerns both avoiding the need for people to get a car as they grow up and progress in life, it also means that how young people (children, young adults) travel needs to be monitored and evaluated. Although one could argue that students in the Netherlands already enjoy substantial benefits when travelling by public transit, the data suggests that as they grow up, they switch to car. Furthermore, people with children need to be supported in switching to more sustainable modes by either facilitating more child care facilities also in rural areas or by making it easier to travel with a child in public transit. Concretely, this could look like lower entrances in public transit vehicles or more child-friendly carriages (such as in use by Swiss SBB trains or Norwegian trains, see e.g. SBB, 2023). If one tries to search 'reizen met kinderen NS' (translated: travelling with children NS), no specific information provided by the train operator NS (Nederlandse Spoorwegen) comes up, except for information about the ticketing. Other countries, especially Switzerland but also Germany

and Nordic countries, offer specific family areas in public transit, they enable dealing with babies (e.g. having specific regulations on where and how the child can be diapered), and make it seem more possible and less difficult to travel with a child. When googling how to travel with a baby in public transit in the Netherlands, the first webpage that comes up refers to 'helpful other travellers' who happily help if a stroller needs to be carried into a public transit vehicle (WJJ, 2023). Further down on that infopage, however, one is alerted to avoid the rush hour time periods (6:30 - 9:00 am and 4:00-6:30pm), as the vehicles will be too busy to accommodate travelling with a stroller. While this seems logical and is not at all surprising, changes must happen. Otherwise, if it means that people, once they become parents, need to get a car, because of a lack of child care facilities which are reachable by active modes or public transit, a shift to more sustainable modes will be hard to realise for a substantial part of the Dutch population. And surely for the majority of Dutch parents. A first step here requires changing the lack of information about what facilities for babies/children are on board of public transit vehicles. This information has to be provided by the operators. Next, operators need to devise clear policies of how to deal with e.g. the feeding of a baby on public transit or the changing of diapers (although this is possible in most on-board restrooms, information on this is rather difficult to find). Third, child-friendly areas should be developed, at least on trains, to make travelling with a young child an experience that does not feel like invading other travellers' spaces. Otherwise, either parents' mobility is vastly limited or a car is a must-have when having a child. A last recommendation with regards to this finding is to tap into the possibility offered by the fact that young people still use more sustainable modes than older people. Reasons for young adults switching to car at some point in their lives need to be investigated further. If this has to do with life circumstances (such as having children), the aforementioned policy recommendation holds, as it also becomes apparent that once one has a car, one is more inclined to use it. Avoiding the need for young people to switch to a car is one of the most important recommendations that emerged from this research.

Regarding the presence of car travel even in urbanised areas and the relationship between owning and using a car, a policy recommendation is to further promote the concept of car sharing. Thus, not only car sharing as offered by an employer but car sharing for individuals is a good way to limit convenience-driving. With car sharing, people have access to a car if they need it and if travelling by other modes is not feasible. This concept would not allow for using the car out of mere convenience or laziness, because one does not own a car or has all day round access to it. Overall, promoting car sharing would also help to improve those groups' accessibility levels that seemed restricted by the costs and/or availability of a car. This could be further assisted by financially subsidising car sharing for people with restricted car access whose lives are limited because of this restriction.

Other recommendations concern the restricted accessibility faced by those people that seem to be forced into using more affordable modes of transport, such as the lone public transit users. For them, the typical recommendations for people with arbitrarily restricted accessibility due to modal disadvantage (as outlined in chapter 3) apply. It needs to be made sure that by having to travel with public transit, people are not put at a higher safety risk (this especially applies to women and people with a non-Dutch ethnic background). Empirical research in the Dutch context on this issue is rather rare, so a policy recommendation would be to first investigate the perceived safety levels of travellers on public transit and then take relevant policy consequences. This could look like having more staff on board at certain times or have specific designated supervised areas for people who generally feel vulnerable.

Moreover, people living in rural environments with bad access to public transit as well as people with limited physical mobility (e.g. people with a stroller, people with physical or mental impairments, elderly people) could be enabled to access public transit and made more car-independent by introducing on-demand services. Such services could be state-funded and either function as feeder systems to public transit stations or even as point to point systems. Such services are already introduced in multiple cities in Germany (see e.g. kvgOF, 2023) and their ticketing is organised in such a way that people with lower physical mobility levels have a pricing advantage. Thus, while for people living in rural environments this can help overcome the spatial disadvantage, people with physical disadvantages can also be helped this way. Most on demand systems in operation in e.g. Germany are funded partly by the (regional) government together with the local public transit operators and thereby manage to offer journeys for public transit ticket prices or less. It is generally thought to be a cheaper way for govern-

ments to enable people to become car independent and feed the public transit systems and due to learning and more efficient artificial intelligence supported systems, this can make public transit overall more efficient and user-friendly (see e.g. kvgOF, 2023).

The initially posited claim that this research helps identify people who seem to depend on a car and would thus suffer from prohibitive car policies in inner cities can be confirmed. The findings of high car use when traveling with a child and the faced challenges of traveling by public transit with a child combined with ultra short distanced being travelled actively and with children leads to the following conclusion: For people with strollers the car is indeed a need. Thus, a recommendation would be to differentiate policy making with regards to reasons to use cars. If public transit is indeed not an option for people travelling with children and the aim of policies is not to punish people for having children, those people should be exempt from prohibitive policies (e.g. high parking pricing), or they should be enabled to use other services than have their own car (e.g. subsidised car-sharing or on-demand services), until public transit is child-/and stroller-friendly. This could be realised by testing out alternatives to car travel in urban areas by targeting parents through their children who go to school in urban areas. This could be an opportunity for further research in the setting of policy-testing.

7.5.1. Future research

In this section, ideas for future research are outlined. First, as suggested by the experts in the focus group session, the analyses could be repeated but including urbanisation level of the destination, or even destination postcodes to be able to understand people's itineraries even better. Especially the role of parking, which is a central aspect for many workers in cities could thereby be taken into account in the analyses. Along the same lines, the same Latent models could be run but for specific urbanisation levels separately, thereby uncovering even more details about the sociodemographic impact. This would be a first step into the direction of moving from an explorative study, as this has been, towards more specific detail-oriented hypothesis testing. In any case, for many of the conclusions drawn from this study, for example regarding the role of gender or regarding the role of ethnicity and education level it would be interesting to have follow up in-depth quantitative analyses or qualitative interviews to test the conclusions drawn here. Especially regarding the relevant topic of car-culture, pride and status in suburban medium-educated males, interviews could shed lights on what motivates their car use and what (if anything) could lead to less car use.
Moreover, what became apparent from the brief interaction-effect analysis, is that more research is needed on specific underresearched and underrepresented groups. As these groups are minorities by definition, it is crucial to direct more data collection towards them to understand how they travel or to what extent they have special needs that are not met in the current transport system. Interesting also is the effect of different constraints on people and their attitude towards travelling. If one feels unsafe while travelling with public transit but has no other choice for e.g. economic reasons, investigating how that impacts their behaviour might uncover how policy and public transit operators could help people feel safer. Research from other countries exists into e.g. travel itineraries at night, adapted behaviour in general or people who do not travel at all anymore (Kern, 2021; Bersch and Osswald, 2021) and it might be very useful to apply similar methodologies in the Dutch context. Especially adapted TB at night might be interesting to assess from a mobility justice standpoint.

From a more technical and methodological perspective, other avenues for future research could be to apply this very model as a latent transition model to test the hypothesized life stage effect on TB and include becoming parents as a life stage effect. Specific life events that should be tested on top of becoming a parent are switching to a full-time job after graduation of e.g. studies as well as buying a car. From the findings of research it can be hypothesised that even irrespective of location, these changes will materialise in adapted TB. Related to the life stage association, more research is necessary to investigate the association of higher age and car use. As the above discussion showed, with this granularity of information, it it is rather difficult to assess with certainty whether for example the association between car use and higher age has to do with the ability to afford the comfort out of free choice or with the need due to limited health. As also stated by Durmus (2022) age is not necessarily a proxy for health. Nevertheless, it is very possible that the two reasons (comfort as well as health needs) overlap. Either way, without knowing whether people of a certain age would actually need certain support (such as the suggested on demand services) or not, just bluntly funding it for them

also would not make sense. Furthermore, as this research showed significant differences in TB based on sociodemographic profiles, a follow-up in-depth assessment of more complex spatial variables to uncover these relations seems necessary. Methods like geographically weighted regression as employed by Lucas et al. (2018) could complement the findings with regards to sociodemographics. This would also help to highlight in a more applied way in which areas spatial circumstances play a more significant role than sociodemographics. What's more, future research could build on these findings by conducting interviews with travellers from the classes identified as surprising and investigate more in-depth reasons for why they travel a certain way, thereby contributing to the needs vs preference debate. Also, more qualitative research could fill the here developed profiles with life. While many of the theories surrounding travel realities are already long-established in different academic fields (see e.g.Lucas, Bates, et al., 2016), confirming the findings of this research with qualitative input would be even more useful for policy making and give a general indication of people's travel realities.

More research also seems to be necessary in the field of travel time assessment. Due to the fact that leisure travel characteristics and the diversity underlying leisure travel seems to be something that causes people to use active modes more often, further research could assess travel duration bias of people depending on what mode they travel with. While there is research in the field of perceived public transit travel time that has established that travels for leisure are perceived differently than travels for work, such as Meng et al. (2018), a more in-depth assessment in that matter would be interesting. Specifically, it would be interesting to assess differences of perceived travel time for different purposes as well as different modes. Additionally, this thesis indicates that people might be more willing to undertake active travels for leisure, and it would be helpful to understand if the general perception of leisure related travels as enjoyable and less annoying contributes to that or if there are other reasons. Lastly, this research could be repeated for different countries, thereby uncovering differences in general TB. This would enable assessing why people in the Netherlands travel a certain way. Comparing Dutch TB with e.g. TB from (parts of) Germany could show how much more relevant active modes actually are and whether areas in Germany that are more similar to the Netherlands also show more similar TB. This could be especially interesting when assessing policies from the past, in similar fashion as done by Schwanen et al. (2004).

7.6. Conclusion

The aim of this research was partly to uncover to what extent a significant relationship between sociodemographics and TB exists and to evaluate to what extent that can be said to influence people's mobility to the extent that one can speak of restricted accessibility. Uncovering this kind of information could enable better and more specific policy making to the extent that different sociodemographic groups may need different policy incentives or may not be responsive to certain prohibitive policies at all because their choices may resemble a need rather than a substitutable preference. Especially in light of the Brede Welvaart policy aim of the Netherlands, it is pivotal to assess people's mobility options in using more sustainable transport while staying mobile. This research indeed found that TB differs depending on the specific sociodemographic profile of a person. It was first established that arbitrary sociodemographic factors as well as the spatial factor of urbanisation level are relevant to investigate. Furthermore, it was outlined that different travel purposes lead to different TB patterns, and that LCA was a fitting method to assess the issue at hand. The general analysis of the data first showed that not only TB differed depending on travel purpose but also the general sociodemographic makeup was different. The subsequent LCA resulted in 7-8 clear travel patterns, from which 3 (4 for work and education related travels) represent car journeys, 3 active trips and 1 public transit. When assessing the different impact of the sociodemographics on TB groups with regards to travel purpose it became apparent that level of education had the largest impact on TB patterns of all travel purposes. Level of urbanisation and age had the subsequent substantial impacts on work and education related travels, whereas income and travelling with a child had a larger impact on leisure. It could be observed that specific sociodemographic factors and combinations thereof which are generally considered more disadvantaged in society are associated with using more sustainable modes (active modes and public transit) more than groups that seem better off (i.e. high income, higher education). An interaction effects analysis uncovered that while education was the largest impact for work and work and education related travels, it had changed to income for leisure. Nevertheless, for leisure the second and third

most impactful covariates then proceeded to be interaction terms, namely single household and low income as well as living with one's partner and low income. Only then did age follow. Overall, for a more in-depth analysis of the impact of the interaction terms on the individual clusters proved difficult due to the limited data availability of some of the interaction terms. Answering the main research question "To what extent are different travel behaviour patterns associated with specific sociodemographic profiles (rather than spatial accessibility) and what are implications for transport policy?", it could be established that some sociodemographics have a specific impact on TB irrespective of other sociodemographics (e.g. low income will always restrict car use due to difficult car availability), while other sociodemographics such as gender could be shown to be dependent on the spatial circumstances. Low income, low education and non-Dutch women were thus more likely to travel by active modes or public transit while women in combination with e.g. travelling with children and with higher income were more likely to travel by car for shorter and medium distances. The effect of spatial circumstance on TB patterns found in this research was particularly interesting. Against expectations, it was found that very short distances were travelled by active modes by people in rural environments more than by people in urban environments. The car was also not generally only associated with rural areas, hence showing that while car-dependency in rural areas is high, car-use in urban areas is also high. This is problematic from a sustainable transport policy perspective. For other TB patterns, association with a certain geographic location was much more obvious, for example the public transit group across all purposes was almost exclusively associated with the (very urban) Randstad area in the Netherlands. The findings help policy making in that they give more context to certain TB choices and show that certain combinations warrant different policies. While anyone could use public transit in the city, it seems like those who have access and can afford it will choose going by car. Behaviour like this has to be countered by policies such as subsidising other travel forms for work travel to make them more interesting. Public transit operators should also be alarmed to make travelling by public transit not a 'poor people's thing' but enjoyable and attractive to anyone. Furthermore, those groups that seem to use the car only because they own it have to be targeted with policies aiming at keeping them from needing a car, by promoting e.g. car sharing or other services, such as on demand ones. What's more, the expected finding of a strong association of travelling with children and going by car (or travelling very short distances with active modes) highlighted the need to enable people (and to inform people) about other travel options. Overall further research is needed into some specific travel groups, such as the dedicated active travellers without alternative who appeared across all travel purposes but had very different sociodemographic profiles.

Bibliography

Adler, E. S., & Clark, R. (2014). *An invitation to social research: How it's done*. Cengage Learning.

Barbosa, H., Hazarie, S., Dickinson, B., Bassolas, A., Frank, A., Kautz, H., Sadilek, A., Ramasco, J. J., & Ghoshal, G. (2021). Uncovering the socioeconomic facets of human mobility. *Scientific reports*, *11*(1), 1–13.

Bastiaanssen, J., & Breedijk, M. (2022). Toegang voor iedereen? een analyse van de (on) bereikbaarheid van voorzieningen en banen in nederland.

Bastiaanssen, J., Johnson, D., & Lucas, K. (2020). Does transport help people to gain employment? a systematic review and meta-analysis of the empirical evidence. *Transport reviews*, *40*(5), 607–628.

Bauman, A., & Bull, F. (2007). Environmental correlates of physical activity and walking in adults and children: A review of reviews. *London: National Institute of Health and Clinical Excellence*.

Bernier, E., Gumy, A., Drevon, G., & Kaufmann, V. (2019). Motility as a tool to uncover mobility practices. *19th Swiss Transport Research Conference*, (CONF).

Bersch, A.-K., & Osswald, L. (2021). *An alle gedacht?! frauen, gender, mobilität-wie kommen wir aus der debatte in die umsetzung?* (Tech. rep.). IVP-Discussion Paper.

Cain, S., Steward, L., & Wright, N. (2022). Lived experiences of women and girls in relation to everyday journeys. https://ttf.uk.net/wp-content/uploads/2022/11/7448-Innovate-AT-Report-Long-3.pdf

Cascetta, E., Cartenì, A., & Montanino, M. (2013). A new measure of accessibility based on perceived opportunities. *Procedia-Social and Behavioral Sciences*, *87*, 117–132.

Centraal Bureau voor de Statistiek. (2018). *Onderzoeksbeschrijving onderweg in nederland (odin) 2018*. Retrieved November 5, 2022, from https://www.cbs.nl/-/media/_pdf/2020/03/onderweg-in-nederland-odin-2018.pdf

Centraal Bureau voor de Statistiek. (2020). *Onderzoeksbeschrijving onderweg in nederland (odin) 2019*. Retrieved November 5, 2022, from https://www.cbs.nl/-/media/_pdf/2020/37/%20%5C%5C%20onderzoeksbeschrijvingodin-2019v10.pdf

Centraal Bureau voor de Statistiek. (2021). *Population dashboard*. Retrieved October 4, 2022, from https://www.cbs.nl/en-gb/visualisations/dashboard-population

Chowdhury, S., & Van Wee, B. (2020). Examining women's perception of safety during waiting times at public transport terminals. *Transport policy*, *94*, 102–108.

Cohen, G. A. (1989). On the currency of egalitarian justice. *Ethics*, *99*(4), 906–944.

Crass, M. (2020). "gender is one of the most robust determinants of transport choice". https://transportpolicymatters.org/2020/02/06/gender-is-one-of-the-most-robust-determinants-of-transport-choice/

De Witte, A., Hollevoet, J., Dobruszkes, F., Hubert, M., & Macharis, C. (2013). Linking modal choice to motility: A comprehensive review. *Transportation Research Part A: Policy and Practice*, *49*, 329–341.

Dictionary, O. E. (2023). Retrieved August 11, 2023, from https://www.oed.com/dictionary/western_adj?tab=factsheet#14642574

Durmus, I. (2022). *Assessment of transport-related social exclusion among the dutch elderly: A comparative mixed method approach* (Master's thesis). University of Twente.

Dworkin, R. (1981). What is equality? part 2: Equality of resources. *Philosophy Public Affairs*, *10*(4), 283–345. Retrieved December 17, 2022, from http://www.jstor.org/stable/2265047

Ewing, R., & Cervero, R. (2010). Travel and the built environment: A meta-analysis. *Journal of the American planning association*, *76*(3), 265–294.

Fontana, A., & Frey, J. (1994). The art of science. *The handbook of qualitative research*, *361376*.

Fransen, K., & Farber, S. (2019). Using person-based accessibility measures to assess the equity of transport systems. In *Measuring transport equity* (pp. 57–72). Elsevier.

Fransen, K., Vertriest, M., Bracke, A., Delespaul, S., & Vanderbroeck, E. (2022). Minder mobiel - een bewuste keuze? op zoek naar mobiliteitsbarrières die een volwaardige maatschappelijke participatie hinderen.

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport geography*, *12*(2), 127–140.

Handy, S. (2020). Is accessibility an idea whose time has finally come? *Transportation Research Part D: Transport and Environment*, *83*, 102319.

Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behavior? evidence from northern california. *Transportation Research Part D: Transport and Environment*, *10*(6), 427–444.

Handy, S., Weston, L., & Mokhtarian, P. L. (2005). Driving by choice or necessity? *Transportation Research Part A: Policy and Practice*, *39*(2-3), 183–203.

Joshi, S., & Bailey, A. (2023). What happens next? exploring women's transport motility through the story completion method. *Journal of transport geography*, *107*, 103547.

Kapatsila, B., Palacios, M. S., Grisé, E., & El-Geneidy, A. (2023). Resolving the accessibility dilemma: Comparing cumulative and gravity-based measures of accessibility in eight canadian cities. *Journal of Transport Geography*, *107*, 103530.

Kaufmann, V., Bergman, M. M., & Joye, D. (2004). Motility: Mobility as capital. *International journal of urban and regional research*, *28*(4), 745–756.

Kawgan-Kagan, I. (2015). Early adopters of carsharing with and without bevs with respect to gender preferences. *European Transport Research Review*, *7*(4), 1–11.

Kern, L. (2021). *Feminist city: Claiming space in a man-made world*. Verso Books.

Kroesen, M. (2014). Modeling the behavioral determinants of travel behavior: An application of latent transition analysis. *Transportation Research Part A: Policy and Practice*, *65*, 56–67.

Kroesen, M. (2019a). Is active travel part of a healthy lifestyle? results from a latent class analysis. *Journal of Transport & Health*, *12*, 42–49.

Kroesen, M. (2019b). Residential self-selection and the reverse causation hypothesis: Assessing the endogeneity of stated reasons for residential choice. *Travel Behaviour and Society*, *16*, 108–117.

kvgOF. (2023). Retrieved July 29, 2023, from https://www.kvgof-hopper.de/

Lucas, K. (2012). Transport and social exclusion: Where are we now? *Transport policy*, *20*, 105–113.

Lucas, K., Bates, J., Moore, J., & Carrasco, J. A. (2016). Modelling the relationship between travel behaviours and social disadvantage. *Transportation Research Part A: Policy and Practice*, *85*, 157–173.

Lucas, K., Mattioli, G., Verlinghieri, E., & Guzman, A. (2016). Transport poverty and its adverse social consequences. *Proceedings of the institution of civil engineers-transport*, *169*(6), 353–365.

Lucas, K., Philips, I., Mulley, C., & Ma, L. (2018). Is transport poverty socially or environmentally driven? comparing the travel behaviours of two low-income populations living in central and peripheral locations in the same city. *Transportation Research Part A: Policy and Practice*, *116*, 622–634.

Lucas, K., Tyler, S., & Christodoulou, G. (2009). Assessing the 'value'of new transport initiatives in deprived neighbourhoods in the uk. *Transport Policy*, *16*(3), 115–122.

Lynch, G., & Atkins, S. (1988). The influence of personal security fears on women's travel patterns. *Transportation*, *15*(3), 257–277.

Maat, K., Van Wee, B., & Stead, D. (2005). Land use and travel behaviour: Expected effects from the perspective of utility theory and activity-based theories. *Environment and Planning B: Planning and Design*, *32*(1), 33–46.

Magidson, J., & Vermunt, J. (2002). Latent class models for clustering: A comparison with k-means. *Canadian journal of marketing research*, *20*(1), 36–43.

Maria Kockelman, K. (1997). Travel behavior as function of accessibility, land use mixing, and land use balance: Evidence from san francisco bay area. *Transportation research record*, *1607*(1), 116–125.

Martens, K. (2012). Justice in transport as justice in accessibility: Applying walzer's 'spheres of justice'to the transport sector. *Transportation*, *39*(6), 1035–1053.

Martens, K., & Bastiaanssen, J. (2019). An index to measure accessibility poverty risk. In *Measuring transport equity* (pp. 39–55). Elsevier.

Martens, K., Bastiaanssen, J., & Lucas, K. (2019). Measuring transport equity: Key components, framings and metrics. In *Measuring transport equity* (pp. 13–36). Elsevier.

Meng, M., Rau, A., & Mahardhika, H. (2018). Public transport travel time perception: Effects of socioeconomic characteristics, trip characteristics and facility usage. *Transportation Research Part A: Policy and Practice*, *114*, 24–37.

Miller, E. J. (2018). Accessibility: Measurement and application in transportation planning. *Transport Reviews*, *38*(5), 551–555.

Molin, E., Mokhtarian, P., & Kroesen, M. (2016). Multimodal travel groups and attitudes: A latent class cluster analysis of dutch travelers. *Transportation Research Part A: Policy and Practice*, *83*, 14–29.

Mouter, N., van Cranenburgh, S., & van Wee, B. (2017). An empirical assessment of dutch citizens' preferences for spatial equality in the context of a national transport investment plan. *Journal of Transport Geography*, *60*, 217–230.

Muromachi, Y. (2017). Experiences of past school travel modes by university students and their intention of future car purchase. *Transportation Research Part A: Policy and Practice*, *104*, 209–220.

Nussbaum, M. C. (2009). Creating capabilities: The human development approach and its implementation. *Hypatia*, *24*(3), 211–215.

Pereira, R. H., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. *Transport reviews*, *37*(2), 170–191.

Planbureau voor de Leefomgeving. (2022). *Brede welvaart in de regio*. Retrieved July 15, 2023, from https://www.pbl.nl/brede-welvaart-in-de-regio#:~:text=Brede%20welvaart%20omvat%20alles%20wat,ontplooiing%20en%20(on)veiligheid

Pot, F. J., Koster, S., & Tillema, T. (2023). Perceived accessibility and residential self-selection in the netherlands. *Journal of Transport Geography*, *108*, 103555.

Pritchard, J. P., Stępniak, M., & Geurs, K. T. (2019). Equity analysis of dynamic bike-and-ride accessibility in the netherlands. In *Measuring transport equity* (pp. 73–83). Elsevier.

Pritchard, J. P., Tomasiello, D. B., Giannotti, M., & Geurs, K. (2019). Potential impacts of bike-and-ride on job accessibility and spatial equity in são paulo, brazil. *Transportation research part A: policy and practice*, *121*, 386–400.

Rawls, J. (2004). A theory of justice. In *Ethics* (pp. 229–234). Routledge.

Saeidizand, P., Fransen, K., & Boussauw, K. (2022). Revisiting car dependency: A worldwide analysis of car travel in global metropolitan areas. *Cities*, *120*, 103467.

SBB. (2023). *Im zug mit kindern*. Retrieved July 14, 2023, from https://www.sbb.ch/de/fahrplan/reisehinweise/reisen-mit-kindern/zug-kinder.html?#unterhaltung

Scanlon, T. M. (1975). Preference and urgency. *The Journal of Philosophy*, *72*(19), 655–669.

Schwanen, T., Dijst, M., & Dieleman, F. M. (2004). Policies for urban form and their impact on travel: The netherlands experience. *Urban studies*, *41*(3), 579–603.

Sen, A. (2005). Human rights and capabilities. *Journal of human development*, *6*(2), 151–166.

Simma, A., & Axhausen, K. W. (2003). Interactions between travel behaviour, accessibility and personal characteristics: The case of upper austria. *European Journal of Transport and Infrastructure Research*, *3*(2).

statista. (2022). *Largest cities in the netherlands in 2022, by number of inhabitants*. Retrieved October 4, 2022, from https://www.statista.com/statistics/993709/largest-cities-in-the-netherlands-by-number-of-inhabitants/

van de Coevering, P. (2021). The interplay between land use, travel behaviour and attitudes: A quest for causality.

Van Eenoo, E., Fransen, K., & Boussauw, K. (2022). Car dependency beyond land use: Can a standardized built environment indicator predict car use? *Journal of Transport and Land Use*, *15*(1), 117–136.

Van Wee, B., De Vos, J., & Maat, K. (2019). Impacts of the built environment and travel behaviour on attitudes: Theories underpinning the reverse causality hypothesis. *Journal of transport geography*, *80*, 102540.

Van Wee, B., & Geurs, K. (2011). Discussing equity and social exclusion in accessibility evaluations. *European journal of transport and infrastructure research*, *11*(4).

Van Wee, B., Geurs, K., & Chorus, C. (2013). Information, communication, travel behavior and accessibility. *Journal of Transport and Land Use*, *6*(3), 1–16.

van Wee, B., & de Jong, T. (2023). Differences in levels of accessibility: The importance of spatial scale when measuring distributions of the accessibility of health and emergency services. *Journal of Transport Geography*, *106*, 103511.

van Wee, B., & Mouter, N. (2021). Evaluating transport equity. *Advances in Transport Policy and Planning*, *7*, 103–126.

Vermunt, J. K., & Magidson, J. (2013). Technical guide for latent gold 5.0: Basic, advanced, and syntax. *Belmont, MA: Statistical Innovations Inc*.

WJJ. (2023). Retrieved July 14, 2023, from https://wij.nl/baby/eropuit/met-je-baby-in-het-openbaar-vervoer/#:~:text=Kinderen%20tot%204%20jaar%20oud,%2C%20tram%2C%20trein%20en%20metro.

Appendix - Detailed analysis of descriptives

In this Appendix, the general descriptive statistics for the joined 2018/2019 ODiN dataset by means of cross-tabulations will be presented. Different distributions of the travel behaviour indicators (mode choice, distance, time) for different levels of the socioeconomic characteristics are shown, for all travel purposes.

A.1. Work and Education

In this section, the effect of sociodemographics on work and education related travels will be presented. The tables are coloured to show the differences in distributions more clearly.

A.1.1. Mode choice

First, the effect of different levels of sociodemographics on mode choice are presented.

urbanisation level		car, PT, active, other				Total
		car	PT	active	other	
urban	% of urban	40.30%	12.8%	40.50%	6.40%	100.00%
rural	% of rural	50.6%	5.6%	33.90%	9.90%	100.00%

Table A.1: Mode choice - urbanisation level cross-tabulations

			car, PT, active, other				Total
			car	PT	active	other	
Sex	Male	% of male	45.20%	9.5%	34.20%	11.20%	100.00%
	Female	% of female	41.1%	12.1%	44.10%	2.60%	100.00%

Table A.2: Mode choice - gender cross-tabulations

ethnic background		car, PT, active, other			
		car	public transit	active	other
Dutch	% of Dutch	45.3%	8.60%	38.20%	7.90%
Western	% of Western	39.4%	15.10%	39.90%	5.70%
non-Western	% of non-Western	34.2%	20.90%	39.50%	5.40%

Table A.3: Mode choice -ethnic background cross-tabulations

age		car, PT, active, other			
		car	PT	active	other
6-29yrs	%	25.9%	14.20%	54.90%	5.00%
30-64	%	56.5%	8.40%	25.70%	9.40%
65+	%	49.3%	4.20%	40.30%	6.20%

Table A.4: Mode choice - age cross-tabulations

income group		car, PT, active, other			
		car	PT	active	other
1	%	32.7%	15.50%	44.30%	7.50%
2	%	43.2%	10.70%	37.40%	8.60%
3	%	46.6%	9.10%	37.50%	6.80%

Table A.5: Mode choice - income level cross-tabulations

children younger than 6		car, PT, active, other			
		car	PT	active	other
no	% e	43.60%	10.80%	38.00%	7.60%
yes	%	37.00%	4.80%	54.50%	3.70%

Table A.6: Mode choice - travel with children cross-tabulations

educational level		car, PT, active, other			
		car	PT	active	other
unknown or younger than 15	%	17.5%	3.9%	75.6%	3.0%
basic or low	%	18.5%	9.5%	62.7%	9.3%
medium	%	47.6%	10.9%	29.2%	12.4%
high	%	54.8%	13.8%	28.1%	3.3%

Table A.7: Mode choice - education level cross-tabulations

HHconstellation		car, PT, active, other			
		car	PT	active	other
single	%	39.7%	14.9%	38.8%	6.7%
couple	%	44.6%	9.2%	38.5%	7.7%
other	%	29.7%	24.6%	37.1%	8.5%

Table A.8: Mode choice - household constellation cross-tabulations

dep children		car, PT, active, other			
		car	PT	active	other
no	%	45.1%	12.6%	34.3%	8.0%
yes	%	39.6%	6.2%	48.1%	6.2%

Table A.9: Mode choice - dependent children cross-tabulations

A.1.2. Travel Distance

In this subsection, the effect of different levels of sociodemographics on travel distance are presented.

urbanisation level					
		0-1.5	1.5-7.5	7.5-20	20+
1	%	18.0%	35.3%	20.8%	25.9%
2	%	19.4%	24.5%	27.4%	28.7%

Table A.10: Travel distance - urbanisation level cross-tabulations

gender					
		0-1.5	1.5-7.5	7.5-20	20+
male	%	15.7%	30.0%	23.1%	31.2%
female	%	21.9%	34.6%	22.4%	21.1%

Table A.11: Travel distance - gender cross-tabulations

age group		distance			
		0-1.5	1.5-7.5	7.5-20	20+
6-29	%	28.1%	35.8%	18.1%	18.0%
30-64	%	10.5%	28.6%	26.6%	34.3%
65+	%	23.2%	38.6%	20.2%	18.0%

Table A.12: Travel distance - age cross-tabulations

income groups		distance 0-1.5	1.5-7.5	7.5-20	20+
1	%	19.3%	37.9%	20.4%	22.4%
2	%	18.3%	32.8%	23.5%	25.4%
3	%	18.2%	29.9%	23.0%	28.9%

Table A.13: Travel distance - income level cross-tabulations

		distance 0-1.5	1.5-7.5	7.5-20	20+
children					
no	%	17.4%	32.0%	23.2%	27.4%
yes	%	48.1%	33.5%	10.6%	7.9%

Table A.14: Travel distance - travel with children cross-tabulations

education level		distance 0-1.5	1.5-7.5	7.5-20	20+
unknown or younger than 15	%	49.3%	36.2%	10.6%	3.9%
low or basic	%	19.7%	46.2%	23.0%	11.0%
medium	%	13.1%	32.3%	26.9%	27.7%
high	%	9.7%	27.5%	23.7%	39.2%

Table A.15: Travel distance - education level cross-tabulations

dep children		distance 0-1.5	1.5-7.5	7.5-20	20+
no	%	12.8%	32.9%	25.0%	29.3%
yes	%	31.1%	30.1%	17.9%	20.9%

Table A.16: Travel distance - dependent children cross-tabulations

A.1.3. Travel Time

This section presents the effect of different sociodemographics on travel time distributions.

income groups		TT 0-5	5-15	15-30	30+
1	%	11.90%	32.70%	23.90%	31.50%
2	%	13.80%	33.30%	23.00%	29.90%
3	%	15.70%	35.80%	22.40%	26.10%

Table A.17: Travel time - income level cross-tabulations

		TT			
		0-5	5-15	15-30	30+
age groups					
6-29	% s	17.1%	34.5%	23.4%	25.0%
30-64	%	8.4%	27.9%	30.8%	32.8%
65+	%	15.4%	40.5%	23.8%	20.3%

Table A.18: Travel time - age cross-tabulations

travel with children		TT			
		0-5	5-15	15-30	30+
no	%	11.8%	30.7%	27.9%	29.6%
yes	%	27.4%	46.3%	14.3%	12.0%

Table A.19: Travel time - travel with children cross-tabulations

educational level		TT			
		0-5	5-15	15-30	30+
unknown or younger than 15	%	29.4%	42.8%	17.0%	10.8%
basic or low	%	12.3%	35.9%	27.5%	24.4%
medium	%	10.4%	31.4%	29.9%	28.3%
high	%	6.5%	24.6%	29.5%	39.4%

Table A.20: Travel time - education level cross-tabulations

household constellation		TT			
		0-5	5-15	15-30	30+
single	%	9.5%	31.2%	29.1%	30.1%
couple	%	13.2%	31.2%	26.9%	28.6%
other	%	6.0%	32.0%	28.6%	33.3%

Table A.21: Travel time - household constellation cross-tabulations

dependent children		TT			
		0-5	5-15	15-30	30+
no	%	9.0%	29.7%	29.5%	31.9%
yes	%	20.0%	34.7%	22.8%	22.5%

Table A.22: Travel time - dependent children cross-tabulation

A.2. Leisure

In the following part, the cross-tabulations of the TB indicators with different sociodemographics are presented for the leisure travel purpose.

A.2.1. mode choice - leisure travel

:

The cross-tabulations are first presented with regards to mode choice. The cross-tabulations are only reported if there was a deviant distribution from the average.

		car, PT, active, other			
		car	PT	active	other
Dutch	% of Dutch	44.8%	3.10%	49.60%	2.50%
Western	% of Western	39.2%	5.60%	52.80%	2.40%
non-Western	% of non-Western	38.5%	9.30%	49.30%	2.80%

Table A.23: Mode choice - ethnic background cross-tabulation

age group		car, PT, active, other			
		car	PT	active	other
6-29	%	39.3%	5.20%	52.60%	2.80%
30-64	%	47.1%	3.10%	47.50%	2.20%
65+	%	43.5%	3.20%	50.70%	2.60%

Table A.24: Mode choice - age cross-tabulation

income group		car, PT, active, other			
		car	PT	active	other
1	%	33.5%	7.20%	55.50%	3.90%
2	%	43.8%	3.50%	50.10%	2.50%
3	%	47.5%	2.80%	47.60%	2.10%

Table A.25: Mode choice - income level cross-tabulation

children under 6		car, PT, active, other			
		car	PT	active	other
no	%	42.6%	4.00%	50.70%	2.60%
yes	%	57.3%	2.00%	39.60%	1.10%

Table A.26: Mode choice - travel with children cross-tabulation

education level		car, PT, active, other			
		car	PT	active	other
unknown or younger than 15	%	33.50%	4.00%	56.70%	5.80%
low or basic	%	45.80%	3.50%	47.60%	3.10%
medium	%	45.30%	5.20%	47.90%	1.60%
high	%	38.40%	1.90%	57.80%	1.90%

Table A.27: Mode choice - education level cross-tabulation

HHconstellation		car, PT, active, other			
		car	PT	active	other
single	%	37.90%	6.70%	52.20%	3.20%
couple	%	45.80%	2.90%	49.10%	2.20%
other	%	27.60%	14.40%	52.60%	5.40%

Table A.28: Mode choice - household constellation cross-tabulation

A.2.2. Travel time

In this section, the cross-tabulations of different sociodemographics on travel time distributions are presented. Only those differing from the average are presented.

ethnic background		TT			
		0-5	5-15	15-30	30+
Dutch	% of Dutch	15.00%	34.80%	22.70%	27.60%
Western	% of Western	12.30%	32.40%	24.10%	31.20%
non-Western	% of non-Western	10.90%	31.20%	23.20%	34.70%

Table A.29: Travel time - ethnic background cross-tabulation

age group		TT			
		0-5	5-15	15-30	30+
6-29	%	17.00%	37.30%	21.80%	23.90%
30-64	%	13.80%	33.20%	23.80%	29.20%
65+	%	10.70%	31.30%	22.50%	35.50%

Table A.30: Travel time -age cross-tabulation

income groups		TT			
		0-5	5-15	15-30	30+
1	%	11.90%	32.70%	23.90%	31.50%
2	%	13.80%	33.30%	23.00%	29.90%
3	%	15.70%	35.80%	22.40%	26.10%

Table A.31: Travel time - income level cross-tabulation

education level		TT			
		0-5	5-15	15-30	30+
unknown or younger than 15	%	13.70%	35.20%	24.60%	26.50%
low or basic	%	13.60%	33.90%	23.50%	29.10%
medium	%	12.60%	33.00%	23.40%	31.00%
high	%	20.30%	37.80%	19.50%	22.30%

Table A.32: Travel time - education level cross-tabulation

HHconstellation		TT			
		0-5	5-15	15-30	30+
single	%	12.90%	33.70%	23.30%	30.00%
couple	%	14.80%	34.50%	22.70%	28.00%
other	%	13.00%	28.10%	22.40%	36.50%

Table A.33: Travel time - household constellation cross-tabulation

child younger than 12		TT			
		0-5	5-15	15-30	30+
no	%	12.80%	33.10%	23.60%	30.50%
yes	%	18.40%	37.40%	20.90%	23.30%

Table A.34: Travel time - depnendent children cross-tabulation

A.2.3. Travel distance

In this section, the cross-tabulations of travel distance with different sociodemographics are shown. Only those that differ from the average are presented.

age group		distance			
		0-1.5	1.5-7.5	7.5-20	20+
6-29	%	27.00%	43.40%	15.70%	13.90%
30-64	%	22.40%	41.70%	18.00%	18.00%
65+	%	20.90%	39.80%	19.90%	19.40%

Table A.35: Travel time - age cross-tabulation

level of education		distance			
		0-1.5	1.5-7.5	7.5-20	20+
unknown or younger than 15	%	32.60%	43.40%	14.20%	9.80%
low or basic	%	26.40%	43.20%	18.10%	12.30%
medium	%	22.10%	42.20%	18.40%	17.20%
high	%	21.10%	40.70%	17.90%	20.30%

Table A.36: Travel time - level of education cross-tabulation

HHconstellation		distance			
		0-1.5	1.5-7.5	7.5-20	20+
single	%	25.00%	41.10%	17.20%	16.60%
couple	%	23.30%	42.10%	17.70%	16.90%
other	%	18.20%	47.60%	13.30%	20.80%

Table A.37: Travel time - household constellation cross-tabulation

dep children		distance			
		0-1.5	1.5-7.5	7.5-20	20+
no	%	22.10%	41.40%	18.20%	18.40%
yes	%	28.00%	43.30%	15.90%	12.80%

Table A.38: Travel time - dependent children cross-tabulation

B

Focus Group Transcription

In this appendix, the focus group workshop transcription is presented. The researcher's are anonymized and only their input on the topics discussed is presented.

Are you surprised by these findings, especially that car is the dominant mode?
All: No
Also not by the fact that car is also most common for very short trips?
All: No
R1: No, many people combine using the car and dropping kids off at daycare and then it is just really convenient to get your car. Also, if you want to go to the shops afterwards.
R4: I am not sure how to interpret this. I think for very short distances the bicycle is a very important transport mode, also to work. But the general picture that car is used predominantly for work does not surprise me because people are in a hurry when going to work. On a leisure trip or going to sports you are not in such a hurry.
R5: 60% is car, 30% is bike and 10% is public transit, so in that sense this really is not surprising, so for short distances you can imagine that cycling is more important.
R2: You do not see the car cluster being very common for very short distances, you see two in Limburg, one in Gelderland, one in Friesland. You can see the urban pattern.
R1: You have nice pictures or graphs where you can see the travel distance and in bar charts and then you can see the mode choice share depending on distance.
R5: You can do basic cross-tabs, to see that.
R2: I am curious to see which classes are present where, but the overall pattern makes a lot of sense. I am tempted to look if they are each other's mirror image but they are not really.
R1: It is interesting to see if people are driving to leisure motives, so excluding the tours might be interesting to see that.
R4: Actually I am also a bit surprised that there are no or hardly any classes where public transport is predominant. I think if you map them not by residential area but by working area there might be a different picture.

specific profiles of people using car vs sustainable modes
R4: travel to work is more a daily routine where you use the same mode of transport everyday so it makes sense that it is more clear cut in terms of mode choice, they have a long time to develop their optimal transport pattern whereas for leisure I think in some cases you go to the tennis club and although it is also a fixed routine I think there are more possibilities to choose a different mode every time
R5: I would look at the distribution over trip length, I would image that home to work travel is between 5 and 20 kilometres and in leisure you have a big share of shorter distances, and then if it is shorter distances, your bicycle is a good alternative
R2: The diversity of the type of trips in leisure is much larger within each group so even if you look at the 1.5-7.5 kilometres, within that range that could be going to the sports club, going to meet friends, going to the cinema, so there is a very different set of activities at different times of day which could mean that there is a much less clear cut pattern there and less clear cut proof, while the trip to work is

always the same at the same time of day and it is just one trip. The different type of activity and the different time of day will cause a less clear cut profile. The diversity that is underlying these groups is causing this.

R2: If we are talking about things that surprise me, I am a bit puzzled by the high income level for the very short trips, while all of the other are low or medium to low, and then for the very short work related trips whereas for leisure you have high income everywhere. So I wonder what is it that the high income groups tend to, they are a separate group just for the very short trips.
R5: Might be that they think they are too expensive to walk a longer distance.
R4: In this group you would really like to know, what is the motive, is it jogging, is it going golfing or is it something else.
R2: Oh and they are in education. So they are students, but why are they high income then. That's a bit.
R6: Yeah, how sure are the sociodemographics? Because they are high income, in education but they also live in rural areas,
R2: Oh, those are the students who live at home!
All: oh!
R6: But don't you have the risk that you have a lot of subgroups, within each cluster? It is difficult to distinct a clear profile, right?
R2: Could this represent the dichotomy that in a rural area you have either a very short trips with active modes or longer trips with car? So that in the whole data analysis, something happened that in these rural areas, if you have a combination with active modes in rural areas it is but almost per definition a very short trip within the village.
R1: That is in terms of policy then also very interesting.
R2: Yeah
R2: Cause the top left and bottom right are both urban and the other is indistinctive at least for level of urbanisation, it is more general.

car groups
R2: Yeah the person who lives closest to work will take the children. And the bottom right that is car plus some other mode. Aah that is the white van group, ah 92% males, ah that is very typical. Ah yeah they are definitely not taking the children.
R7: But the bottom left is in this sense very interesting for policy, because if we want to reduce car use for the shorter distances, in this case for work related travelling, then there is a constraint related to travelling with a child. It might simply be difficult for people to swap to either public transport or active modes, if they have to travel with a child, if they have to trip chain.
R2: Yeah, especially in the non-urban areas.
All: Yeah
R7: So in terms of policy recommendations, if you would like to try to promote using active modes or public transport, they need to think about the type of trips they need to make in combination with travelling with a child. It needs to facilitate making these trips. Either you need to bring the child care closer to home or the schools perhaps or you make sure that you can actually use the bus to get to the nursery and then continue to the center or to work. Oh but this also says older, I didn't really get that. So there is older people in the bottom left cluster? Travelling with a child and being 64 and older is odd in the Netherlands, I'd say.
R2: That's very judgemental (laughs)
R7: Right, maybe the grandparents.
R2: You can see the longer trips are higher income which is completely in line with other research, higher education levels as well. If we want to be more sustainable we definitely need the females.
R4: There are three groups for which it makes sense that they do not have a car, it is young people, it is females , for which it does not make sense but it is reality
R2: Well in the lower income households, that only have one car, statistically it is usually the man who takes the car
R4: Right, that's the one. And non-Western people usually, but they probably also have lower..
R2: but if you look at the sustainable modes, and work, cause they probably pop up there
(proceeding to look at sustainable work modes)

R2: so they do work but they travel in a different way.
R4: but in all cases they have no car
r2: but what we do not see is whether they have no car by choice or because they cannot afford it
R1: you would expect that there are subgroups the
R2: Yeah, there must be subgroups. You have the very short ones, so it is not the children, so it is the youngsters and the students and then again it's - if you look at the top right, there is younger people or 65+, so it is the older generations and the up to 29 year olds. So this is also all students who have a job which is probably close by. And then that is rural, that is interesting, I would expect more research. On the one hand it is so interesting to have the data talk to you but on the other hand it is also so difficult.
R6: Have you thought about making a cut for urbanisation and repeating the analysis for urban and rural separately? Would be interesting to check out what clusters would you find if you focus on specific urbanisation grades. Because the problems are probably also different in different areas.

substitution possibilities
R2: I think it makes sense. What you're looking for is whether you could substitute or why you cannot. Well income and car ownership is an important one. But that does not mean that if you have a car you have to use it. Having a car is not a limitation on using active modes (laughs) well for some it is but it should not be so that is not necessarily a problem. I think the most limitation is with travelling with children. People find that difficult. If they have a set pattern of if I take my child, I have to take the car cause otherwise it is impractical. It is very difficult to get people out of that. people are not really sensitive to the fact that there are many many many people travelling with their children without a car and they still seem to manage, it is not impossible to travel without a car with your child!
R7: This is roughly what we just discussed, right? If you substitute the car here towards active travel, then one of the constraints is that often or more often travelling with a child and hence the need to facilitate other modes and trip chaining as well. So you can come up with measures, like either the land use and transport system, apart from cultural things is what you can influence as the government. so that means that perhaps having nursery or schools in closer proximity to your home or being able to indeed use the bus and then travel to those locations and then continue to the center or work might help to make this substitution.
R4: I am a bit intrigued by the spatial pattern. Because the distances are the same in both groups. So it might be differences in car ownership or, I'm not sure what the spatial pattern means.
R5: If you combine work and education, those are completely different groups and you're mixing them.
N: Yes, but you have an overlap of about 60%.
R1. It would also be interesting to see if you can see on the map or in different zones if the characteristics of the people living there is really different or if it is rather homogeneous. So to see if the location is making subgroups of people. If we can see in the rural areas, people getting different subgroups or is the area more homogeneous.
R2: I think it is also a traffic culture thing. which is not in the variables but it is a thing.
R7: would be indeed interesting to run the models again for urban and rural and see if you can still find the effect for ethnic background. Cause currently it is difficult to single out now if the effect is due to living in a specific environment or really to the intrinsic effect of ethnic background.
R4: but still, you can see that they even travel the same distances and then it seems to be a culture thing
R2: Yeah, it is definitely a culture thing.

leisure
R2: Again, it is she sheer diversity of leisure trips that complicates it. Because this combines going to grandma on Sunday afternoon with going to the gym and going to the cinema.
R5: but i would expect that high income and medium education is more car oriented than high income high education.
R2: yeah we also saw that in the previous one, that car group is the medium education one.
R4: Yeah
R2: and that the other is not the medium education one
R5: Yeah medium education is also the more suburban. Bigger cities have more high and low education and the suburban areas see more medium education. And these are more car-oriented.

medium distance trips work and education
R2: yeah, cause this is just active travellers not pt. this is confusing
R4: what is confusing?
R2: the ethnicity.
R4: Low levels of car ownership
R2: yes but they also tend to have a generally lower level of active mobility, because you are not going to walk over 7.5 kilometres, so it must by cycling

medium distance
R2: it is interesting that there is a clear urbanisation effect.
R4: that is an interesting group
R3: yeah because you do not take the bakfiets for 10km
R2: you seem to loose the gender effect if you have more than 1 car in the household

long distance work
R4: the urbanisation effect is much clearer
R2: I think there is a relation between the highest ratio of urban and the ethnicity because if you have a high ratio of people in urban environments then you have by definition also a high effect of non-Dutch people R3: Is there any research on how sort of the culture like the willingness of people to choose car or bike or something like that? so outside of these factors, it would be interesting to see how much those cultural aspects factor into that,
R2: there is some work there, so different travel cultures per cities, even if they have similar patterns there are different travel cultures, there is some research on travel preference but the direction of causality there is very complicated

C

Latent Class Model statistical details and Logit Parameters

In this Appendix, the statistical information for all latent class models are presented. First, the BIC-value tables are presented followed by the covariate statistical information.

C.1. Selection of number of classes, BIC values and BVRs

In this section, the class estimation results are presented for the leisure and work travel purpose. The work and education model statistics are presented in chapter 5.

cluster #	LL	BIC(LL)	Npar	L^2	df	p-value	Max. BVR
1-Cluster	-4E+10	79609061568	9	1.87E+10	41886	0.00E+00	5.94E+09
2-Cluster	-3.6E+10	72562275604	27	1.17E+10	41868	0.00E+00	7.92E+08
3-Cluster	-3.5E+10	69495580797	45	8.63E+09	41850	2.1e-1874549253	2.92E+08
4-Cluster	-3.4E+10	67067167878	63	6.2E+09	41832	1.6e-1347229045	62696544
5-Cluster	-3.3E+10	66027725621	81	5.17E+09	41814	3.2e-1121518648	21938634
6-Cluster	-3.3E+10	65027368598	99	4.16E+09	41796	9.2e-904295790	17583914
7-Cluster	-3.2E+10	64737932264	117	3.88E+09	41778	2.5e-841446096	8186888
8-Cluster	-3.2E+10	64575855998	135	3.71E+09	41760	6.7e-806252024	7277666
9-Cluster	-3.2E+10	64399317948	153	3.54E+09	41742	5.3e-767917669	6716764
10-Cluster	-3.2E+10	64317319836	171	3.45E+09	41724	8.7e-750112172	5082941

Table C.1: Leisure travel purpose BIC values for different number of classes

cluster #	LL	BIC(LL)	Npar	L^2	df	p-value	Max. BVR
1-Cluster	-2.7E+10	53309598715	9	1.54E+10	30294	0.00E+00	5.39E+09
2-Cluster	-2.3E+10	45952831335	27	8.03E+09	30276	2.2e-1742612433	5.43E+08
3-Cluster	-2.2E+10	43994437739	45	6.07E+09	30258	2.2e-1317354465	90135408
4-Cluster	-2.1E+10	42725894297	63	4.8E+09	30240	4.8e-1041895256	1.44E+08
5-Cluster	-2.1E+10	41817874477	81	3.89E+09	30222	4.3e-844722592	81410261
6-Cluster	-2.1E+10	41346914763	99	3.42E+09	30204	3.0e-742455793	66543068
7-Cluster	-2E+10	40995346687	117	3.07E+09	30186	2.0e-666114423	62285273
8-Cluster	-2E+10	40734355791	135	2.81E+09	30168	3.2e-609441509	28504367
9-Cluster	-2E+10	40600405464	153	2.67E+09	30150	1.2e-580354841	6937197
10-Cluster	-2E+10	40487793721	171	2.56E+09	30132	1.0e-555901749	6875016

Table C.2: Work travel purpose BIC values for different number of classes

C.1.1. Logit Parameters terms work and education model

In the following sections, the logit parameters for all estimated models are presented. For the base models, work and education, work and leisure, these parameters are all statistically significant. For the interaction temrs, this is not the case.

C.1.2. Logit Parameters terms work model

C.1.3. Logit Parameters terms leisure model

C.1.4. Logit Parameters terms leisure interactions model

C.1.5. Logit Parameters terms work and education interactions model

C.1.6. Logit Parameters terms work and education interactions model

Intercept	**Cluster1**	**Cluster2**	**Cluster3**	**Cluster4**	**Cluster5**	**Cluster6**	**Cluster7**	**Cluster8**	**Wald**	**p-value**
	0.8081	1.3014	0.4304	-1.5293	0.8863	0.1139	-0.8015	-1.2093	175795278.8	3.7e-38173441
Covariates	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Wald	p-value
Level of urbanisation										
urban	0.403	-0.0079	-0.2221	-0.1798	-0.0759	-0.0175	0.2662	-0.166	180629283	8.7e-39223132
rural	-0.403	0.0079	0.2221	0.1798	0.0759	0.0175	-0.2662	0.166		
Gender										
Male	-0.2629	-0.2849	-0.098	0.0063	-0.062	-0.1569	-0.1775	1.0359	89142761	8.4e-19357087
Female	0.2629	0.2849	0.098	-0.0063	0.062	0.1569	0.1775	-1.0359		
Herkomst										
Dutch	-0.0436	0.1476	0.0329	0.1195	0.1486	-0.1821	-0.2798	0.0568	52839890	2.4e-11473995
Western	0.0418	-0.0968	0.0222	-0.0072	-0.0841	0.0519	0.063	0.0092		
Non-Dutch	0.0018	-0.0508	-0.0551	-0.1124	-0.0646	0.1302	0.2168	-0.066		
K_age										
6-29	0.3435	-0.0342	-0.2412	0.068	-0.5093	0.3022	1.0772	-1.0062	439864237	4.8e-95515259
30-64	-0.3672	-0.4212	0.1824	0.1098	-0.0237	-0.1929	-0.1567	0.8695		
65+	0.0237	0.4554	0.0588	-0.1778	0.533	-0.1093	-0.9205	0.1367		
K_income										
0-30%	0.3047	0.2122	-0.093	-0.2373	-0.1322	0.1739	0.0789	-0.3072	80209899	3.6e-17417316
30-70%	-0.1058	-0.0862	0.0449	-0.0291	0.0617	-0.0844	-0.0035	0.2024		
70-100%	-0.199	-0.126	0.048	0.2664	0.0705	-0.0895	-0.0753	0.1049		
Level of education										
low education	0.5414	0.1484	-0.082	-1.9818	0.0153	0.6924	-0.1274	0.7938	798056767	4.5e-173295750
medium education	-0.6441	-0.6832	0.2834	1.267	-0.0284	-0.6269	0.302	0.1301		
high education	-0.3926	-0.8269	0.1797	2.3352	-0.4373	-0.3395	0.9811	-1.4997		
in education/unknown	0.4954	1.3618	-0.3811	-1.6204	0.4504	0.2739	-1.1558	0.5758		
Travel with child										
No	0.2681	-0.2066	-0.0696	0.1636	-0.5055	0.3997	0.0213	-0.071	46404392	1.6e-10076568
Yes	-0.2681	0.2066	0.0696	-0.1636	0.5055	-0.3997	-0.0213	0.071		

Table C.3: Parameters of logit model of Latent Class model for work and education

Intercept	**Cluster1**	**Cluster2**	**Cluster3**	**Cluster4**	**Cluster5**	**Cluster6**	**Cluster7**	**Cluster8**	**Wald**	**p-value**
	-0.1544	0.4137	0.7524	0.4769	0.8159	0.3501	-0.8146	-1.8399	54319156.26	1.4e-11795237
Covariates	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Wald	p-value
Urbanisation level										
urban	-0.1941	-0.2755	0.3814	-0.1828	-0.1484	0.1457	0.5299	-0.2562	173147128.4	1.3e-37598402
rural	0.1941	0.2755	-0.3814	0.1828	0.1484	-0.1457	-0.5299	0.2562		
Gender										
Male	0.0481	-0.1443	-0.3467	-0.0723	-0.3885	-0.2016	-0.1784	1.2836	123691202.8	3.4e-26859185
Female	-0.0481	0.1443	0.3467	0.0723	0.3885	0.2016	0.1784	-1.2836		
Ethnic background										
Dutch	0.0614	0.0452	-0.0478	0.1546	0.1232	-0.2164	-0.332	0.2118	38861630.39	1.1e-8438655
Western	-0.0193	0.0221	0.0005	-0.0433	-0.0461	0.0404	0.1066	-0.0609		
Non-Western	-0.0422	-0.0672	0.0473	-0.1114	-0.077	0.1761	0.2255	-0.151		
Age										
6-29	-0.0596	-0.1064	0.0947	-0.3134	-0.1478	0.0484	0.7004	-0.2164	153633540	1.4e-33361055
30-64	0.1776	0.1158	-0.2461	-0.1215	-0.4134	-0.0937	0.0545	0.5269		
65+	-0.118	-0.0093	0.1514	0.4349	0.5612	0.0453	-0.7549	-0.3105		
Income										
0-30%	-0.2526	-0.1372	0.2664	-0.2004	0.1591	0.1902	0.1798	-0.2053	64215341.43	9.2e-13944143
30-70%	-0.0139	0.0471	-0.0659	0.0681	-0.0835	-0.077	-0.0353	0.1603		
70-100%	0.2664	0.0901	-0.2005	0.1323	-0.0756	-0.1132	-0.1446	0.0451		
Level of education										
low or no education	-1.0001	-0.1947	0.3139	0.2304	0.525	0.0208	-0.6936	0.7983	259484420.2	1.2e-56346255
medium education level	0.2363	0.2202	-0.2379	0.1621	-0.1595	-0.3003	-0.231	0.3102		
high educ. level	0.8977	0.0635	-0.0168	-0.3759	-0.4172	0.0405	0.9375	-1.1292		
in education/unknown	-0.134	-0.0889	-0.0591	-0.0165	0.0517	0.239	-0.0129	0.0208		
Travel with child										
No	0.2554	0.0821	0.0807	-0.1895	-0.0575	-0.1078	0.0231	-0.0865	3730400.817	8.1e-810032
Yes	-0.2554	-0.0821	-0.0807	0.1895	0.0575	0.1078	-0.0231	0.0865		

Table C.4: Work purpose logit parameters

Intercept	**Cluster1**	**Cluster2**	**Cluster3**	**Cluster4**	**Cluster5**	**Cluster6**	**Cluster7**	**Wald**	**p-value**
	0.3036	0.4186	0.2419	0.4341	0.1819	0.4325	-2.0126	78473878.12	5.8e-17040372
Covariates	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Wald	p-value
Urbanisation									
urban	0.1754	-0.1364	-0.0785	-0.148	-0.1103	-0.0314	0.3293	93074106.74	3.6e-20210771
rural	-0.1754	0.1364	0.0785	0.148	0.1103	0.0314	-0.3293		
Gender									
Male	-0.0281	-0.0551	-0.0016	-0.0029	0.1176	0.0466	-0.0764	29413036.11	2.5e-6386946
Female	0.0281	0.0551	0.0016	0.0029	-0.1176	-0.0466	0.0764		
Ethnic background									
Dutch	0.0803	0.112	0.1131	0.0067	0.1273	-0.1695	-0.2699	48524012.75	2.3e-10536821
Western	0.1083	0.0058	-0.0251	-0.0295	-0.0683	0.0116	-0.0027		
Non-Western	-0.1886	-0.1178	-0.088	0.0229	-0.059	0.1579	0.2726		
Age									
6-29	0.1425	0.0244	-0.0138	-0.1148	-0.2556	-0.3789	0.5962	127237894.7	1.4e-27629321
30-64	0.0139	0.0757	0.0884	0.0275	0.0601	0.0905	-0.3561		
65+	-0.1564	-0.1001	-0.0746	0.0872	0.1955	0.2885	-0.24		
Income									
0-30%	0.1733	-0.0031	-0.2448	-0.1496	-0.1971	0.0942	0.3271	84853426.6	3.9e-18425652
30-70%	-0.0737	0.0016	0.0447	0.0143	0.056	0.0243	-0.0673		
70-100%	-0.0996	0.0015	0.2001	0.1353	0.1412	-0.1185	-0.2598		
Education level									
no or low education	0.2119	-0.0088	-0.1322	0.0199	-0.134	0.018	0.0252	156292732	9.9e-33938478
medium education	-0.1356	-0.2078	0.0812	0.0293	0.0991	-0.1301	0.2639		
high education	-0.1399	-0.2754	-0.1524	-0.0584	0.1268	-0.2239	0.7232		
in education/unknown	0.0636	0.492	0.2035	0.0092	-0.0919	0.3359	-1.0123		
Travel with child									
No	0.216	0.0596	-0.1436	-0.1829	-0.2091	-0.1375	0.3974	54951933.16	8.0e-11932647
Yes	-0.216	-0.0596	0.1436	0.1829	0.2091	0.1375	-0.3974		

Table C.5: Leisure purpose logit parameters

Covariates	**Cluster1**	**Cluster2**	**Cluster3**	**Cluster4**	**Cluster5**	**Cluster6**	**Cluster7**	**Wald**	**p-value**
urbanisation lvl									
urban	0.1398	-0.0717	-0.0501	-0.1797	-0.1078	-0.0959	0.3654	20022538.98	4.0e-4347826
rural	-0.1398	0.0717	0.0501	0.1797	0.1078	0.0959	-0.3654		
Gender									
male	-0.0435	-0.0453	-0.0211	-0.0195	0.1035	0.029	-0.003	8561961.022	5.6e-1859194
female	0.0435	0.0453	0.0211	0.0195	-0.1035	-0.029	0.003		
Ethnic backgr.									
Dutch	0.0405	0.0883	0.0542	0.0225	0.2084	-0.1852	-0.2287	14235001.89	6.3e-3091060
Western	0.0824	-0.055	-0.1553	0.04	-0.0827	0.0219	0.1487		
non-Western	-0.1229	-0.0333	0.1011	-0.0625	-0.1257	0.1633	0.08		
Age									
6-29	0.0885	0.1089	0.0201	-0.1095	-0.2549	-0.4277	0.5744	98010313.56	1.6e-21282633
30-64	-0.0267	0.1409	0.1033	0.0069	0.0458	0.0535	-0.3238		
65+	-0.0618	-0.2499	-0.1234	0.1026	0.209	0.3742	-0.2507		
Income									
1	2.5392	-3.9637	2.6126	0.5035	0.9564	-1.5654	-1.0827	188988499.8	3.2e-41038294
2	-1.2641	1.9868	-1.3682	-0.3115	-0.5199	0.8478	0.6291		
3	-1.2751	1.9769	-1.2445	-0.192	-0.4365	0.7176	0.4536		
Education lvl									
1	0.2765	-0.0411	-0.1684	-0.0163	-0.1287	0.0524	0.0257	120792920.8	1.4e-26229792
2	-0.1463	-0.203	0.1228	0.0721	0.0868	-0.1321	0.1998		
3	-0.1818	-0.2266	-0.1265	-0.0482	0.1129	-0.2541	0.7243		
4	0.0516	0.4707	0.1721	-0.0076	-0.0709	0.3338	-0.9497		
with child									
no	0.1692	0.0658	-0.2041	-0.2313	-0.2318	-0.09	0.5222	18761519.1	3.4e-4073999
yes	-0.1692	-0.0658	0.2041	0.2313	0.2318	0.09	-0.5222		

Table C.6: Leisure purpose Interaction model covariate parameters part 1

lowedu_rural	0.0517	0.1098	-0.0371	-0.0639	0.006	-0.0651	-0.0014	1945330.243	3.8e-422412
lowedu_female	-0.0494	-0.0319	-0.0714	-0.0388	-0.0039	0.0238	0.1715	1096635.328	6.9e-238121
lowedu+western	-0.0337	0.1011	0.1937	-0.0297	-0.0775	-0.1839	0.0301	2221557.534	5.0e-482394
lowedu+non-W.	-0.146	0.0345	0.0089	0.0997	0.0925	0.0093	-0.0989	924692.9239	3.2e-200784
lowedu+low inc.	0.0355	0.0755	0.0134	-0.1019	-0.1416	0.0179	0.1013	1380026.091	3.3e-299658
old_rural	-0.0341	0.2028	0.1135	-0.055	0.0674	-0.001	-0.2936	2475672.124	3.3e-537574
old_female	-0.0399	0.2015	-0.0836	-0.1094	-0.1222	-0.1279	0.2815	4868634.972	6.6e-1057199
old_western	-0.2142	0.196	0.1617	0.0829	0.0568	-0.1303	-0.1529	2291972.513	2.0e-497684
old_nonwestern	0.2331	0.0044	-0.6132	0.1767	-0.1398	-0.0309	0.3696	1490653.513	1.4e-323680
old_lowincome	-0.2105	0.1721	0.484	0.1295	-0.0308	-0.1091	-0.4352	8678565.806	2.3e-1884514
oldage_child6	0.1238	-0.0456	-0.4009	-0.1589	-0.4193	0.2975	0.6033	1776094.774	3.3e-385663
rural_female	-0.0576	-0.0091	0.0283	0.0297	0.0251	-0.0212	0.0047	462621.0208	3.5e-100447
rural_western	-0.2776	-0.2311	-0.1215	0.1309	0.154	0.0053	0.34	3762685.121	3.6e-817045
rural_nonwestern	0.1281	-0.1458	-0.3097	-0.2007	0.241	-0.2595	0.5465	3470880.677	1.0e-753680
rural_lowincome	-0.1485	-0.0251	0.1349	0.085	-0.0298	0.0202	-0.0367	1141555.376	4.1e-247875
rural_child6	0.0665	-0.1028	-0.174	-0.024	0.0971	-0.0398	0.1769	1053200.984	2.8e-228689
rural_kids12	0.0664	0.3735	0.2337	-0.0192	-0.118	-0.0452	-0.4914	15012135.11	5.4e-3259831
female_western	0.1125	0.0249	0.0019	-0.1505	0.1082	0.0708	-0.1678	1627614.629	3.1e-353421
female_non-W.	-0.124	-0.0601	-0.237	0.1389	0.177	-0.0249	0.1302	3047177.285	8.4e-661675
female_low inc.	0.0215	-0.0252	0.2215	0.0334	-0.1028	-0.1698	0.0215	3141100.187	7.1e-682070
female_child6	0.0555	0.1704	0.0456	-0.0603	-0.0059	0.2853	-0.4907	2434390.229	5.6e-528610
West+low inc.	-0.0117	0.0209	0.043	-0.136	0.1916	0.0448	-0.1526	836627.708	3.5e-181661
non-W. + low inc.	0.0233	-0.1323	0.0039	-0.0402	-0.2619	0.083	0.3241	1678056.419	1.7e-364374
western_child6	-0.1397	0.1568	0.0355	0.2458	0.2144	0.4151	-0.9279	1508186.572	8.0e-327488
nonwestern_child6	-0.3342	-0.2377	-0.1798	0.1754	0.4613	-0.0678	0.1828	4803323.461	1.1e-1043016
lowincome_child6	0.5802	-0.1345	0.369	-0.264	0.708	0.2852	-1.5439	4036906.455	1.6e-876591
low inc.+livealone	-3.7958	5.971	-4.1629	-0.5968	-1.2407	2.4233	1.4019	186955739.6	4.0e-40596908
lowincome_couple	-3.7455	5.7799	-4.3085	-0.6646	-1.0637	2.6012	1.4011	176720873.5	3.2e-38374435
lowincome_other	-3.7047	5.7404	-4.0103	-1.1546	-1.1398	2.6924	1.5765	0.0001	1
lowincome_kids12	-0.1663	0.2946	0.5617	0.3634	-0.1994	0.1789	-1.0329	6292997.442	4.6e-1366495
child6_single	-0.4409	-0.195	-0.1944	0.4843	-0.0432	-0.2707	0.6598	4772370.561	2.3e-1036295
rural_nocar	0.1136	-0.1204	-0.3185	-0.1612	-0.159	-0.2873	0.9328	5462808.48	6.1e-1186222
child6_nocar	-0.0375	-0.0809	-0.2842	-0.3308	-0.3986	-0.3245	1.4564	2500027.981	5.2e-542863
nocar + low inc.	0.6668	0.1515	-0.8987	-0.7375	-0.808	0.4234	1.2025	92306645.64	4.0e-20044119
lowedu_old	-0.4451	0.172	0.1901	0.1397	-0.065	-0.1894	0.1978	4226372.551	1.6e-917733
lowedu_child6	-0.7105	0.7037	0.229	-0.5334	-0.1576	0.378	0.0909	1996672.503	5.9e-433561
nocar_kidsinHH	0.1839	-0.0464	-0.4821	-0.0947	-0.4855	0.2425	0.6823	8198906.76	8.8e-1780358

Table C.7: Leisure purpose Interaction model covariate parameters part 2

Covariates	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Wald	p-value
K_urbanisation										
1	0.3332	0.032	-0.09	-0.1742	-0.0923	-0.104	0.315	-0.2197	57556063	7.1e-12498123
2	-0.3332	-0.032	0.09	0.1742	0.0923	0.104	-0.315	0.2197		
Ethnic backgr.										
Dutch	-0.0352	0.1858	0.0695	0.0222	0.1068	-0.1652	-0.2901	0.1061	21513595	3.7e-4671579
Western	0.0273	-0.1767	-0.0437	-0.0331	-0.044	0.142	0.1007	0.0275		
non-Wes.	0.0079	-0.0091	-0.0259	0.0109	-0.0628	0.0232	0.1894	-0.1337		
Gender										
male	-0.319	-0.3475	0.0088	-0.1233	-0.1681	-0.2105	-0.1709	1.3304	64145345	3.1e-13928967
female	0.319	0.3475	-0.0088	0.1233	0.1681	0.2105	0.1709	-1.3304		
Age										
6-29yrs	0.3329	0.0098	0.0613	-0.2662	-0.477	0.1765	1.0727	-0.91	3.65E+08	1.9e-79202815
30-64 yrs	-0.3299	-0.3728	0.1646	0.1623	-0.0345	-0.291	-0.1191	0.8204		
65+ yrs	-0.0031	0.363	-0.2259	0.1039	0.5115	0.1145	-0.9536	0.0896		
Income										
1	-0.1555	0.0287	0.2776	0.2899	0.3584	-0.1016	-0.2987	-0.3988	27529268	2.4e-5977865
2	0.1192	-0.0488	-0.2382	-0.1387	-0.2571	0.1177	0.2638	0.1822		
3	0.0362	0.0201	-0.0394	-0.1512	-0.1013	-0.016	0.0349	0.2166		
Education lvl										
1	2.4529	1.9824	-13.8758	1.4826	1.45	2.3688	1.2697	2.8693	6.76E+08	8.0e-146691475
2	-1.258	-1.2386	5.1019	-0.2208	-0.5053	-1.1769	-0.1601	-0.5421		
3	-1.0376	-1.3936	6.086	-0.3119	-0.8511	-0.9034	0.5103	-2.0985		
unknown/in education	-0.1573	0.6498	2.6879	-0.9499	-0.0935	-0.2885	-1.6199	-0.2287		
Travel w child										
no	0.3997	-0.3764	-0.0848	-0.0035	-0.6696	0.4828	-0.0831	0.3348	25100980	4.6e-5450592
yes	-0.3997	0.3764	0.0848	0.0035	0.6696	-0.4828	0.0831	-0.3348		

Table C.8: Work and education purpose Interaction model covariate parameters part 1

inter_rural_female	-0.1208	-0.1275	0.1745	0.1204	-0.216	-0.2317	0.1963	0.2049	8356609	3.2e-1814599
inter_rural_western	-0.2083	0.0013	0.2729	0.1905	0.113	-0.2197	-0.1698	0.0201	2133868	1.2e-463349
inter_rural_nonwestern	0.0529	-0.0706	0.0186	-0.0917	-0.1376	-0.0272	-0.0643	0.3198	647077.1	1.8e-140498
inter_rural_old	0.2552	0.5839	0.2327	0.1183	0.1643	-0.7483	-0.5743	-0.0319	6572038	6.5e-1427085
inter_rural_lowincome	0.015	0.0257	0.0229	0.0781	-0.1219	-0.2931	-0.1014	0.3747	1687311	2.7e-366381
inter_rural_lowedu	0.0612	-0.0526	-1.2527	0.4534	0.1327	0.5559	0.8743	-0.7723	10122156	1.2e-2197982
inter_rural_child6	0.5058	-0.413	-0.854	0.0506	-0.1012	-0.0642	0.7924	0.0835	5452137	1.1e-1183901
inter_rural_nocar	0.1411	-0.1009	-0.5719	-0.1997	-0.1165	0.3012	0.5945	-0.0477	6121345	3.4e-1329218
inter_rural_kids12	0.0066	0.4221	0.1453	-0.0366	-0.0057	-0.2092	-0.2908	-0.0317	17556423	1.3e-3812312
inter_western_woman	0.0212	0.1664	-0.0459	0.0257	-0.1782	0.0319	0.0843	-0.1052	1080096	8.6e-234527
inter_nonwestern_woman	-0.2146	-0.1319	-0.2459	-0.2231	-0.0344	0.1067	-0.1225	0.8657	2362311	1.8e-512955
inter_old_woman	2.1809	1.8627	1.9543	1.5922	1.8414	1.8355	2.154	-13.421	2005146	4.0e-435398
inter_woman_lowincome	-0.1362	-0.0977	0.0361	-0.0891	-0.267	-0.0417	0.1975	0.3981	3035491	3.4e-659134
inter_female_lowedu	-2.5518	-2.502	16.0453	-2.7688	-2.2965	-2.3737	-1.9824	-1.5701	2923554	1.5e-634827
inter_woman_child6	0.2341	-0.0255	-0.0314	0.1331	-0.2522	-0.262	-1.0633	1.2672	3635877	3.3e-789506
western_old	-0.5444	0.2289	-0.5652	-0.036	-0.4216	-0.0816	0.3749	1.045	3187389	2.1e-692118
inter_western_lowincome	0.0797	0.0973	0.2397	0.2009	0.0692	0.0703	-0.3837	-0.3733	2151078	7.0e-467087
inter_nonwestern_lowincome	0.1357	0.0276	-0.1717	0.0121	-0.113	0.2861	0.1972	-0.374	1621749	9.1e-352145
inter_western_lowedu	2.3069	2.515	-15.7288	2.4414	2.5704	1.6223	1.9749	2.2981	1979679	3.5e-429868
inter_nonwestern_lowedu	2.1127	2.4482	-15.3445	1.9796	2.7575	2.1199	1.8391	2.0876	2381178	2.5e-517052
inter_western_child6	0.2482	-0.2592	-0.0731	-0.313	0.2786	0.0014	-0.352	0.4691	943412.4	1.9e-204846
inter_nonwestern_child6	-0.0857	-0.4825	-0.6263	0.5433	-0.6945	0.385	-0.1794	1.14	4645488	2.9e-1008740
inter_old_lowincome	0.0048	0.1413	0.3419	0.1012	0.0105	-0.0754	-0.2575	-0.2668	510914.7	1.9e-110931
inter_old_lowedu	-1.7923	0.1158	0.3197	0.4811	0.4632	-0.3662	1.0796	-0.3009	3639594	2.3e-790313
inter_chil6_old	0.3287	-1.0503	-0.2575	-0.0756	-0.4079	-0.259	1.1192	0.6023	1043039	6.1e-226480
inter_lowedu_lowincome	-0.6303	-0.4717	2.5328	0.001	-0.0329	-0.5078	-0.3946	-0.4965	3492538	1.4e-758380
inter_lowincome_child	0.9124	-0.1033	0.0299	0.2839	-1.4269	-0.5014	1.5185	-0.7131	4143751	1.2e-899789
inter_lowincome_nocar	1.5409	0.8248	-2.0958	-1.0545	-1.7425	1.28	1.3304	-0.0832	1.08E+08	1.4e-23373044
inter_lowincome_kidsinHH	-0.2524	0.1769	-0.9633	0.2867	0.3622	-0.0504	0.1791	0.2612	4518382	1.6e-981139
inter_lowedu_child6	4.0597	-16.1649	-12.2249	4.1313	4.3149	5.5319	5.2637	5.0884	614084.1	3.3e-133334
inter_travelwchild_nocar	2.4142	2.1258	-15.4702	2.1682	1.5595	2.0496	2.4012	2.7518	537505.6	1.5e-116705
inter_nocar_kids12	1.5654	1.5195	-7.65	0.3841	0.3493	1.6286	1.3949	0.8082	12702988	4.1e-2758403
inter_single_child6	-0.6632	-0.6308	-0.1094	-0.1896	-0.0174	1.1648	-0.5723	1.0181	3428764	2.8e-744532
inter_single_kids12	-0.0817	0.1147	0.2566	0.2446	0.3948	-0.1718	-0.4347	-0.3225	4752074	5.6e-1031885
nonwestern_old	2.42	2.0195	2.6107	2.5815	2.2263	2.1407	1.9061	-15.9047	460870.9	1.1e-100064
other_lowincom	0.4005	0.5856	-1.9514	0.138	0.9902	0.1015	-0.0548	-0.2097	2440593	5.1e-529954
lowincome_couple	0.0751	0.0552	-0.2255	-0.3426	-0.182	-0.0691	-0.0764	0.7654	4229848	2.8e-918485
lowincome_single	0.0367	0.1394	-0.0942	-0.0232	0.198	-0.1781	-0.2815	0.2028	10321044	1.1e-2241170

Table C.9: Work and education purpose Interaction model covariate parameters part 2

Covariates	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8	Wald	p-value
urbanisation lvl										
urban	-0.195	-0.253	0.3748	-0.147	-0.1489	0.0077	0.644	-0.2827	48059342	3.2e-10435936
rural	0.195	0.253	-0.3748	0.147	0.1489	-0.0077	-0.644	0.2827		
gender										
male	0.1078	-0.1326	-0.3292	-0.1365	-0.3038	-0.1522	-0.0998	1.0464	57037641	6.0e-12385549
female	-0.1078	0.1326	0.3292	0.1365	0.3038	0.1522	0.0998	-1.0464		
ethnic backgr.										
Dutch	0.1339	0.0005	-0.0168	0.0857	0.2136	-0.0874	-0.2246	-0.1049	9819278	1.4e-2132192
Western	-0.083	-0.1239	0.0591	-0.0044	-0.1973	0.1512	0.1399	0.0583		
non-West.	-0.0509	0.1234	-0.0423	-0.0813	-0.0164	-0.0638	0.0847	0.0466		
Age										
1	-0.0702	-0.1675	0.1636	-0.3517	-0.1309	0.0436	0.8555	-0.3425	1.02E+08	5.1e-22170054
2	0.2177	0.073	-0.1958	-0.166	-0.378	-0.0665	0.2425	0.2731		
3	-0.1475	0.0945	0.0322	0.5177	0.5088	0.0229	-1.0981	0.0694		
Income lvl										
1	-0.4393	-0.7395	-0.1216	1.8689	-1.9793	1.2626	-0.3067	0.455	42835557	1.3e-9301582
2	0.0976	0.3519	0.1203	-0.9549	0.9806	-0.6221	0.2023	-0.1757		
3	0.3417	0.3876	0.0013	-0.914	0.9987	-0.6404	0.1044	-0.2793		
Education lvl										
1	-0.8031	-0.3029	0.3693	0.1662	0.5521	0.066	-0.6666	0.619	2.14E+08	1.1e-46383304
2	0.23	0.351	-0.2924	0.1812	-0.2772	-0.3626	-0.3908	0.5609		
3	0.7365	0.0326	-0.0256	-0.3452	-0.3922	0.0262	0.9854	-1.0177		
4	-0.1634	-0.0807	-0.0513	-0.0022	0.1173	0.2704	0.072	-0.1622		
travel w child										
no	0.1736	-0.0165	0.2612	-0.2939	-0.2023	0.1138	0.0659	-0.1019	1352274	3.5e-293629
yes	-0.1736	0.0165	-0.2612	0.2939	0.2023	-0.1138	-0.0659	0.1019		

Table C.10: Work purpose Interaction model covariate parameters part 1

lowedu_old	0.0434	-0.0607	0.1927	-0.1427	0.1322	0.3913	0.3125	-0.8687	2613688	5.0e-567541
lowedu_rural	-0.1995	-0.1555	0.2848	-0.0179	0.0883	-0.1097	0.2413	-0.1318	5863377	3.3e-1273201
lowedu_female	-0.0288	-0.0429	0.1389	0.006	0.3669	0.195	0.1044	-0.7395	7214119	7.6e-1566511
lowedu_western	0.2963	0.1601	-0.0923	0.0612	-0.015	-0.0192	0.2831	-0.6742	3561714	6.6e-773402
lowedu_nonwestern	0.2222	-0.2821	0.0933	-0.0863	-0.0219	0.2606	0.5028	-0.6885	7748835	5.8e-1682623
lowedu_lowincome	-0.0286	-0.1336	0.1655	-0.093	0.0626	0.1285	0.4148	-0.5162	3512658	1.4e-762749
lowedu_child6	0.2459	0.0003	0.3512	-0.274	-0.2813	0.0843	1.0327	-1.1592	1754800	2.8e-381036
old_rural	-0.0616	0.0048	0.1215	0.009	0.1747	-0.4562	0.2684	-0.0606	1353482	1.4e-293891
old_female	2.1976	1.8357	2.3604	2.1227	2.0272	2.1646	2.9842	-15.6923	2518202	1.4e-546806
old_Western	0.1738	-0.0133	-0.1534	-0.4486	0.3777	0.1669	0.3003	-0.4035	1482075	4.7e-321815
old_nonwestern	2.6375	2.9266	2.5937	2.3805	2.1511	1.5782	1.5522	-15.8198	1003401	7.6e-217873
old_lowincome	-0.1826	-0.1255	-0.0431	-0.1204	0.1196	0.0473	0.2989	0.0057	432280.4	2.1e-93856
old_child6	-0.5139	-0.0255	-0.3544	0.2457	-1.2876	-1.1774	0.8797	2.2335	2002565	1.3e-434837
rural_female	0.1413	0.1415	-0.1809	-0.1285	-0.1898	-0.295	0.1962	0.3153	7449636	1.1e-1617652
rural_Western	0.1974	0.1761	-0.0407	0.0348	0.0124	-0.3483	-0.2437	0.212	1349887	6.4e-293111
rural_nonwestern	0.2645	-0.0264	0.0861	0.0576	-0.2135	0.0552	-0.1954	-0.0281	901048	3.3e-195647
rural_lowincome	0.0271	0.1766	0.2218	-0.1123	-0.1148	-0.0856	-0.503	0.3902	2275297	1.6e-494060
rural_child6	-0.4225	0.2337	-0.2341	0.3873	0.298	-0.0577	0.2832	-0.4879	921096	1.6e-200000
rural_kids12	0.0944	0.0226	-0.1619	0.0397	0.2734	-0.2617	-0.2044	0.1979	5145356	5.1e-1117285
female_western	0.0417	0.1184	-0.0069	-0.056	0.4623	0.2319	0.2302	-1.0216	2587128	1.4e-561773
female_nonwestern	-0.1176	-0.1137	-0.1075	0.1309	0.0448	0.366	0.1226	-0.3255	2465023	7.4e-535259
female_lowincome	-0.0593	-0.1792	-0.2885	-0.3383	-0.1456	-0.2038	0.0285	1.1862	5665922	1.6e-1230324
female_child6	0.1946	-0.0308	0.2073	-0.2554	0.1093	0.0739	-0.8969	0.598	955789.9	3.4e-207534
western_lowincome	0.2255	0.2148	0.0817	0.1557	0.0411	-0.2005	-0.5853	0.067	2847596	1.5e-618333
nonwestern_lowincome	-0.1835	-0.0361	0.2875	-0.1959	0.2647	0.2069	0.1351	-0.4786	1911805	1.9e-415129
western_child6	0.2685	-1.2933	1.0926	0.1134	-1.0475	0.3169	-0.0691	0.6186	1534501	3.9e-333199
nonwestern_child6	0.4505	0.5792	0.1106	-0.0401	-1.219	0.9081	-0.4873	-0.302	1579033	3.5e-342869
lowincome_child6	-0.3925	-0.2955	-0.1906	-2.4433	0.9812	-0.482	1.5152	1.3075	2505101	7.4e-543962
lowincome_single	1.0258	1.6002	-0.1504	-2.1164	3.1084	-2.2349	-0.306	-0.9267	30303778	4.1e-6580365
lowincome_couple	0.8605	1.2133	-0.1157	-2.6145	3.014	-2.093	0.0172	-0.2817	28846440	3.5e-6263908
loweincome_other	-0.6301	1.4916	0.0397	-1.5099	3.6429	-1.7788	0.1445	-1.3999	0	1
lowincome_kids12	-0.691	0.1841	-0.4858	0.5627	0.1515	0.0273	0.2012	0.0499	3812541	2.4e-827868
child6_single	0.2227	-0.004	0.0489	0.8084	-1.6941	1.0847	-0.1618	-0.3047	1698448	9.8e-368800
rural_zerocar	-1.0566	-0.3253	0.0007	-0.3207	0.0606	0.3056	1.3968	-0.0611	13017314	4.6e-2826658
nocar_child6	-15.9956	1.7839	2.4668	0.9106	2.8301	2.3339	2.7397	2.9306	500308.2	2.6e-108628
lowincome_nocar	-3.0767	-1.1341	1.6105	-1.726	0.657	1.3854	1.5906	0.6933	79645068	4.3e-17294689
single_kidsinHH	0.4064	0.4908	-0.0826	0.4876	0.0384	0.1704	-0.4272	-1.0838	3822182	8.2e-829962
nocar_kidsinHH	-3.3696	-0.3133	1.1739	-0.3126	0.5649	1.1757	0.7995	0.2815	12933983	6.6e-2808563

Table C.11: Work purpose Interaction model covariate parameters part 2

D

Latent Class Model Probabilistic Details

This chapter entails the composition of all estimated latent class models.

D.1. Work and education

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8
Cluster Size	0.186	0.175	0.150	0.150	0.111	0.084	0.083	0.063
Indicators								
Mode choice								
car	0.0787	0.1078	0.872	0.9946	0.699	0.0448	0.0868	0.5822
public transit	0.04	0.0005	0.01	0	0.0011	0.2668	0.8792	0
active	0.8517	0.8605	0	0.0054	0.1569	0.6524	0.0068	0.0158
other	0.0296	0.0313	0.118	0	0.1431	0.036	0.0273	0.402
travel distance (in km)								
0-1.5	0.0488	1	0	0	0.0019	0	0	0
1.5-7.5	0.9512	0	0.0706	0	0.9981	0.246	0	0
7.5-20	0	0	0.9187	0.0517	0	0.752	0.1706	0.0975
20+	0	0	0.0106	0.9482	0	0.002	0.8294	0.9025
travel time (in mins)								
0-5	0.0048	0.607	0.0011	0	0.1543	0	0	0
5-15	0.5597	0.3913	0.3236	0.0015	0.817	0.003	0	0.0014
15-30	0.4309	0.0017	0.6571	0.284	0.0287	0.3683	0.0221	0.2718
30+	0.0045	0	0.0183	0.7145	0	0.6287	0.9779	0.7268

Table D.1: Model class compositions work/education travel purpose

D.2. Work

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8
Cluster Size	0.2139	0.1746	0.1712	0.1153	0.1119	0.0819	0.0796	0.0517
Indicators								
mode choice								
car	0.9905	0.8759	0.1798	0.6772	0.1492	0.1444	0.1847	0.3184
PT	0.005	0.0045	0.033	0.0009	0.0001	0.2607	0.7902	0
active	0.0037	0	0.7434	0.1522	0.799	0.5656	0.0133	0.0179
other	0.0008	0.1196	0.0438	0.1697	0.0517	0.0292	0.0118	0.6637
travel distance (in km)								
0-1.5	0	0	0.0482	0	1	0	0	0
1.5-7-5	0	0.012	0.9518	1	0	0.2388	0	0
7,5-20	0.0294	0.9798	0	0	0	0.761	0.154	0.117
20+	0.9706	0.0083	0	0	0	0.0002	0.846	0.883
travel duration (in mins)								
0-5	0	0.0007	0.0034	0.1718	0.6485	0	0	0
6-15	0.0015	0.3336	0.5747	0.8118	0.3507	0.0037	0	0.0009
15-30	0.3013	0.6508	0.4183	0.0165	0.0008	0.4231	0.0162	0.237
30+	0.6971	0.0149	0.0036	0	0	0.5733	0.9838	0.7621

D.3. Leisure

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7
Overall	0.203	0.1842	0.1582	0.1542	0.1435	0.1254	0.0316
Indicators							
Mode choice							
car	0.0011	0.0631	0.31	0.3344	0.2816	0	0.0098
public transit	0.1363	0.0034	0.0018	0.07	0.0004	0.0897	0.6985
active	0.3876	0.3087	0.0338	0	0.0293	0.2406	0
other	0.1885	0.1109	0.189	0.1721	0.1934	0.096	0.05
travel duration (in mins)							
0-5	0.0048	0.8158	0.179	0.0005	0	0	0
5-15	0.2934	0.193	0.3715	0.141	0.0007	0.0004	0.0001
15-30	0.3862	0.0009	0.02	0.3962	0.1303	0.0604	0.006
30+	0.0464	0	0	0.0533	0.4003	0.3933	0.1065
travel distance (in km)							
0-1.5	0.2242	0.7758	0	0	0	0	0
1.5-7.5	0.3578	0	0.3778	0.0671	0	0.1973	0
7.5-20	0	0	0	0.7169	0	0.2434	0.0397
20+	0	0	0	0	0.8537	0	0.1463

Table D.2: Model class compositions leisure travel purpose

D.4. Interactions work/education

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8
Cluster Size	0.1818	0.1736	0.1569	0.1519	0.1129	0.0851	0.08	0.0578
Indicators								
K_mode								
car	0.0458	0.1063	0.9937	0.8774	0.7251	0.0386	0.0643	0.5426
pt	0.0385	**0.0005**	0.0015	0.0081	0.0008	0.2779	0.9023	0
active	0.8838	0.8624	0.0048	0	0.1366	0.6437	0.0092	0.0154
other	0.0319	0.0308	0	0.1145	0.1375	0.0398	0.0242	0.442
travel distance (in km)								
0-1.5	0.0512	1	0	0	0.0076	0	0	0
1.5-7.5	0.9488	0	0	0.0861	0.9924	0.2469	0	0
7.5-20	0	0	0.0534	0.905	0	0.7509	0.1642	0.0994
20+	0	0	0.9465	0.0089	0	0.0021	0.8358	0.9006
Mean	1.9488	1	3.9465	2.9227	1.9924	2.7552	3.8357	3.9006
travel time (in mins)								
0-5	0.0065	0.6092	0	0.0014	0.1499	0	0	0
5-15	0.5666	0.3887	0.0019	0.3222	0.8123	0.0039	0	0.0016
15-30	0.4216	0.0021	0.2844	0.654	0.0377	0.3763	0.0207	0.264
30+	0.0053	0	0.7137	0.0224	0	0.6198	0.9793	0.7344
Mean	2.4257	1.393	3.7117	2.6975	1.8878	3.616	3.9793	3.7328
Covariates								
urbanisation level								
1	0.8287	0.6688	0.6543	0.6014	0.6597	0.7016	0.8248	0.5745
2	0.1713	0.3312	0.3457	0.3986	0.3403	0.2984	0.1752	0.4255
ethnic backgr.								
Dutch	0.7523	0.8109	0.8452	0.8283	0.8352	0.7351	0.7057	0.8327
Western	0.1017	0.0732	0.0794	0.0835	0.0717	0.1032	0.1125	0.0733
Non-West.	0.146	0.1159	0.0754	0.0882	0.0931	0.1617	0.1818	0.094
Gender								
male	0.4934	0.4802	0.6121	0.5647	0.5778	0.5384	0.5194	0.9464
female	0.5066	0.5198	0.3879	0.4353	0.4222	0.4616	0.4806	0.0536
Age								
1	0.5777	0.6395	0.2163	0.2314	0.2935	0.5226	0.5521	0.1291
2	0.3831	0.3047	0.7474	0.7219	0.6261	0.4431	0.4354	0.8374
3	0.0392	0.0558	0.0363	0.0468	0.0803	0.0343	0.0125	0.0335
K_income								
1	0.1725	0.12	0.0764	0.0971	0.0931	0.1449	0.1654	0.0824
2	0.3424	0.3462	0.2882	0.3694	0.3823	0.3403	0.3439	0.4446
3	0.4851	0.5338	0.6354	0.5335	0.5246	0.5148	0.4907	0.473
K_edu								
1	0.1047	0.0579	0.0014	0.0252	0.0374	0.1252	0.0298	0.0717
2	0.353	0.3018	0.3466	0.5712	0.5509	0.3696	0.4296	0.7486
3	0.3021	0.1736	0.6466	0.3651	0.2814	0.3189	0.5095	0.1166
4	0.2402	0.4667	0.0053	0.0386	0.1303	0.1863	0.0311	0.0631
Kind6								
Nee	0.9783	0.9152	0.9916	0.9832	0.9456	0.9856	0.9869	0.9871
Ja	0.0217	0.0848	0.0084	0.0168	0.0544	0.0144	0.0131	0.0129
travel purpose								
1	0.5987	0.4739	0.9471	0.9236	0.8291	0.6239	0.6809	0.9497
2	0.4013	0.5261	0.0529	0.0764	0.1709	0.3761	0.3191	0.0503
car ownersh.								
0	0.2486	0.1431	0.0199	0.0444	0.0484	0.2365	0.2977	0.0693
1	0.4327	0.4535	0.3542	0.4126	0.4502	0.4321	0.4157	0.4294
2	0.2508	0.3135	0.4651	0.3862	0.3544	0.2545	0.216	0.381
3	0.0679	0.0898	0.1608	0.1568	0.147	0.0769	0.0706	0.1204
kids								
0	0.7076	0.4709	0.7385	0.7579	0.6984	0.7532	0.8325	0.728
1	0.2924	0.5291	0.2615	0.2421	0.3016	0.2468	0.1675	0.272

K_HHSam<I>								
1	0.2688	0.1929	0.2081	0.2211	0.1945	0.2618	0.2969	0.182
2	0.7233	0.8047	0.7892	0.774	0.8014	0.7319	0.6918	0.8134
3	0.0079	0.0024	0.0027	0.0049	0.004	0.0063	0.0113	0.0045
inter_rural_female								
0	0.9149	0.8324	0.8568	0.8182	0.8662	0.8733	0.9097	0.976
1	0.0851	0.1676	0.1432	0.1818	0.1338	0.1267	0.0903	0.024
Mean	0.0851	0.1676	0.1432	0.1818	0.1338	0.1267	0.0903	0.024
rural + Western								
0	0.9925	0.9856	0.9814	0.9771	0.985	0.9859	0.9909	0.9814
1	0.0075	0.0144	0.0186	0.0229	0.015	0.0141	0.0091	0.0186
Mean	0.0075	0.0144	0.0186	0.0229	0.015	0.0141	0.0091	0.0186
rural + non-West								
0	0.9914	0.9868	0.9918	0.9895	0.9914	0.9826	0.9888	0.9857
1	0.0086	0.0132	0.0082	0.0105	0.0086	0.0174	0.0112	0.0143
Mean	0.0086	0.0132	0.0082	0.0105	0.0086	0.0174	0.0112	0.0143
rural + old								
0	0.9912	0.9757	0.9848	0.9789	0.9678	0.9932	0.9983	0.9852
1	0.0088	0.0243	0.0152	0.0211	0.0322	0.0068	0.0017	0.0148
Mean	0.0088	0.0243	0.0152	0.0211	0.0322	0.0068	0.0017	0.0148
rural + low inc.								
0	0.9846	0.9761	0.9791	0.9679	0.9766	0.9785	0.9848	0.9667
1	0.0154	0.0239	0.0209	0.0321	0.0234	0.0215	0.0152	0.0333
Mean	0.0154	0.0239	0.0209	0.0321	0.0234	0.0215	0.0152	0.0333
inter_rural_lowedu								
0	0.9784	0.9814	0.9997	0.9866	0.9868	0.942	0.9873	0.9816
1	0.0216	0.0186	0.0003	0.0134	0.0132	0.058	0.0127	0.0184
Mean	0.0216	0.0186	0.0003	0.0134	0.0132	0.058	0.0127	0.0184
inter_rural_child6								
0	0.9942	0.9725	0.9978	0.9934	0.9806	0.9964	0.9964	0.9959
1	0.0058	0.0275	0.0022	0.0066	0.0194	0.0036	0.0036	0.0041
Mean	0.0058	0.0275	0.0022	0.0066	0.0194	0.0036	0.0036	0.0041
inter_rural_nocar								
0	0.9833	0.9803	0.9952	0.9874	0.9908	0.9708	0.9792	0.9799
1	0.0167	0.0197	0.0048	0.0126	0.0092	0.0292	0.0208	0.0201
Mean	0.0167	0.0197	0.0048	0.0126	0.0092	0.0292	0.0208	0.0201
inter_rural_kids12								
0	0.9439	0.8251	0.9096	0.9079	0.9029	0.9234	0.9718	0.8866
1	0.0561	0.1749	0.0904	0.0921	0.0971	0.0766	0.0282	0.1134
Mean	0.0561	0.1749	0.0904	0.0921	0.0971	0.0766	0.0282	0.1134
western + woman								
0	0.9459	0.9582	0.9663	0.9603	0.97	0.949	0.9409	0.9967
1	0.0541	0.0418	0.0337	0.0397	0.03	0.051	0.0591	0.0033
Mean	0.0541	0.0418	0.0337	0.0397	0.03	0.051	0.0591	0.0033
non-western+woman								
0	0.9309	0.9409	0.9739	0.9648	0.9589	0.9185	0.9164	0.9877
1	0.0691	0.0591	0.0261	0.0352	0.0411	0.0815	0.0836	0.0123
Mean	0.0691	0.0591	0.0261	0.0352	0.0411	0.0815	0.0836	0.0123
old + woman								
0	0.9786	0.9731	0.9874	0.9844	0.9705	0.9856	0.9937	1
1	0.0214	0.0269	0.0126	0.0156	0.0295	0.0144	0.0063	0
Mean	0.0214	0.0269	0.0126	0.0156	0.0295	0.0144	0.0063	0
woman + low inc.								
0	0.9153	0.9369	0.9661	0.9565	0.9614	0.931	0.9157	0.9929
1	0.0847	0.0631	0.0339	0.0435	0.0386	0.069	0.0843	0.0071
Mean	0.0847	0.0631	0.0339	0.0435	0.0386	0.069	0.0843	0.0071
women + low edu								
0	0.9536	0.9725	0.9986	0.9919	0.985	0.9438	0.983	0.9929
1	0.0464	0.0275	0.0014	0.0081	0.015	0.0562	0.017	0.0071
Mean	0.0464	0.0275	0.0014	0.0081	0.015	0.0562	0.017	0.0071

inter_woman_child6								
0	0.987	0.9542	0.9951	0.9897	0.9744	0.9933	0.9952	0.9965
1	0.013	0.0458	0.0049	0.0103	0.0256	0.0067	0.0048	0.0035
Mean	0.013	0.0458	0.0049	0.0103	0.0256	0.0067	0.0048	0.0035
western_old								
0	0.9973	0.9949	0.998	0.996	0.996	0.9962	0.9978	0.9945
1	0.0027	0.0051	0.002	0.004	0.004	0.0038	0.0022	0.0055
Mean	0.0027	0.0051	0.002	0.004	0.004	0.0038	0.0022	0.0055
inter_western_lowincome								
0	0.9761	0.9862	0.9901	0.9877	0.9907	0.9791	0.9814	0.9939
1	0.0239	0.0138	0.0099	0.0123	0.0093	0.0209	0.0186	0.0061
Mean	0.0239	0.0138	0.0099	0.0123	0.0093	0.0209	0.0186	0.0061
inter_nonwestern_lowincome								
0	0.9645	0.9758	0.9938	0.9879	0.9877	0.9609	0.9601	0.9882
1	0.0355	0.0242	0.0062	0.0121	0.0123	0.0391	0.0399	0.0118
Mean	0.0355	0.0242	0.0062	0.0121	0.0123	0.0391	0.0399	0.0118
inter_western_lowedu								
0	0.9907	0.9959	1	0.998	0.9975	0.9944	0.9977	0.9957
1	0.0093	0.0041	0	0.002	0.0025	0.0056	0.0023	0.0043
Mean	0.0093	0.0041	0	0.002	0.0025	0.0056	0.0023	0.0043
inter_nonwestern_lowedu								
0	0.9796	0.989	1	0.9965	0.9904	0.9753	0.9953	0.9791
1	0.0204	0.011	0	0.0035	0.0096	0.0247	0.0047	0.0209
Mean	0.0204	0.011	0	0.0035	0.0096	0.0247	0.0047	0.0209
inter_western_child6								
0	0.9979	0.996	0.9994	0.9992	0.9952	0.9989	0.9992	0.9981
1	0.0021	0.004	0.0006	0.0008	0.0048	0.0011	0.0008	0.0019
Mean	0.0021	0.004	0.0006	0.0008	0.0048	0.0011	0.0008	0.0019
inter_nonwestern_child6								
0	0.9948	0.9895	0.999	0.9958	0.9952	0.9946	0.9954	0.9949
1	0.0052	0.0105	0.001	0.0042	0.0048	0.0054	0.0046	0.0051
Mean	0.0052	0.0105	0.001	0.0042	0.0048	0.0054	0.0046	0.0051
inter_old_lowincome								
0	0.9924	0.9893	0.9959	0.9943	0.9906	0.9946	0.9985	0.9979
1	0.0076	0.0107	0.0041	0.0057	0.0094	0.0054	0.0015	0.0021
Mean	0.0076	0.0107	0.0041	0.0057	0.0094	0.0054	0.0015	0.0021
inter_old_lowedu								
0	0.9993	0.9953	0.9999	0.9977	0.9946	0.9975	0.9995	0.9975
1	0.0007	0.0047	0.0001	0.0023	0.0054	0.0025	0.0005	0.0025
Mean	0.0007	0.0047	0.0001	0.0023	0.0054	0.0025	0.0005	0.0025
inter_chil6_old								
0	0.9996	0.9997	0.9998	0.9994	0.9978	0.9997	0.9997	0.9987
1	0.0004	0.0003	0.0002	0.0006	0.0022	0.0003	0.0003	0.0013
Mean	0.0004	0.0003	0.0002	0.0006	0.0022	0.0003	0.0003	0.0013
inter_lowedu_lowincome								
0	0.9678	0.9803	0.9988	0.9884	0.9815	0.9602	0.9897	0.9652
1	0.0322	0.0197	0.0012	0.0116	0.0185	0.0398	0.0103	0.0348
Mean	0.0322	0.0197	0.0012	0.0116	0.0185	0.0398	0.0103	0.0348
inter_lowincome_child								
0	0.9964	0.9948	0.9995	0.9982	0.9989	0.9982	0.9964	0.9989
1	0.0036	0.0052	0.0005	0.0018	0.0011	0.0018	0.0036	0.0011
Mean	0.0036	0.0052	0.0005	0.0018	0.0011	0.0018	0.0036	0.0011
inter_lowincome_nocar								
0	0.8708	0.935	0.9943	0.9832	0.9908	0.8994	0.8799	0.9748
1	0.1292	0.065	0.0057	0.0168	0.0092	0.1006	0.1201	0.0252
Mean	0.1292	0.065	0.0057	0.0168	0.0092	0.1006	0.1201	0.0252
inter_lowincome_kidsinHH								
0	0.9806	0.9686	0.9976	0.9906	0.9877	0.9809	0.9884	0.989
1	0.0194	0.0314	0.0024	0.0094	0.0123	0.0191	0.0116	0.011
Mean	0.0194	0.0314	0.0024	0.0094	0.0123	0.0191	0.0116	0.011

lowedu + travelwch								
0	0.9997	1	1	0.9998	0.9991	0.9986	0.9994	0.9988
1	0.0003	0	0	0.0002	0.0009	0.0014	0.0006	0.0012
Mean	0.0003	0	0	0.0002	0.0009	0.0014	0.0006	0.0012
travelwchild+nocar								
0	0.9956	0.9921	1	0.9991	0.9987	0.9963	0.9967	0.9973
1	0.0044	0.0079	0	0.0009	0.0013	0.0037	0.0033	0.0027
Mean	0.0044	0.0079	0	0.0009	0.0013	0.0037	0.0033	0.0027
nocar+kids in HH								
0	0.9617	0.9565	1	0.9934	0.9929	0.9618	0.977	0.9899
1	0.0383	0.0435	0	0.0066	0.0071	0.0382	0.023	0.0101
Mean	0.0383	0.0435	0	0.0066	0.0071	0.0382	0.023	0.0101
single+travelwchild								
0	0.9971	0.9944	0.9991	0.9981	0.9957	0.995	0.998	0.9968
1	0.0029	0.0056	0.0009	0.0019	0.0043	0.005	0.002	0.0032
Mean	0.0029	0.0056	0.0009	0.0019	0.0043	0.005	0.002	0.0032
single+kidsinHH								
0	0.9672	0.9496	0.9913	0.9856	0.9781	0.9689	0.9874	0.9932
1	0.0328	0.0504	0.0087	0.0144	0.0219	0.0311	0.0126	0.0068
Mean	0.0328	0.0504	0.0087	0.0144	0.0219	0.0311	0.0126	0.0068
nonwestern_old								
0	0.998	0.9988	0.9989	0.9984	0.9981	0.9982	0.9995	1
1	0.002	0.0012	0.0011	0.0016	0.0019	0.0018	0.0005	0
Mean	0.002	0.0012	0.0011	0.0016	0.0019	0.0018	0.0005	0
other_lowincom								
0	0.9961	0.9984	0.9998	0.999	0.9985	0.9972	0.9949	0.9998
1	0.0039	0.0016	0.0002	0.001	0.0015	0.0028	0.0051	0.0002
Mean	0.0039	0.0016	0.0002	0.001	0.0015	0.0028	0.0051	0.0002
lowincome_couple								
0	0.9527	0.9601	0.9685	0.9659	0.967	0.9549	0.9456	0.9617
1	0.0473	0.0399	0.0315	0.0341	0.033	0.0451	0.0544	0.0383
Mean	0.0473	0.0399	0.0315	0.0341	0.033	0.0451	0.0544	0.0383
lowincome_single								
0	0.6462	0.6634	0.7757	0.6894	0.662	0.6876	0.6966	0.6165
1	0.3538	0.3366	0.2243	0.3106	0.338	0.3124	0.3034	0.3835
Mean	0.3538	0.3366	0.2243	0.3106	0.338	0.3124	0.3034	0.3835

Table D.3: Work/education travel motive latent class model with interactions

D.5. Interactions work

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7	Cluster8
Cluster Size	0.2256	0.1875	0.1516	0.1233	0.1107	0.0791	0.0772	0.045
Indicators								
mode								
car	0.9899	0.8808	0.0753	0.7022	0.1535	0.0995	0.1774	0.1842
public transit	0.0064	0.0031	0.0342	0.001	0.0001	0.2789	0.809	0
active	0.0036	0	0.8478	0.1408	0.7944	0.5898	0.0136	0.02
other	0	0.1162	0.0427	0.1561	0.052	0.0317	0	0.7957
travel distance								
0-1.5 km	0	0	0.0619	0	1	0	0	0
1.5-7.5 km	0	0.0774	0.9381	1	0	0.2504	0	0
7.5-20 km	0.0414	0.9173	0	0	0	0.7485	0.152	0.128
20+ km	0.9586	0.0053	0	0	0	0.0011	0.848	0.872
Mean	3.9586	2.9279	1.9381	2	1	2.7507	3.848	3.872
travel time								
0-5 mins	0	0.0008	0.0038	0.1603	0.6552	0	0	0
5-15 mins	0.002	0.3309	0.5801	0.82	0.3439	0.0052	0	0.0011
15-30 mins	0.2997	0.6484	0.4115	0.0197	0.0008	0.4313	0.0156	0.2335
30+ mins	0.6983	0.0199	0.0046	0	0	0.5635	0.9844	0.7654
Mean	3.6963	2.6874	2.4168	1.8595	1.3456	3.5584	3.9844	3.7642
Covariates								
Urbanis. lvl								
urban	0.6425	0.5962	0.8425	0.6421	0.632	0.7917	0.9036	0.5543
rural	0.3575	0.4038	0.1575	0.3579	0.368	0.2083	0.0964	0.4457
gender								
Man	0.671	0.5775	0.4837	0.6004	0.466	0.5437	0.5421	0.9512
Vrouw	0.329	0.4225	0.5163	0.3996	0.534	0.4563	0.4579	0.0488
Herkomst								
Dutch	0.843	0.8343	0.7741	0.8454	0.8417	0.7315	0.6868	0.8672
Western	0.079	0.0825	0.1001	0.0731	0.0739	0.1142	0.135	0.06
Non-Western	0.078	0.0832	0.1258	0.0815	0.0844	0.1544	0.1782	0.0727
Age								
1	0.1757	0.1955	0.3101	0.2027	0.2769	0.2584	0.352	0.1605
2	0.7888	0.759	0.6301	0.7121	0.612	0.6925	0.6313	0.8113
3	0.0356	0.0454	0.0598	0.0852	0.1111	0.049	0.0167	0.0282
K_income								
1	0.0726	0.0951	0.1934	0.0956	0.151	0.1638	0.1758	0.1043
2	0.3079	0.3727	0.3678	0.3913	0.3707	0.3611	0.3503	0.4311
3	0.6194	0.5322	0.4388	0.5131	0.4783	0.4751	0.4739	0.4646
K_edu								
1	0.0089	0.0216	0.056	0.0403	0.0713	0.0428	0.0128	0.0674
2	0.4079	0.5851	0.464	0.6259	0.5705	0.4388	0.2726	0.7616
3	0.5714	0.3749	0.454	0.3101	0.327	0.4799	0.6964	0.1479
4	0.0118	0.0184	0.026	0.0237	0.0312	0.0385	0.0182	0.0231
Kind6								
Nee	0.9923	0.9887	0.9909	0.9844	0.9865	0.9869	0.9899	0.9928
Ja	0.0077	0.0113	0.0091	0.0156	0.0135	0.0131	0.0101	0.0072
HH constel.								
1	0.2009	0.2221	0.3012	0.2042	0.2463	0.2889	0.3124	0.1968
2	0.7964	0.773	0.6909	0.7912	0.7496	0.7024	0.6752	0.7973
3	0.0026	0.0049	0.0079	0.0046	0.0041	0.0087	0.0124	0.0059
car ownership								
0	0.0163	0.0415	0.2781	0.0504	0.1716	0.2725	0.3253	0.1085
1	0.3568	0.4129	0.4612	0.4537	0.4773	0.4558	0.4326	0.4721
2	0.4706	0.3902	0.2001	0.3425	0.25	0.209	0.1895	0.3144
3	0.1564	0.1554	0.0606	0.1535	0.1011	0.0627	0.0526	0.105
kids								
0	0.734	0.7664	0.8192	0.7763	0.7983	0.7961	0.8082	0.7519
1	0.266	0.2336	0.1808	0.2237	0.2017	0.2039	0.1918	0.2481

lowedu_old								
0	0.9859	0.9746	0.9687	0.9509	0.9354	0.9746	0.9938	0.9854
1	0.0141	0.0254	0.0313	0.0491	0.0646	0.0254	0.0062	0.0146
Mean	0.0141	0.0254	0.0313	0.0491	0.0646	0.0254	0.0062	0.0146
lowedu_rural								
0	0.8379	0.7422	0.9016	0.7523	0.7635	0.8928	0.9603	0.6412
1	0.1621	0.2578	0.0984	0.2477	0.2365	0.1072	0.0397	0.3588
Mean	0.1621	0.2578	0.0984	0.2477	0.2365	0.1072	0.0397	0.3588
lowedu_female								
0	0.8799	0.7682	0.7677	0.761	0.6865	0.8043	0.8849	0.9709
1	0.1201	0.2318	0.2323	0.239	0.3135	0.1957	0.1151	0.0291
Mean	0.1201	0.2318	0.2323	0.239	0.3135	0.1957	0.1151	0.0291
lowedu_western								
0	0.9679	0.9549	0.9635	0.9587	0.9636	0.96	0.9675	0.9655
1	0.0321	0.0451	0.0365	0.0413	0.0364	0.04	0.0325	0.0345
Mean	0.0321	0.0451	0.0365	0.0413	0.0364	0.04	0.0325	0.0345
lowedu_nonwestern								
0	0.9655	0.9598	0.944	0.9558	0.9596	0.9294	0.9354	0.9647
1	0.0345	0.0402	0.056	0.0442	0.0404	0.0706	0.0646	0.0353
Mean	0.0345	0.0402	0.056	0.0442	0.0404	0.0706	0.0646	0.0353
lowedu_lowincome								
0		0.9423	0.9071	0.939	0.9136	0.9224	0.9412	0.9324
1	0.0349	0.0577	0.0929	0.061	0.0864	0.0776	0.0588	0.0676
Mean	0.0349	0.0577	0.0929	0.061	0.0864	0.0776	0.0588	0.0676
lowedu_child6								
0	0.997	0.9944	0.9953	0.9918	0.9935	0.9946	0.9953	0.9978
1	0.003	0.0056	0.0047	0.0082	0.0065	0.0054	0.0047	0.0022
Mean	0.003	0.0056	0.0047	0.0082	0.0065	0.0054	0.0047	0.0022
old_rural								
0	0.9856	0.979	0.9863	0.9647	0.9502	0.9895	0.9966	0.9868
1	0.0144	0.021	0.0137	0.0353	0.0498	0.0105	0.0034	0.0132
Mean	0.0144	0.021	0.0137	0.0353	0.0498	0.0105	0.0034	0.0132
old_female								
0	0.9906	0.9866	0.9697	0.9713	0.9487	0.9808	0.9904	1
1	0.0094	0.0134	0.0303	0.0287	0.0513	0.0192	0.0096	0
Mean	0.0094	0.0134	0.0303	0.0287	0.0513	0.0192	0.0096	0
old_Western								
0	0.9971	0.9967	0.9958	0.9964	0.9903	0.9944	0.9974	0.9974
1	0.0029	0.0033	0.0042	0.0036	0.0097	0.0056	0.0026	0.0026
Mean	0.0029	0.0033	0.0042	0.0036	0.0097	0.0056	0.0026	0.0026
old_nonwestern								
0	0.999	0.9983	0.997	0.9982	0.998	0.9988	0.9995	1
1	0.001	0.0017	0.003	0.0018	0.002	0.0012	0.0005	0
Mean	0.001	0.0017	0.003	0.0018	0.002	0.0012	0.0005	0
old_lowincome								
0	0.9971	0.9953	0.9886	0.9909	0.9793	0.9919	0.9964	0.997
1	0.0029	0.0047	0.0114	0.0091	0.0207	0.0081	0.0036	0.003
Mean		0.0047	0.0114	0.0091	0.0207	0.0081	0.0036	0.003
old_child6								
0	0.9998	0.9994	0.9992	0.9974	0.9994	0.9996	0.9995	0.9976
1	0.0002	0.0006	0.0008	0.0026	0.0006	0.0004	0.0005	0.0024
Mean		0.0006	0.0008	0.0026	0.0006	0.0004	0.0005	0.0024
rural_female								
0	0.8744	0.8203	0.9234	0.8637	0.8135	0.9184	0.953	0.9749
1	0.1256	0.1797	0.0766	0.1363	0.1865	0.0816	0.047	0.0251
Mean	0.1256	0.1797	0.0766	0.1363	0.1865	0.0816	0.047	0.0251
rural_Western								
0	0.981	0.977	0.9926	0.9848	0.9841	0.9902	0.9937	0.9828
1	0.019	0.023	0.0074	0.0152	0.0159	0.0098	0.0063	0.0172
Mean	0.019	0.023	0.0074	0.0152	0.0159	0.0098	0.0063	0.0172

rural_nonwestern								
0	0.9902	0.9902	0.9942	0.9915	0.9921	0.9898	0.9947	0.9913
1	0.0098	0.0098	0.0058	0.0085	0.0079	0.0102	0.0053	0.0087
Mean	0.0098	0.0098	0.0058	0.0085	0.0079	0.0102	0.0053	0.0087
rural_lowincome								
0	0.9792	0.9673	0.9798	0.975	0.9656	0.9785	0.9882	0.959
1	0.0208	0.0327	0.0202	0.025	0.0344	0.0215	0.0118	0.041
Mean	0.0208	0.0327	0.0202	0.025	0.0344	0.0215	0.0118	0.041
rural_child6								
0	0.9978	0.995	0.999	0.9933	0.9934	0.9984	0.9989	0.9985
1	0.0022	0.005	0.001	0.0067	0.0066	0.0016	0.0011	0.0015
Mean	0.0022	0.005	0.001	0.0067	0.0066	0.0016	0.0011	0.0015
rural_kids12								
0	0.9065	0.9092	0.9735	0.9224	0.9165	0.9611	0.9823	0.8848
1	0.0935	0.0908	0.0265	0.0776	0.0835	0.0389	0.0177	0.1152
Mean	0.0935	0.0908	0.0265	0.0776	0.0835	0.0389	0.0177	0.1152
female_western								
0	0.9721	0.9623	0.9459	0.9711	0.9519	0.9407	0.9299	0.9984
1	0.0279	0.0377	0.0541	0.0289	0.0481	0.0593	0.0701	0.0016
Mean	0.0279	0.0377	0.0541	0.0289	0.0481	0.0593	0.0701	0.0016
female_nonwestern								
0	0.9775	0.9685	0.9413	0.9654	0.9559	0.9204	0.9219	0.9968
1	0.0225	0.0315	0.0587	0.0346	0.0441	0.0796	0.0781	0.0032
Mean	0.0225	0.0315	0.0587	0.0346	0.0441	0.0796	0.0781	0.0032
female_lowincome								
0	0.972	0.9578	0.9044	0.9619	0.9141	0.925	0.9137	0.9855
1	0.028	0.0422	0.0956	0.0381	0.0859	0.075	0.0863	0.0145
Mean	0.028	0.0422	0.0956	0.0381	0.0859	0.075	0.0863	0.0145
female_child6								
0	0.9957	0.9929	0.9934	0.9908	0.9898	0.9914	0.9956	0.9989
1	0.0043	0.0071	0.0066	0.0092	0.0102	0.0086	0.0044	0.0011
Mean	0.0043	0.0071	0.0066	0.0092	0.0102	0.0086	0.0044	0.0011
western_lowincome								
0	0.9907	0.988	0.974	0.99	0.9842	0.9787	0.9792	0.9908
1	0.0093	0.012	0.026	0.01	0.0158	0.0213	0.0208	0.0092
Mean	0.0093	0.012	0.026	0.01	0.0158	0.0213	0.0208	0.0092
nonwestern_lowincome								
0	0.9932	0.9893	0.9668	0.9897	0.9788	0.9638	0.9597	0.9896
1	0.0068	0.0107	0.0332	0.0103	0.0212	0.0362	0.0403	0.0104
Mean	0.0068	0.0107	0.0332	0.0103	0.0212	0.0362	0.0403	0.0104
western_child6								
0	0.9993	0.9998	0.998	0.9988	0.9996	0.9985	0.9989	0.9979
1	0.0007	0.0002	0.002	0.0012	0.0004	0.0015	0.0011	0.0021
Mean	0.0007	0.0002	0.002	0.0012	0.0004	0.0015	0.0011	0.0021
nonwestern_child6								
0	0.9987	0.998	0.9986	0.9988	0.9993	0.995	0.9971	0.9987
1	0.0013	0.002	0.0014	0.0012	0.0007	0.005	0.0029	0.0013
Mean	0.0013	0.002	0.0014	0.0012	0.0007	0.005	0.0029	0.0013
lowincome_child6								
0	0.9995	0.9992	0.9993	0.9998	0.9983	0.9984	0.9966	0.9983
1	0.0005	0.0008	0.0007	0.0002	0.0017	0.0016	0.0034	0.0017
Mean	0.0008	0.0007	0.0002	0.0017	0.0016	0.0034	0.0017	
lowincome_single								
0	0.9588	0.9393	0.8586	0.9392	0.8977	0.8873	0.8884	0.941
1	0.0412	0.0607	0.1414	0.0608	0.1023	0.1127	0.1116	0.059
Mean	0.0412	0.0607	0.1414	0.0608	0.1023	0.1127	0.1116	0.059
lowincome_couple								
0	0.9687	0.9665	0.9514	0.9668	0.954	0.9522	0.9411	0.955
1	0.0313	0.0335	0.0486	0.0332	0.046	0.0478	0.0589	0.045
Mean	0.0313	0.0335	0.0486	0.0332	0.046	0.0478	0.0589	0.045

loweincome_other								
0	0.9998	0.9991	0.9967	0.9983	0.9974	0.9967	0.9947	0.9997
1	0.0002	0.0009	0.0033	0.0017	0.0026	0.0033	0.0053	0.0003
Mean	0.0002	0.0009	0.0033	0.0017	0.0026	0.0033	0.0053	0.0003
lowincome_kids12								
0	0.9969	0.993	0.9935	0.9913	0.9911	0.9882	0.9896	0.9914
1	0.0031	0.007	0.0065	0.0087	0.0089	0.0118	0.0104	0.0086
Mean	0.0031	0.007	0.0065	0.0087	0.0089	0.0118	0.0104	0.0086
child6_single								
0	0.9992	0.9989	0.9986	0.9974	0.9995	0.996	0.9977	0.9978
1	0.0008	0.0011	0.0014	0.0026	0.0005	0.004	0.0023	0.0022
Mean	0.0008	0.0011	0.0014	0.0026	0.0005	0.004	0.0023	0.0022
rural_zerocar								
0	0.9967	0.9881	0.9808	0.9904	0.9724	0.9738	0.9775	0.9697
1	0.0033	0.0119	0.0192	0.0096	0.0276	0.0262	0.0225	0.0303
Mean	0.0033	0.0119	0.0192	0.0096	0.0276	0.0262	0.0225	0.0303
nocar_child6								
0	1	0.9997	0.9985	0.9997	0.999	0.997	0.9975	0.9979
1	0	0.0003	0.0015	0.0003	0.001	0.003	0.0025	0.0021
Mean	0	0.0003	0.0015	0.0003	0.001	0.003	0.0025	0.0021
lowincome_nocar								
0	0.9982	0.9855	0.8547	0.9907	0.9235	0.8841	0.8693	0.953
1	0.0018	0.0145	0.1453	0.0093	0.0765	0.1159	0.1307	0.047
Mean	0.0018	0.0145	0.1453	0.0093	0.0765	0.1159	0.1307	0.047
single_kidsinHH								
0	0.9921	0.9882	0.9872	0.9876	0.9893	0.9813	0.9909	0.9982
1	0.0079	0.0118	0.0128	0.0124	0.0107	0.0187	0.0091	0.0018
Mean	0.0079	0.0118	0.0128	0.0124	0.0107	0.0187	0.0091	0.0018
nocar_kidsinHH								
0	0.9998	0.9948	0.9752	0.995	0.9867	0.9681	0.977	0.991
1	0.0002	0.0052	0.0248	0.005	0.0133	0.0319	0.023	0.009
Mean	0.0002	0.0052	0.0248	0.005	0.0133	0.0319	0.023	0.009

Table D.4: Interactions model work travel purpose with all values

D.6. Interactions Leisure

	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Cluster7
Cluster Size	0.2058	0.1836	0.1597	0.1503	0.1438	0.1252	0.0317
Indicators							
mode							
1	0.0022	0.1515	0.8776	0.9563	0.8703	0.0016	0.093
2	0.0253	0.0006	0.0002	0.0166	0.0052	0.0262	0.8016
3	0.9463	0.833	0.0948	0	0.0943	0.9545	0.0431
7	0.0262	0.0148	0.0273	0.0271	0.0302	0.0178	0.0623
travel time							
1	0.0055	0.6403	0.1576	0.002	0	0	0
2	0.4895	0.3576	0.7996	0.3246	0.006	0.0016	0.0002
3	0.4549	0.0021	0.0425	0.5592	0.1996	0.1098	0.0394
4	0.0502	0	0.0003	0.1143	0.7944	0.8886	0.9604
Mean	2.5497	1.3618	1.8854	2.7858	3.7884	3.8869	3.9602
travel distance							
1	0.2617	1	0	0	0	0	0
2	0.7383	0	1	0.1602	0	0.6619	0
3	0	0	0	0.8398	0	0.3381	0.2323
4	0	0	0	0	1	0	0.7677
Mean	1.7383	1	2	2.8398	4	2.3381	3.7677
Covariates							
Urbanisation							
Level							
1	0.776	0.644	0.6687	0.6385	0.6563	0.7037	0.8587
2	0.224	0.356	0.3313	0.3615	0.3437	0.2963	0.1413
Geslacht							
Man	0.463	0.4502	0.4706	0.4704	0.5265	0.4942	0.443
Vrouw	0.537	0.5498	0.5294	0.5296	0.4735	0.5058	0.557
Herkomst							
Dutch	0.8234	0.8447	0.849	0.8361	0.8586	0.7782	0.7272
Western	0.097	0.0805	0.0768	0.0827	0.0743	0.105	0.1136
Non-Western	0.0795	0.0747	0.0743	0.0812	0.0671	0.1168	0.1593
K_age							
1	0.3952	0.408	0.3474	0.3095	0.2519	0.271	0.4761
2	0.4406	0.434	0.4925	0.4929	0.525	0.4821	0.3621
3	0.1642	0.1579	0.1601	0.1976	0.2231	0.2469	0.1619
K_income							
1	0.1944	0.1404	0.1055	0.1224	0.1133	0.1783	0.2886
2	0.3568	0.3719	0.3676	0.376	0.3918	0.4201	0.3548
3	0.4488	0.4877	0.5268	0.5016	0.4949	0.4016	0.3566
K_edu							
1	0.0702	0.0538	0.0404	0.049	0.0363	0.057	0.0516
2	0.4136	0.3962	0.4642	0.4577	0.4557	0.4476	0.4012
3	0.3493	0.3045	0.3235	0.357	0.4057	0.3333	0.4942
4	0.167	0.2455	0.1719	0.1363	0.1023	0.1621	0.053
Kind6							
Nee	0.9539	0.9313	0.9047	0.9039	0.9026	0.9125	0.9744
Ja	0.0461	0.0687	0.0953	0.0961	0.0974	0.0875	0.0256
K_carownership<I>							
0	0.231	0.1506	0.0586	0.0771	0.0723	0.1923	0.4379
1	0.44	0.4607	0.4562	0.469	0.493	0.4809	0.3749
2	0.2599	0.3039	0.3659	0.3411	0.3277	0.2569	0.1427
3	0.069	0.0848	0.1193	0.1127	0.107	0.0699	0.0446
K_kids12<I>							
0	0.7505	0.6471	0.6654	0.7204	0.7677	0.7485	0.8948
1	0.2495	0.3529	0.3346	0.2796	0.2323	0.2515	0.1052
K_HHSam<I>							
1	0.2839	0.2429	0.2007	0.2222	0.2101	0.2515	0.4162
2	0.7101	0.7539	0.7963	0.7751	0.7866	0.7441	0.5673
3	0.006	0.0032	0.003	0.0027	0.0033	0.0043	0.0165

lowedu_rural							
0	0.893	0.8429	0.8323	0.8181	0.8209	0.8523	0.93
1	0.107	0.1571	0.1677	0.1819	0.1791	0.1477	0.07
Mean	0.107	0.1571	0.1677	0.1819	0.1791	0.1477	0.07
lowedu_female							
0	0.7732	0.7737	0.749	0.751	0.7759	0.7638	0.7663
1	0.2268	0.2263	0.251	0.249	0.2241	0.2362	0.2337
Mean	0.2268	0.2263	0.251	0.249	0.2241	0.2362	0.2337
lowedu_western							
0	0.9648	0.9692	0.9636	0.9658	0.9703	0.9618	0.9573
1	0.0352	0.0308	0.0364	0.0342	0.0297	0.0382	0.0427
Mean	0.0352	0.0308	0.0364	0.0342	0.0297	0.0382	0.0427
lowedu_nonwestern							
0	0.9738	0.9758	0.9702	0.9669	0.973	0.9574	0.9369
1	0.0262	0.0242	0.0298	0.0331	0.027	0.0426	0.0631
Mean	0.0262	0.0242	0.0298	0.0331	0.027	0.0426	0.0631
lowedu_lowincome							
0	0.9063	0.9286	0.9382	0.934	0.9395	0.9074	0.8811
1	0.0937	0.0714	0.0618	0.066	0.0605	0.0926	0.1189
Mean	0.0937	0.0714	0.0618	0.066	0.0605	0.0926	0.1189
old_rural							
0	0.9602	0.9376	0.9424	0.9254	0.9154	0.9178	0.9733
1	0.0398	0.0624	0.0576	0.0746	0.0846	0.0822	0.0267
Mean	0.0398	0.0624	0.0576	0.0746	0.0846	0.0822	0.0267
old_female							
0	0.9116	0.9046	0.917	0.9015	0.9049	0.8822	0.9008
1	0.0884	0.0954	0.083	0.0985	0.0951	0.1178	0.0992
Mean	0.0884	0.0954	0.083	0.0985	0.0951	0.1178	0.0992
old_western							
0	0.9862	0.9841	0.9844	0.9811	0.9816	0.9757	0.9822
1	0.0138	0.0159	0.0156	0.0189	0.0184	0.0243	0.0178
Mean	0.0138	0.0159	0.0156	0.0189	0.0184	0.0243	0.0178
old_nonwestern							
0	0.995	0.9968	0.9983	0.9949	0.9969	0.9905	0.9879
1	0.005	0.0032	0.0017	0.0051	0.0031	0.0095	0.0121
Mean	0.005	0.0032	0.0017	0.0051	0.0031	0.0095	0.0121
old_lowincome							
0	0.9605	0.9586	0.9643	0.96	0.9649	0.9455	0.9596
1	0.0395	0.0414	0.0357	0.04	0.0351	0.0545	0.0404
Mean	0.0395	0.0414	0.0357	0.04	0.0351	0.0545	0.0404
oldage_child6							
0	0.9985	0.9985	0.9982	0.997	0.997	0.995	0.9981
1	0.0015	0.0015	0.0018	0.003	0.003	0.005	0.0019
Mean	0.0015	0.0015	0.0018	0.003	0.003	0.005	0.0019
rural_female							
0	0.8819	0.8025	0.8204	0.8055	0.8349	0.8493	0.9231
1	0.1181	0.1975	0.1796	0.1945	0.1651	0.1507	0.0769
Mean	0.1181	0.1975	0.1796	0.1945	0.1651	0.1507	0.0769
rural_western							
0	0.9893	0.983	0.9836	0.9769	0.9806	0.9783	0.9868
1	0.0107	0.017	0.0164	0.0231	0.0194	0.0217	0.0132
Mean	0.0107	0.017	0.0164	0.0231	0.0194	0.0217	0.0132
rural_nonwestern							
0	0.9933	0.9914	0.9936	0.9913	0.9907	0.9906	0.9867
1	0.0067	0.0086	0.0064	0.0087	0.0093	0.0094	0.0133
Mean	0.0067	0.0086	0.0064	0.0087	0.0093	0.0094	0.0133
rural_lowincome							
0	0.9742	0.9647	0.9701	0.9629	0.9684	0.9633	0.9694
1	0.0258	0.0353	0.0299	0.0371	0.0316	0.0367	0.0306
Mean	0.0258	0.0353	0.0299	0.0371	0.0316	0.0367	0.0306

rural_child6							
0	0.9884	0.9741	0.9694	0.9678	0.9681	0.9762	0.9969
1	0.0116	0.0259	0.0306	0.0322	0.0319	0.0238	0.0031
Mean	0.0116	0.0259	0.0306	0.0322	0.0319	0.0238	0.0031
rural_kids12							
0	0.9386	0.866	0.891	0.9042	0.9206	0.9254	0.9832
1	0.0614	0.134	0.109	0.0958	0.0794	0.0746	0.0168
Mean	0.0614	0.134	0.109	0.0958	0.0794	0.0746	0.0168
female_western							
0	0.9441	0.9545	0.9592	0.9595	0.9634	0.9443	0.9391
1	0.0559	0.0455	0.0408	0.0405	0.0366	0.0557	0.0609
Mean	0.0559	0.0455	0.0408	0.0405	0.0366	0.0557	0.0609
female_nonwestern							
0	0.9626	0.9637	0.9674	0.9571	0.9675	0.9458	0.9104
1	0.0374	0.0363	0.0326	0.0429	0.0325	0.0542	0.0896
Mean	0.0374	0.0363	0.0326	0.0429	0.0325	0.0542	0.0896
female_lowincome							
0	0.8867	0.9159	0.9345	0.9285	0.9434	0.9084	0.8284
1	0.1133	0.0841	0.0655	0.0715	0.0566	0.0916	0.1716
Mean	0.1133	0.0841	0.0655	0.0715	0.0566	0.0916	0.1716
female_child6							
0	0.9726	0.9582	0.9449	0.9452	0.9483	0.9465	0.9852
1	0.0274	0.0418	0.0551	0.0548	0.0517	0.0535	0.0148
Mean	0.0274	0.0418	0.0551	0.0548	0.0517	0.0535	0.0148
western_lowincome							
0	0.9747	0.9839	0.989	0.9885	0.9875	0.9767	0.9644
1	0.0253	0.0161	0.011	0.0115	0.0125	0.0233	0.0356
Mean	0.0253	0.0161	0.011	0.0115	0.0125	0.0233	0.0356
nonwestern_lowincome							
0	0.9766	0.9849	0.9884	0.9849	0.9901	0.9645	0.9368
1	0.0234	0.0151	0.0116	0.0151	0.0099	0.0355	0.0632
Mean	0.0234	0.0151	0.0116	0.0151	0.0099	0.0355	0.0632
western_child6							
0	0.996	0.9945	0.9931	0.9913	0.9925	0.9878	0.9986
1	0.004	0.0055	0.0069	0.0087	0.0075	0.0122	0.0014
Mean	0.004	0.0055	0.0069	0.0087	0.0075	0.0122	0.0014
nonwestern_child6							
0	0.9954	0.9934	0.9903	0.9866	0.9853	0.9848	0.9906
1	0.0046	0.0066	0.0097	0.0134	0.0147	0.0152	0.0094
Mean	0.0046	0.0066	0.0097	0.0134	0.0147	0.0152	0.0094
lowincome_child6							
0	0.9954	0.9968	0.9949	0.9955	0.994	0.9911	0.9975
1	0.0046	0.0032	0.0051	0.0045	0.006	0.0089	0.0025
Mean	0.0046	0.0032	0.0051	0.0045	0.006	0.0089	0.0025
lowincome_livealone							
0	0.8591	0.8968	0.9307	0.9195	0.9317	0.8813	0.7844
1	0.1409	0.1032	0.0693	0.0805	0.0683	0.1187	0.2156
Mean	0.1409	0.1032	0.0693	0.0805	0.0683	0.1187	0.2156
lowincome_couple							
0	0.9499	0.9641	0.9648	0.9588	0.9561	0.9425	0.9372
1	0.0501	0.0359	0.0352	0.0412	0.0439	0.0575	0.0628
Mean	0.0501	0.0359	0.0352	0.0412	0.0439	0.0575	0.0628
lowincome_other							
0	0.9966	0.9987	0.9989	0.9994	0.9989	0.9979	0.9899
1	0.0034	0.0013	0.0011	0.0006	0.0011	0.0021	0.0101
Mean	0.0034	0.0013	0.0011	0.0006	0.0011	0.0021	0.0101
lowincome_kids12							
0	0.9858	0.9852	0.987	0.9879	0.9918	0.9789	0.9924
1	0.0142	0.0148	0.013	0.0121	0.0082	0.0211	0.0076
Mean	0.0142	0.0148	0.013	0.0121	0.0082	0.0211	0.0076

child6_single							
0	0.9957	0.9948	0.994	0.9897	0.9933	0.9918	0.9925
1	0.0043	0.0052	0.006	0.0103	0.0067	0.0082	0.0075
Mean	0.0043	0.0052	0.006	0.0103	0.0067	0.0082	0.0075
rural_nocar							
0	0.9774	0.9758	0.9886	0.9828	0.9856	0.9772	0.9622
1	0.0226	0.0242	0.0114	0.0172	0.0144	0.0228	0.0378
Mean	0.0226	0.0242	0.0114	0.0172	0.0144	0.0228	0.0378
child6_nocar							
0	0.9935	0.9944	0.9961	0.9936	0.9957	0.9893	0.9858
1	0.0065	0.0056	0.0039	0.0064	0.0043	0.0107	0.0142
Mean	0.0065	0.0056	0.0039	0.0064	0.0043	0.0107	0.0142
nocar_lowincome							
0	0.8705	0.9269	0.9735	0.9641	0.9702	0.9	0.7661
1	0.1295	0.0731	0.0265	0.0359	0.0298	0.1	0.2339
Mean	0.1295	0.0731	0.0265	0.0359	0.0298	0.1	0.2339
lowedu_old							
0	0.9866	0.9836	0.9892	0.9844	0.989	0.9803	0.9869
1	0.0134	0.0164	0.0108	0.0156	0.011	0.0197	0.0131
Mean	0.0134	0.0164	0.0108	0.0156	0.011	0.0197	0.0131
lowedu_child6							
0	0.9995	0.9983	0.9985	0.999	0.9986	0.9973	0.9994
1	0.0005	0.0017	0.0015	0.001	0.0014	0.0027	0.0006
Mean	0.0005	0.0017	0.0015	0.001	0.0014	0.0027	0.0006
nocar_kidsinHH							
0	0.975	0.9787	0.9898	0.9856	0.9922	0.9711	0.9659
1	0.025	0.0213	0.0102	0.0144	0.0078	0.0289	0.0341
Mean	0.025	0.0213	0.0102	0.0144	0.0078	0.0289	0.0341

Table D.5: Latent Class model leisure travel purpose with interactions

E

Scientific Paper

The following pages entail a scientific paper summary of this thesis.

Why policy makers need to take into account the effect of sociodemographics on travel behaviour profiles: an explorative application of latent class analysis

N. M. Eichenauer, J. Bastiaanssen[1,*], N. van Oort[2], J.A.Annema[3] G.P. van Wee[3]

[1] *Verkeer & Mobiliteit, PBL Netherlands Environmental Assessment Agency, Den Haag, the Netherlands*
[3] *Technology, Policy and Management, Delft University of Technology, Delft, the Netherlands*
[2] *Civil Engineering and Geosciences, Delft University of Technology, Delft, the Netherlands*

E-mail: n.m.eichenauer@gmx.de

13 September 2023

Abstract The relation between sociodemographics and travel behaviour (TB) patterns is relevant to understand to devise policies that can direct people towards more sustainable travel options as well as to be aware of people's possibly restricted mobility for the sake of mobility justice. Especially in the Netherlands, both of these interests are relevant to the aim of broad welfare which has been formulated in 2019. In this research Latent Class Analysis was performed on the Dutch National Travel Survey combined datasets from 2018 and 2019 to uncover TB patterns. This analysis was conducted for necessary travels, such as work and work/education and leisure travel purposes and resulted in 7 distinct classes (8 for necessary travels) which each showed clear associations with specific sociodemographics. The results could be related to axes of disadvantage previously identified in a literature study and were subsequently assessed with 7 experts from the PBL Netherlands Environmental Assessment Agency. It was found that people who conform to many of the disadvantaging factors identified, such as low income, low education levels and women travel with active modes as well as public transit more often, possibly due to general modal disadvantage (i.e. difficult or no access to a car). Travellers who travel with children but besides that have other advantaging factors (high income, older age) or travellers who live in rural areas and thus have spatial disadvantages, travel by car more often, also for very short distances. Against initial expectations, the research did not necessarily show extensive difference in distance travelled for travellers with disadvantaging factors. Recommendations concluded from these findings include the need to detach car use from car ownership, by e.g. promoting car-sharing more as well as enabling travelling with young children to be possible on public transit (physically as well as information wise).

Key words: Transport justice, Sociodemographics, Accessibility, Latent Class Model

Introduction

How people travel and why they travel the way they do has become the focus of research and politics in recent years. On the one hand, this debate concerns the normative claim that people should be able to reach desired destinations by whatever mode they want to (Bersch and Osswald, 2021; Lucas, Mattioli, et al., 2016). On the other hand, the debate evolves around a practical need to shift to more sustainable modes of transportation to mitigate climate change and pollution especially in urban areas (Molin et al., 2016). In this context, the question arises whether it is possible for people to substitute less sustainable modes such as car with more sustainable ones (Lucas, Bates, et al., 2016). In a way, the two work together as people who cannot reach certain destinations by any other mode than car also will not be able to switch to a more sustainable option (leaving electric cars and the like aside). Thus, it is important to have knowledge of the capacity and ease to reach desired destinations that different people have by different modes both for mobility justice as well as to achieve a more sustainable future in terms of transport. Travel options can be constrained in a spatial sense, meaning that where someone lives there is e.g. just no good public transit connection but they can also be constrained by other factors, such as whether or not someone travels with a child, what their disposable income is, what their cultural upbringing is and so on. Understanding specific travel profiles and what causes them will thus shed light on why people travel a certain way and give

an idea of how that can be influenced through policy. Therefore, this research uncovers travel behaviour (hereafter TB) groups and how sociodemographic factors are connected to that by utilising Latent Class Analysis. Subsequently, the classes are mapped out to see the spatial distribution of TB to answer the main research question

"To what extent are different travel behaviour patterns associated with specific sociodemographic profiles and what are implications for transport policy?"

Literature Study

The costs and benefits of transport policy measures as well as of the wider transport system are generally unequally distributed over (groups of) people (van Wee and Mouter, 2021). Nevertheless, put simply, the aim of the transport system and transport policy in particular should be to enable people to travel from where they are to where they want to be (Van Wee and Geurs, 2011; Miller, 2018; Martens and Bastiaanssen, 2019; van Wee and de Jong, 2023; Pot et al., 2023; Lucas, Mattioli, et al., 2016). In addition, there is academic consensus that a good transport system should work towards enabling travellers to reach their desired destination by environmentally friendly, healthy and affordable modes such as active modes or public transit (Kroesen, 2019a; Bastiaanssen and Breedijk, 2022; Lucas, Bates, et al., 2016; Schwanen et al., 2004; Maat et al., 2005;Molin et al., 2016; Kroesen, 2019a).

While traditionally the measure for good transport policy has been mobility levels (i.e. to facilitate high throughput in the transport system) and thereby has focused on optimal car use, a rather recent shift in thinking has seen the focus move towards the concept of spatial accessibility (i.e. people being able to reach crucial destinations) by all modes (Pot et al., 2023; Handy, 2020; Mouter et al., 2017; Martens et al., 2019; van Wee and Mouter, 2021; Fransen and Farber, 2019; Kapatsila et al., 2023; Bastiaanssen and Breedijk, 2022).

Beyond mere spatial accessibility, other, mostly intangible factors also impact an individual's ability to travel and reach a certain destination. Apart from spatial and mode-related disadvantages, other axes of disadvantage include arbitrary non-chosen personal characteristics such as age, gender and ethnicity as well as possible impairments or special needs and other morally arbitrary factors such as income (Martens et al., 2019; Bastiaanssen et al., 2020 Van Wee and Geurs, 2011; Bersch and Osswald, 2021; Simma and Axhausen, 2003; Durmus, 2022; Fransen and Farber, 2019; Chowdhury and Van Wee, 2020; Lucas, 2012; Lucas et al., 2018 Kroesen, 2014; Lucas, Bates, et al., 2016). Some of those categories coincide with the other axes (such as low income and car ownership) whereas others can worsen the ability to fully make use of the transport system (see e.g. Chowdhury and Van Wee, 2020; Lucas, Bates, et al., 2016 or Lynch and Atkins, 1988).

while the general research on accessibility has increased in the past years, relatively little research has actually evolved around mobility realities for different travel groups (Lucas, Bates, et al., 2016). Although there is a significant body of literature regarding income-related accessibility inequality (see for example Bastiaanssen et al., 2020; Lucas, 2012; Barbosa et al., 2021; Lucas, Bates, et al., 2016), research on other personal characteristics such as gender is either merely qualitative or rather limited, or only used as control variables (see e.g. Cain et al., 2022; Joshi and Bailey, 2023; Durmus, 2022; Lucas, Bates, et al., 2016) and almost entirely lacking in the Netherlands (Durmus, 2022 being a notable exception). Although there is general agreement in the academic literature that specific personal characteristics (such as gender, ethnic background, age) (can) have a strong impact on the travel options that someone has in a similar manner as the built environment (see e.g. (Van Wee and Geurs, 2011; Bersch and Osswald, 2021; Kawgan-Kagan, 2015; Crass, 2020; Lynch and Atkins, 1988; Cascetta et al., 2013; Saeidizand et al., 2022), sociodemographics are not widely recognised as factors that restrict mobility so much that they could be called to limit accessibility. Contrary to that wide belief, recent studies, e.g. a study on travel barriers perceived by women and girls by InnovateUK (Cain et al., 2022), and a study on the differences in socio-economic characteristics of people in transport poverty (Fransen et al., 2022) conclude that while some physical barriers to transport are present for everyone, TB differs substantially based on personal circumstances and inherent characteristics. For some groups, while their spatial accessibility may be sufficient, certain personal characteristics inhibit travel decisions further. Most studies conclude that it is necessary to investigate TB in a differentiated manner in order to be able to direct policies towards the necessary groups (Lucas, Bates, et al., 2016). It needs to be established to what extent certain sociodemographics influence TB as if they were physical barriers. Assuming that everyone faces the same travel barriers may lead to overkill in policies for some groups and not having a sufficiently strong effect for others, thus helping no one. Especially in the policy context of broad welfare it is crucial to understand to what extent certain sociodemographic factors impact TB and also how, to be able to formulate fair and effective transport policy in the Netherlands (Chowdhury and Van Wee, 2020; Bersch and Osswald, 2021;Crass, 2020; Lynch and Atkins, 1988; Van Eenoo et al., 2022;Saeidizand et al., 2022).

Most of the studies on this topic known to the researcher and reviewed in this literature study assessed either only a certain, isolated TB dimension, such as travel time or mode choice or focused only on one specific sociodemographic factor. none of the studies reviewed examined TB patterns as comprised of multiple dimensions together (i.e. mode choice and trip distance and duration) although in reality those are all factors that appear together in any trip made by a traveller. There are many studies assessing certain social disadvantage factors and different travel dimensions separately, assessing these factors separately keeps the researcher from being able to holistically interpret people's TBs. When knowing that someone with a car travels longer distances, it is relevant to assess for what purpose they travel longer distances and what their other characteristics are. Policies are made for people, and assessing characteristics that people could have or could be part of without trying to understand their whole realities will miss out on central aspects of their travel decisions. A method that seems to enable the researcher to interpret the data more holistically is Latent Class

Analysis (LCA). The method allows for clustering of the data based on the aforementioned TB indicators mode choice, travel distance and travel time while including sociodemographics in the model to test their relation with the TB clusters. As for example outlined by Kroesen (2014), Latent class analysis is useful as a cluster method in transport domain as its probabilistic assignment reduces misclassification biases and the availability of statistical criteria to establish optimal cluster number allows for truly data-driven analyses. In that, it is superior to more traditional cluster methods, such as k-means deterministic clustering. Although it is a rather new technique, there are some studies that successfully applied LCA. For example, Kroesen (2014) built a latent transition model and thereby analyses to what extent there are travel clusters present in the Dutch travel population and how they change over time. The analysis showed that besides age and residential environment, a life changing event such as moving house has an effect on one's transport profile, but that is to a certain extent dependent on prior preferences and prior behaviour. A similarly strong effect was observed with regards to changing jobs. Generally, a main conclusion is that life events make people re-evaluate their travel patterns. However, this study mainly focused on mode choice, it was also pointed out to focus on other aspects of TB, such as travel duration or travel distance to get an even better understanding of people's TB. Molin et al. (2016) apply a related method, namely latent class cluster analysis to analyse the association of sociodemographics and attitudes with multimodal travel. They, however, do not include spatial variables in their analysis, limiting the conclusions regarding reasons for people's negative attitudes or non-multi-modal TB.

Methodology

As the overarching aim of this research is to establish to what extent specific TB patterns are associated with certain sociodemographic profiles, and what implications this brings for policy making, a mixed-methods approach was used. Accordingly, first the TB patterns and connection to sociodemographics were assessed based on quantitative data and by means of a quantitative method, namely Latent Class Analysis. In a second step, the findings were discussed with experts and researchers. The goal of applying qualitative methods to interpret and relate the findings to policy making in the Netherlands is to arrive at more meaningful conclusions and be able to understand the implications more in-depth.

Data

Data from the Dutch National Travel survey (Onderweg in Nederland, ODiN) from the years 2018 and 2019 was used. The dataset entails information about daily mobility of residents of the Netherlands aged 6 or older, excluding that of people living in closed health facilities or institutions (Centraal Bureau voor de Statistiek, 2018; Centraal Bureau voor de Statistiek, 2020 translated by author). Daily mobility means regular mobility including mobility due to tourism and excluding work related trip chains and excluding mobility with heavy freight vehicles and aviation. The dataset includes different travel purposes. They are defined on the journey level and not on the trip level and represent the general purpose of travel instead of the purpose of each individual trip travelled. For example, if one were to drop off their child on the way to work, the travel purpose of both of these trips would be 'work'. It is established in the scientific literature that trips that must be made (such as work or education related ones) show a different behaviour than leisure travels (Schwanen et al., 2004; Lucas, Bates, et al., 2016; Simma and Axhausen, 2003; Kroesen, 2014). When travelling for work, people have other kinds of considerations than when they travel for leisure (Bastiaanssen et al., 2020; Lucas, 2012; Lucas et al., 2009). For leisure, people might accept longer travel times as long as it is more affordable but for work there might be other considerations. Also, it is possible that leisure trips might not be made at all if the costs (monetarily or otherwise) are too high. Either way, it is considered crucial to differentiate between necessary travels (such as for work or education) and leisure travels as travels for both of these purposes are relevant to someone's life but might look very different. Studies have also shown different TB and effects of sociodemographics depending on the purpose of travel (Lucas, Bates, et al., 2016; Simma and Axhausen, 2003).

Latent Class Analysis

TB patterns are defined as the combination of the TB indicators mode choice, travel distance and travel duration. In order to assess which combinations of these indicators are most common and thereby identify which TB patterns exist in the Netherlands, a method had to be chosen that was able to find combinations in these indicators in the data. This method also had to accommodate including sociodemographic factors as predictor variables for the TB patterns in order to assess the role of sociodemographics. Latent Class Analysis (LCA hereafter) is a method that is used to find underlying classes in the data based on certain indicators. It subsequently assigns each research unit to a specific class with a certain probability. The goal of LCA is to maximise homogeneity within clusters and minimise heterogeneity between clusters (Magidson and Vermunt, 2002) which means that units within each group should be as similar as possible while groups itself should be very different from one another. Thus, by means of applying LCA, combinations in these TB indicators could be assessed and grouped. Moreover, when building a Latent Class model it is possible to include specific covariates that predict membership in the classes that were formed on the basis of the TB indicators. For the estimation of the model, the software Latent Gold will be used.
In order to keep the LCA meaningful and the model interpretable, the local independence assumption was relaxed. This meant that the model was not run with more than 10 clusters, even if some of the indicators are associated within-classes (thus even if no perfect heterogeneity is achieved). The calculated bivariate residuals were checked to see which variables are strongly correlated to be informed for further analysis. From the 10 estimated models, the one with

the best model-fit statistics while still being meaningfully interpretable was chosen.
Covariates were included in the model that were used to predict class membership. Conceptually, covariates (i.e sociodemographic factors) are prior to the observed TB and thus can be assumed to also logically precede the latent variable of TB patterns.
Once the model was obtained it was re-parameterised as a logit model and thus able to predict membership to certain classes based on the characteristics of a research unit (Vermunt and Magidson, 2013). This was done to not only assess mere class composition but to also identify which factors contribute more or less to class membership. Some variables had to be included as inactive covariates rather than active ones because the direction of causality was not clear. This was the case with car ownership as it is contested in the academic literature to what extent car ownership is a result of the need to travel further/lack of other choices or whether further travel is partly caused by car ownership (Handy, Weston, et al., 2005; Pot et al., 2023; Kroesen, 2019b). Once the model was run with up to ten clusters, the relevant goodness of fit and model parsimony indicators were assessed. Especially the Bayesian Information Criterion (BIC) was used as a guiding criterion - the lower the value the better fitting the model. The BIC indicator is estimated by evaluating the log-likelihood (L) and correcting for the number of parameters (k) as well as the number of observations (n) (Magidson and Vermunt, 2002) and is estimated as shown below:

$$BIC = k\ln(n) - 2\ln(L) \tag{1}$$

Latent Class Analysis Results

The LCA was performed with the indicators and covariates shown in tables 4 and 3. For each of the travel purposes, a separate latent class model was built with identical indicators and covariates and each model was estimated with up to 10 classes as can be seen in table 1. The optimal number of classes was determined using multiple criteria as outlined above. The model fit statistics for the LCA models for the work and education travel purpose as estimated for 1-10 classes is shown in table 1. It can be seen that the BIC values are lowest for the 10th model, however, the class sizes drop below 5% after the model with 8 classes. Hence, regarding work and education as well as work travels, the model with 8 classes fits best, while for leisure a model with 6 would be best. Nevertheless, in a model with only 6 classes, there would be no class with a public transit-dominant mode choice. Hence, it was decided to continue working with the model with 7 classes for leisure travels, although the 7th class, the public transit dominant class, entails only 3.16% of the sample size. What also becomes apparent from table 1, is that there is still very extensive association between the covariates. This is captured by the BVR which stands for bivariate residuals. Thus, it needs to be noted that the model does not achieve full heterogeneity between the estimated classes.

For all classes, class composition in terms of active as well as inactive covariates will be reported. As outlined above, the active covariates contribute to class formation while the inactive covariates do not define how classes are formed.

Estimation results

In all models, the sociodemographic covariates proved statistically significant in predicting class membership as all covariates had a sufficiently high Wald-test at significant p-values (¡ 0.001). It can be seen in table 2 that level of education is the most relevant covariate in terms of statistical effect across all travel purposes. The second and third most relevant covariate are age and level of urbanisation respectively, while this is the other way around for work. Gender comes fourth for necessary travels but it is the least impactful for leisure travel purposes. Instead, income comes fourth for leisure. Fifth most important for leisure is travelling with a child, while this is the least relevant for necessary travels. For necessary travel purposes (work and work/education), the two least relevant covariates are ethnic background and travel with a child, while it is ethnic background and gender for leisure.

Due to the similarities between the work and education as well as the work only model, only the work only model and the leisure model will be reported. The findings with regards to the work and education model can be summarised as lying in between the work and leisure models. There is more use of active modes and shorter distances, but the class compositions look very similar. In the work and education model, there are more traveller in the in-education category of level of education and in the youngest age group. Apart from this, the work and education model is rather similar to the work only model. Whenever the models have grave differences, this will be noted.

Latent class model - Work purpose

It can be stated that travelling by car is a more common way of transport than in the work and education motive travel as well as in leisure travel. The car clusters in only work travel make up 55.6% while it is 47.3% in work and education travels. Moreover, the active clusters amount to only 36.5% in only work travel, while it is 44.4% in work and education trips. The public transit user class is 8% large which is similar to work and education. However, the lone public transit user cluster has a larger portion of car travellers in only work related travels than they do in work and education related travels, namely 18.5%.

Class 1: Well situated long car travellers, 21.39%

More than a fifth of trips made for work only purposes last longer than 30 minutes and cover more than 20 kilometres by car. This class is dominated by Dutch males who are in the working age (30-64), have a high educational level and high income (in fact, this is the cluster with the highest income). Travellers in this class do not travel with children and tend to live in rural environments. Regarding the inactive covariates, this is the class with the highest ratio of 2 and 3 or more cars and the lowest ratio of people without a car. Moreover,

# of clusters	Log-Likelihood	BIC(LL)	# of parameters	Max. BVR
5-Cluster	-27859966534	55719934929	81	87174912
6-Cluster	-27500899367	55001801010	99	82864691
7-Cluster	-27198483047	54396968784	117	63679960
8-Cluster	-27042513608	54085030319	135	34546879
9-Cluster	-26965750326	53931504169	153	12513427
10-Cluster	-26913158049	53826320029	171	17595774

Table 1 Number of class estimation for work and education travel purpose selection of models with 5-10 classes

covariate	Work/education	Work	Leisure
Level of education	1	1	1
Age	2	3	2
Urbanisation level	3	2	3
Gender	4	4	7
Income	5	5	4
Ethnic background	6	6	6
Travel with child	7	7	5

Table 2 Covariate Ranking different travel purposes according to Wald test size

travellers live with their partner and with children younger than 12 above average.

Class 2: Suburban worker (medium distance car travel), 17.46%

The second class is similar to the first in terms of the sociodemographic makeup, but it differs in terms of the distance and travel time in so far as distances in between 7.5 and 20 kilometres are covered in 15-30 minutes. Similarly to class one, travellers in this class are also Dutch and are in between 30 and 64 years old. Travellers in this class tend to live in rural environments and have medium or high household income and a medium level of education. They also do not travel with children. As for the inactive covariates, they tend to have 2 or more cars. Interestingly, the gender divide is less extreme than in the well-situated-long-car-travellers' class, with 42% females in this class.

Class 3: Young urban new workforce/Low earner (Active 15 minute traveller), 17.12%

Class three is characterised by travellers who mainly use active modes (74%) and cover 1.5-7.5 kilometres in about 15 minutes (ranging from 6-30). It is the class with the second-highest ratio of female travellers and non-Western travellers and the class with the highest ratio of the lowest income group and above average medium-level income. Travellers in this class tend to have everything but a medium education level above average and they tend to be younger than 30 and live in an urban environment. Travellers in this class have up to one car only, 81% do not live with children and it is the class with the highest ratio of people living alone.

Class 4: Comfortable car travellers (Short car trips), 11.53%

Travellers in the short car trip group mostly travel by car and cover 1.5-7.5 kilometres in 6-15 minutes. People in this class tend to be of Dutch ethnic descent, are older, have medium or high income and medium education level. Moreover, it is the class with the highest ratio of travellers who travel with children and travellers in this class tend to live in more rural environments. People tend to have at least two cars and live with their partner.

Class 5: Work where they live travellers (¡15 mins active modes), 11.2%

In this active travel class, people cover up to 1.5 kilometres in up to 5 minutes (and in 35% up to 15 minutes). This class is defined by an above-average amount of travellers living in rural environments, they are majority females of Dutch descent. Travellers are either younger than 30 or older than 65 as this class has the lowest working age ratio. Travellers tend to travel with a child younger than 6 years old above average (1.4%) and also tend to have low and medium education levels and own up to one car per household. This class has the highest ratio of people with low education levels. The income levels are slightly lower than average but not alarmingly. This class can be interpreted as people who seem to work where they live, these people possibly even walk to where they work.

Class 6: Dedicated active travellers without alternative, 8.29%

Class six is also majority active-travels, although it also sees 26% of travellers going by public transit and 14% travelling by car. Generally, in this class trips take 16-30 minutes and cover distances of 7.5-20 kilometres. Travellers in this class live in urban environments, are above average females, non-Dutch and have lower income. They have everything but medium education levels and tend to travel with a child younger than 6.

Class 7: Lone public transit users, 7.96%

Travellers in class 7 use public transit in 79% of their trips (18.5% use car) and cover more than 20 kilometres while taking more than 20 minutes for it. This is the class with the highest ratio

of urban dwellers, non-Dutch travellers, it has the highest ratio of people younger than 30 but also with high education level. Travellers in this class tend to have lower income. People in this class have no car, and live alone.

Class 8: Skilled working class (Car and other work related travels), 5.17%

Class 8 is work related travel by using car and other modes. Trips in this class cover more than 20 kilometres and more than 30 minutes. 96% of travellers in this class are male. Moreover, this class is defined by being Dutch, aged 30-64, with medium income, low or medium education level and people do not travel with a child. Also, travellers in this class tend to live in rural environments and own at least one car. Travellers in this class live with their partners.

Axes of disadvantage

The largest covariate impact is that of gender on being in the work and other class (namely +1.3 for being male). Leaving this class aside, the largest impact is that of a high education level on being in class 7 (lone public transit users, +0.94) and the smallest impact is that of of Western descent on class 3 (active 15-minute city/young urban new workforce/low earner, +0.0005).
As for urbanisation level, living in a rural environment has the largest impact on class 7 (public transit class), namely -0.53. A similar effect (-0.38) can be observed with regards to class 3 (active 15-minute city/young urban new workforce/low earner). People living in rural environments are the most likely to be in class two, the suburban worker class (+0.28). Regarding the effect of gender, it is almost completely absent for classes 1 (well situated long car travellers) and 4 (comfortable car travellers (short car trips). Women are more likely, however, to be in all sustainable modes classes across all travel distances and time categories. Namely, the Active 15 minute/Young urban new workforce/Low earner class (+0.35), the Work where they live travellers (¡15 minutes active modes) (+0.39), dedicated active travellers without alternative (+0.2) and the Lone public transit users class (+0.18). The magnitude of the effect of ethnic background on class membership also differs a lot per class. For classes 1-3 it is almost entirely irrelevant (all effects ¡0.1), while class 4, 5 and 8 see a stronger effect of being Dutch (+0.15, +0.12 and +0.2 respectively). Classes 6 and 7 (dedicated active travellers and public transit users) however, are very negatively associated with being Dutch (-0.23 and -0.33) and are much more strongly associated with being of Western or non-Western ethnic background. Age has the largest effect on membership of class 7 (public transit users) whereas the youngest group is much more likely (+0.7) to be part of that group and the oldest much less likely (-0.76). However, being in the oldest age group is strongly associated with being in class 4 (comfortable car travellers (short car trips) or 5 (work where they live (¡15 minute active trips)) (0.44 and 0.56 respectively), indicating that older age is more strongly associated with shorter distances and travel times. The effect of income is strongest on class 1 (well situated long car travellers), 8 (skilled working class) and 4 (comfortable car travellers (short car trips)) where low income is very negatively associated with these classes (-0.25, -0.21 and -0.2 respectively). However, class 1 is most strongly associated with high income (+ 0.27) whereas class 8 is most associated with medium income (+0.16). Similarly, classes 5 (work where they live), 6 (dedicated active), and 7 (lone public transit users) are all associated with low income (+0.16, +0.19 and +0.18 respectively), showing a clear effect of lower income and more affordable options, yet covering all distances. As for education level, the effects on most classes are rather substantial. The largest effect is present for class 8 where high educational level is very negatively associated with class membership (-1.13), and a low and medium education level are very positively associated with it (+0.79 and +0.31 respectively). This effect is reverse for class 1 (well situated long car travellers). The impact of having low education level on being in this class is -1 while it is +0.89 for high education. Similar to class 1, class 7 (lone public transit users) is also strongly associated with the highest education level (+0.94) and strongly negatively associated with the low but also the medium education level. The low education level is most associated with being in class 8 (skilled workers class) (0.79) and class 5 (work where they live (¡15 minutes active modes)) (0.53). There are also strong associations with class 3 (Young urban new workforce/Low earner)(0.31) and class 4 (comfortable car travellers) (0.23).
Lastly, travelling with a child has a substantial negative effect on class 1 (well situated long car travels)(-0.26), and a strong positive effect on class 4 (comfortable car travellers (short car trips)) (+0.19), indicating an association of travelling shorter distances with a child, irrespective of mode. Apart from these two, however, the effects are very small (¡0.1).

Latent Class model - Leisure purpose

Overall, leisure travels tend to be more active, with 51.3% of the trips falling within active clusters. Car clusters amount to 45.6% of all trips and public transit was used in only 3.2%.

Class 1: Urban active 15-minute travellers, 20.3%

The largest class for leisure travel purposes is that of the active 15 minute travellers and it comprises trips of up to 7.5 kilometres and around 15 minutes (6-30 minutes). Travellers in this class tend to live in an urban environment, they are below-average non-Western but above average young, have low income and are in education or have a low level of education. People in this class do not travel with children, in fact, this is the class with the highest ratio of people not travelling with children. Regarding the inactive covariates, travellers of the active 15-minute class tend not to own a car and live alone.

Class 2: Nearby activities (¡15 minute active trips), 18.4%

The second largest class with 18.4% is also an active-travel class, but it comprises distances of up to 1.5 kilometres only and shorter travel times, namely a maximum of 5 minutes in 64% and in between 6 and 15 minutes in 36%. People in this class live in rural environments above average and are above average females. They are younger, Dutch, have a high household income and are in

	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Class 6**	**Class 7**	**Class8**	**Sample**
Cluster size	21%	17%	17%	12%	11%	8%	8%	5%	
Indicators (mean)									
Mode choice	car	car	active	car	active	active	public transit	other	
travel distance									
0-1.5km	0%	0%	5%	0%	100%	0%	0%	0%	
1.5-7.5km	0%	1%	95%	100%	0%	24%	0%	0%	
7.5-20km	3%	98%	0%	0%	0%	76%	15%	12%	
20+ km	97%	1%	0%	0%	0%	0%	85%	88%	
mean	3.97	3.00	1.95	2.00	1.00	2.76	3.85	3.88	
travel time									
0-5 min	0%	0%	0%	17%	65%	0%	0%	0%	
6-15 min	0%	33%	57%	81%	35%	0%	0%	0%	
16-30 min	30%	65%	42%	2%	0%	42%	2%	24%	
30+ mins	70%	1%	0%	0%	0%	57%	98%	76%	
mean	3.70	2.68	2.42	1.84	1.35	3.57	3.98	3.76	
Active Covariates									
Urbanisation									
Urban	64%	58%	85%	61%	63%	79%	90%	57%	69.4%
Rural	36%	42%	15%	39%	37%	21%	10%	43%	30.6%
Gender									
Male	66%	58%	48%	62%	47%	55%	54%	96%	58.6%
Female	34%	42%	52%	38%	53%	45%	46%	4%	41.4%
Ethnic background									
Dutch	85%	84%	77%	86%	84%	73%	69%	86%	80.4%
Western	8%	8%	10%	7%	7%	11%	14%	6%	9.2%
Non-Western	8%	8%	13%	7%	8%	15%	18%	7%	10.4%
Age									
6-29	18%	19%	30%	20%	28%	26%	35%	14%	23.6%
30-64	79%	76%	64%	72%	61%	69%	63%	83%	71%
65+	4%	4%	6%	9%	11%	5%	2%	3%	5.4%
Income									
0-30%	7%	9%	19%	9%	15%	16%	18%	9%	12.2%
30-70%	30%	37%	37%	39%	37%	36%	35%	44%	35.5%
70-100%	63%	54%	44%	52%	48%	48%	47%	46%	51.7%
Education level									
in edu/unknown	1%	2%	3%	2%	3%	4%	2%	2%	2.4%
low education	1%	2%	5%	4%	7%	4%	1%	7%	3.5%
medium education	39%	59%	46%	65%	57%	44%	27%	78%	49.9%
high education	59%	37%	46%	29%	33%	48%	69%	13%	44.2%
Travel with child younger than 6									
No	99%	99%	99%	98%	99%	99%	99%	99%	98.9%
Yes	0.7%	1.0%	1.0%	1.6%	1.4%	1.5%	1.1%	0.8%	1.1%
Inactive covariates									
Car ownership									
0	3%	5%	24%	7%	18%	25%	30%	8%	13.6%
1	35%	41%	47%	44%	48%	46%	45%	47%	42.5%
2	47%	39%	22%	34%	25%	22%	20%	34%	32.3%
3+	16%	16%	7%	16%	10%	7%	6%	11%	11.6%
Children aged 12 and younger in household									
No	73%	77%	81%	78%	80%	80%	81%	75%	77.7%
Yes	27%	23%	19%	22%	20%	20%	19%	25%	22.3%
Household constellation									
Single	20%	22%	29%	20%	25%	28%	31%	20%	24.4%
Couple	80%	77%	70%	80%	75%	71%	68%	80%	75%
Other	0%	0%	1%	0%	0%	1%	1%	1%	0.6%

Table 3 Latent Class Proportions; work travel purpose

education. In fact, this is the class with the highest in-education ratio of all leisure classes. Furthermore, 35% of travellers live with children in the household.

Class 3: Comfortable convenient short car trips, 15.82%

The third largest class for leisure purpose travel is that of short car trips. Trips in this class last in between 6 and 15 minutes and cover distances of 1.5-7.5 kilometres. Travellers in this class are Dutch, 30-64 years old and have medium education level. It is the class with the highest household income and travellers also tend to travel with children. As for the inactive covariates, this class is the one with the highest ratio of people owning 2 and 3 or more cars and the lowest ratio of people who own no car. Additionally, it is the class with the highest ratio of couple-households and 33% of travellers in this class have children aged 12 or younger.

Class 4: Medium distance car travel, 15.42%

Travellers in the fourth class tend to travel around 15-30 minutes and in between 7.5-20 kilometres by car. The travel time specifically is not very clear-cut, as 30% of trips are 6-15 minutes long while 10% are longer than 30%. However, 56% of trips in this class last 16-30 minutes. Travellers in this class tend to live in the rural areas of the Netherlands, as this is the class with the highest percentage of people living in a rural environment. Generally, this class is very similar to the short car travellers in terms of sociodemographic makeup. Travellers are in the working age or older, they have high income, medium education level and tend to travel with a child that is younger than 6. Moreover, travellers in this class have around 2 cars in the household and almost a third live with children younger than 12.

Class 5: Long car travel, 14.35%

The fifth leisure-purpose travel class are long car journeys and it is defined by being the class with the highest ratio of males, Dutch people and people who travel without children. Travellers in this class tend to live in rural environments, are older and have medium and high household income as well as medium and high education levels. As for the inactive covariates, this class sees 77% of travellers with no children in their household, travellers own at least one car and the majority lives with their partner.

Class 6: Dedicated active travellers, 12.54%

Similar to the other travel purposes, there is a class of active travellers who travel rather long (up to 20 kilometres) for leisure. These travellers take more than 30 minutes and are above average non-Dutch (both of Western and non-Western descent), are 30 years or older (this is the class with the highest ratio of travellers older than 65) and tend to have medium or high income (this is the class with the highest ratio of medium income). Regarding education level, travellers in this class have all but high education levels and tend to travel with a child younger than 6. Also, travellers in this class tend to have maximum one car.

Class 7: Lone public transit users, 3.16%

The smallest class, with only 3.16% is that of public transit users. Trips in this class take longer than 30 minutes and cover distances of more than 20 kilometres. This class has the highest ratio of travellers living in an urban environment, who are female, non-Dutch as well has have a low income and are not travelling with a child. Moreover, it also has the highest ratio of travellers with a high educational level. Additionally, this class also has the highest ratio of people with no car, and who live alone. Also, 89% do not live with children.

Comparison with work model

Regarding leisure, the effect of gender overall is much smaller than it is for the travel purpose of work, while the effect of income and travelling with a child or not is more significant. As for the general composition of the classes, it seem like the same, or rather similar profiles apply as in the work travel purpose. Interestingly, all car classes are associated with travelling with a child, which is one of the only differences from the work classes.

Effect of axes of disadvantage

Regarding the covariates for leisure travel, it can be stated that overall they have less severe impacts as the magnitude of the covariate coefficients ranges from 0.0015 effect of income on being in the nearby activities class) to -1.0123 (effect of being in education on being in the public transit class). Excluding the class of public transit, the largest effect shrinks to 0.492 (effect of being in education on being in the nearby activities class). This indicates that generally, sociodemographics are less relevant in predicting leisure travel behaviour than it is in predicting needs travels. The covariate with the largest impact is again educational level (see table 2) while gender is the covariate with barely any relevant coefficients as the coefficients for all clusters are smaller than 0.1. As it was decided to include the 7th class although it is smaller than 5%, the effects of covariates on this class are higher. Thus, in analysing the effect of the covariates and specifically the covariates that represent the axes of disadvantage, the largest impact without the public transit class also has to be listed.

Urbanisation level has the largest association with the urban active 15-minute class (class 1). Living in a rural environment is associated with this class with -0.175. Similarly, the 'lone PT user' cluster (cluster 7) is also negatively associated with rural environments, namely by -0.32. Nevertheless, very short active trips (nearby activities) and medium car trips are positively associated by living in a rural environment (0.14 and 0.15 respectively). This indicates that people living in rural environments decide their mode choice partly based on the distance that is to be covered.

Regarding ethnic background, similar to education and work related travels, having a Western (but non-Dutch) ethnic background has little to no effect in comparison to Dutch or non-Western ethnic background. Only regarding cluster one (urban affordable 15-minute travels), a slight effect of 0.11 of being Western non-Dutch can be observed, while a non-Western ethnic background has a negative effect of -0.19. Dutch ethnic background is associated by 0.08 with cluster one. Larger effects of ethnic background with regards to leisure travel can

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Sample
Cluster size	20%	18%	16%	15%	14%	13%	3%	
Indicators								
Mode choice (majority)	active	active	car	car	car	active	public transit	
travel distance								
0-1.5km	26%	100%	0%	0%	0%	0%	0%	
1.5-7.5km	74%	0%	100%	18%	0%	66%	0%	
7.5-20km	0%	0%	0%	82%	0%	34%	22%	
20+km	0%	0%	0%	0%	100%	0%	78%	
mean	1.74	1.00	2.00	2.82	4.00	2.34	3.78	
travel time								
0-5min	0%	64%	16%	0%	0%	0%	0%	
6-15min	48%	36%	81%	33%	1%	0%	0%	
16-30min	46%	0%	3%	56%	20%	11%	4%	
30+	5%	0%	0%	11%	79%	89%	96%	
mean	2.56	1.36	1.87	2.78	3.79	3.89	3.96	
Active Covariates								
Urbanisation								
Urban	78%	64%	67%	64%	66%	70%	86%	69.3%
Rural	22%	36%	33%	36%	34%	30%	14%	30.7%
Gender								
Male	46%	45%	47%	47%	53%	49%	43%	47.6%
Female	54%	55%	53%	53%	47%	51%	57%	52.4%
Ethnic background								
Dutch	82%	85%	85%	83%	86%	78%	73%	82%
Western	10%	8%	8%	8%	7%	10%	11%	9%
Non-Western	8%	7%	7%	8%	7%	12%	16%	8.7%
Age								
6-29	39%	41%	35%	31%	25%	27%	49%	34.6%
30-64	44%	43%	49%	49%	53%	48%	36%	47%
65+	16%	16%	16%	20%	22%	25%	15%	18.4%
Income								
0-30%	19%	14%	11%	12%	11%	18%	28%	14.9%
30-70%	36%	37%	37%	38%	39%	42%	35%	37.7%
70-100%	45%	49%	53%	50%	49%	40%	37%	47.4%
Education level								
in education/unknown	17%	25%	17%	14%	10%	16%	5%	16.5%
low education	7%	5%	4%	5%	4%	6%	5%	5.2%
medium education	41%	40%	46%	46%	46%	45%	39%	43.3%
high education	35%	30%	32%	36%	40%	33%	50%	35%
Travel with child younger than 6								
No	95%	93%	91%	90%	90%	91%	97%	92.2%
Yes	4.6%	6.9%	9.5%	9.6%	9.7%	8.7%	2.8%	7.8%
Inactive covariates								
Car ownership								
0	22%	15%	7%	8%	8%	20%	40%	15%
1	45%	46%	45%	47%	49%	48%	40%	45.9%
2	26%	30%	36%	34%	33%	26%	15%	30%
3+	7%	8%	12%	11%	11%	7%	5%	9.1%
Children aged 12 and younger in household								
No	75%	65%	67%	72%	77%	75%	89%	72%
Yes	25%	35%	33%	28%	23%	25%	11%	28%
Household constellation								
Single	28%	24%	20%	22%	21%	25%	40%	24.6%
Couple	71%	75%	80%	77%	78%	74%	58%	75%
Other	1%	0%	0%	0%	0%	0%	2%	0.4%

Table 4 Latent Class Proportions; leisure travel purpose

be observed in relation to cluster 6 (dedicated active travellers) and 7 (lone PT users). These are similar effects as observed in education and work related travels. Having a Dutch ethnic background is negatively associated with clusters 6 and 7, (-0.17 and -0.27 respectively) while having a non-Western background is positively associated with these clusters (0.16 and 0.27 respectively). The Western background effects are rather negligible.
As for age, the largest effects are observed with regards to cluster 6 and 7. Regarding the dedicated active travellers cluster (cluster 6), the older one gets, the higher the chance of being in this cluster. Regarding cluster 7, 'lone PT users', this is negatively affected by being middle aged (recall, this is the working age group) by -0.36, while being in the younger age group is both positively associated (0.6).
Regarding income, there is a positive association between higher income and being in the car clusters (clusters 3-5). The opposite is true for the lone PT users cluster (cluster 7) and the active travel clusters. Notably, especially the effect on the car clusters is larger on average than in the work/education and work related travel clusters.
As for the effect of educational level, there are some effects of size. First, the largest effect apart from that on being in the public transit class is the effect of being in education on being in the nearby activities class (0.492). All other education levels are negatively associated with being in this class. Moreover, having low levels of education is most strongly associated with being in class one, the affordable active 15-minute class. The effect of level of education on cluster 7 (lone PT users) is that it is negatively associated with still being in education (-0.8) and gradually increases with level of education until about 0.52 in the highest level of education. The reverse is true for cluster 7 (dedicated active travellers), albeit of smaller magnitude. Generally the active travel clusters are positively associated with lower educational level while the reverse is true for long distance car trips.
Travelling with a child has the largest effect on cluster 7 (lone PT users), where it is negatively associated with this cluster by -0.4. A similar association can be observed with regards to cluster 1 (affordable urban 15-minute travels), (-0.22), while the reverse holds for car-related clusters. Interestingly, the effect of this covariate on cluster membership overall is larger than when investigating needs travels (see also table 2).

Assessment of reasons for specific TB choices

Having reviewed the composition of the classes, the next step is to analyse to what extent certain TB can be attributed to specific sociodemographic profiles. This is relevant in order to infer how people's TB could be influenced by policy and to understand why people travel a certain way. First, in this section classes with similar mode choice are analysed in terms of their similarities or differences of sociodemographics. Next, classes with similar travel times and distances, yet different mode choices are analysed regarding their sociodemographic composition and spatial extension. Thus, it will be analysed to what extent sociodemographic factors seem to contribute to the specific mode choice or rather spatial circumstances.

Mode choice

In this section it will be assessed to what extent specific sociodemographic profiles for the specific mode choice clusters can be identified. For the assessment the mode choices will be divided along the lines of what modes would be desirable from a policy perspective. Thus, active modes and public transit are seen as desirable while the car is seen as less desirable.

Sustainable modes

Assessing the sustainable mode classes for work and education related travels, it becomes apparent that all classes share certain characteristics. While all active classes entail younger people, the 15-minute city, below 15 minute city as well as the dedicated active travellers classes are above average female. All active classes share that people have low levels of education or are in education, whereas the 15-minute class, the dedicated active travellers and the lone public transit users are all characterised by non-Dutch people with low income and with no car. Nevertheless, both the 15 minute city cluster and the public transit one also have an above average ratio of single households which could explain low household income.
Regarding work only, a similar profile can be identified. All active modes see above average ratios of females, all active classes and the public transit class are characterised by people that own 0 or max. 1 car. The very short active class has the same make-up in both work and education as well as education. For work only, however, urbanisation level is much more relevant. All sustainable clusters apart from the very short active class are defined by people living in urban environments.
As for the leisure motive, the profiles are not as similar as are the work and work/education travel purpose profiles, but extensive overlap in terms of sociodemographics becomes apparent. While the very short active modes cluster is characterised by people with high income, Dutch and younger people in rural environments, the long distance active class is characterised by non-Dutch, working age and older, medium or low income travellers who are in all but in the high education class. Contrastingly, the public transit class is characterised by female, urban, non-Dutch, young, low income but single household highly educated travellers with no car and no children. Overall, it can be stated that it can not be generalised in terms of which sociodemographics predict sustainable mode choice in leisure travels.

Car

As for the less sustainable mode choice of car for work and education related travels, some sociodemographics become apparent that are correlated to car use, namely being Dutch, in the working age or older, having medium education levels and owning at least one car. While the very short car class is characterised by travelling with children, the longer car travel one and the class in conjunction with other modes are not. Regarding the motive work only, class compositions seem very similar and will thus not be analysed in further detail.
Regarding trips made for leisure reasons, a more clear-cut profile than for the leisure sustainable modes can be identified. Travellers of all three classes are aged 30 or older, have higher

income and medium education level. Moreover, all travel with children above average and two out of three classes have an above average number of people living with children and with a partner. All classes see travellers with at least two cars.

Conclusion mode comparison

From this comparison it can be concluded that although there are some differences in the classes that have similar mode choice, a general tendency for sustainable modes to be chosen by young travellers, females and lower income groups can be observed. Interestingly, ethnic background also plays a role across all motives when looking at medium to long distance sustainable mode travels. However, the impact of ethnic background is very low, statistically speaking. Walking distances of up to 15 minutes as well as car use in general are associated with being of Dutch ethnic descent for all travel purposes. On the contrary, active travels of longer distances and public transit use is associated with not being Dutch. For car use clear profiles for both work (and education) and leisure could be identified. For leisure, this is an indication that while there is no clear trigger to use sustainable modes (as is income, ethnic background, gender for work), there seems to be a clear car-use profile. Car use seems to be a luxury that is reserved for the privileged. This can be seen from the clear association of it with working age, high income and medium education level. Although these sociodemographics cannot necessarily be said to trigger the need to travel by car, travelling with a child is. The fact that ownership of at least 1-2 cars is associated with car use especially for shorter distances, leads to the question as to whether one uses a car because one needs to or because one just has a car. It becomes a chicken-egg debate as to whether having a car causes people to use it or if they need it to fulfill their travel needs because any other mode is not feasible.

Journey types

The following section assesses the classes in which journey types (defined as similar travel duration and travel distance) are similar, yet the mode choice is different. The academic literature generally associates specific modes with certain journey types (i.e. car choice with longer and farther journeys), but the findings of this research suggest otherwise. Surprisingly, it does not seem like specific modes are necessarily only associated with specific spatial circumstances either.

Short journeys

The first journey type to be analysed is the short one. Specifically, this type is characterised by a journey distance of 1.5-7.5 kilometres and travel times around 15 minutes.

Assessing the work-only motive, it becomes apparent that the short car trips class is characterised by above-average rural travellers, whereas the active travellers are very clearly predominantly urban dwellers. The active travellers are above average females and belong to the younger age groups while the car travel class is characterised by older travellers. The active travellers are also those with the lowest income across all classes while in the work only car class, the car travellers have a higher income. Overall, the active travellers also have the highest ratio of people living in single households with 0-1 car and no children. Contrarily, short car trip travellers have 2 or more cars, have the highest ratio of people living in with their partners and travelling with children. On top, a spatial contrast between the Randstad and the more rural areas of the Netherlands becomes apparent. However, it can also be seen from both the statistics as well as the maps, that the effect of rurality/non-urban environments on whether or not someone travels by active modes is larger than that of living in an urban environment is on short car trips. Statistically, the effect of urbanisation level is more than twice as high for active travels than it is for car travels. Thus, while rurality seems a deterrent to active travels, urbanity is not as much for short car trips.

Regarding short journeys for leisure, similarly to work only the active 15-minute cluster seems to be good fit as a possible substitution cluster. Similarly to work and education trips, travellers in the active travel cluster are more confined to the urban environment of the Randstad area while short car trip travellers are not so much to be found only in rural environments. Also similar to the other motives, active travellers tend to be younger while car travellers are in the second age group (29-64). Again, active travellers have lower incomes than car travellers, however, they also tend to live alone, whereas short car trip travellers have the highest ratio of people living with their partners (which can also increase household income). Nevertheless, the active travellers also tend to have a lower education level than the car travellers. The latter also have the highest ratio of 2 and 3 or more cars as well as the lowest ratio of travellers owning 0 cars. In line with expectations, the leisure active travellers have the highest ratio of people not travelling witch children whereas that is the exact opposite for short car trip travellers.

Overall, it seems like the short journey classes have similar characteristics for all of the purposes. Moreover, while a connection between factors cannot be assumed without doubt, it seems like these findings can be categorised in groups of life stages. Whereas it seems that being 'further in life' (i.e. older age, living with a partner, higher household income, higher education levels, having children) is associated with short distance car travel, 'earlier life stages' (i.e. younger, lower income, living alone, not owning a car, in education or low education) are associated with active travels. This trend is consistent over all travel purposes and can be assumed to be connected to people's need for comfort and convenience. Nevertheless, the spatial aspect of the travel choice is very interesting. As noted for leisure travels, short car trips are present in all areas of the Netherlands. For the work travel purpose, the effect of urbanisation level is less strong for car than for active modes. This effect indicates that for work short car travels, spatial circumstances are less relevant than sociodemographic ones.

Long distance travel

On the other end of the journey-characteristic-spectrum are the long travel times (30+ mins) and long distance (20+km) journeys. As for the work travel purpose, 2 modes could be substituted in this journey type, namely car and public transit. The long car travel class is the largest for work travels and it

entails 21% of the trips. The public transit group, cluster 7, is 8% of the trips. The long car travel cluster is characterised by consisting mostly of males and people who are in the working age group (29-64). It is the cluster with the highest ratio of Dutch people, and of people who have both high income as well as high levels of education. While it is the cluster with the highest ratio of people fulfilling these characteristics, it is also the highest ratio of people not travelling with children and most of those travellers also do not live with children. This cluster is neither confined to a specific geographic area in the Netherlands, nor to a specific level of urbanisation.
On the contrary, the public transit cluster consists mainly of travellers from the urban areas. They almost perfectly mirror the medium distance car class as they are above average female, non-Dutch, younger and have rather low income (again, this can be due to the fact that they have a very high ratio of travellers living in single households). While the car cluster travellers own at least 2 cars, the public transit class is the one with the highest ratio of people who do not own a car. Both the car and the public transit cluster have travellers with a high educational level and both classes do not travel with children.
Regarding leisure travel, the long car travel and public transit clusters look similar to the ones in the work motive ones, with a few differences. While it seems to be a lot more rare in general to travel long distances and long times for leisure (as the clusters are overall much smaller than in the work-related motives), the compositions are diametrical opposites. Whereas the long car trip class is characterised by more rural travellers, it is the class with the highest ratio of males, of Dutch people and with the lowest ratio of people younger than 29. On the contrary, the public transit class sees the highest ratio of urban dwellers, females and non-Dutch travellers. It consists of rather young travellers and has the highest ratio of single as well as low income households, while also entailing the highest ratio of travellers with high educational level and of people with no car and no children. On the contrary, the car cluster is characterised by people with medium or high income who live with their partners and have at least one car. Whereas the car class has the highest ratio of people travelling with children, the public transit class has the highest ratio of people travelling without children. Spatially, in line with the level of urbanisation trend apparent in the different classes, it becomes obvious that people living in the randstad area have a higher chance of belonging to the long public transit class instead of the long car class. The contrast, however, is less clear than with the aforementioned short trip classes.
Overall it becomes apparent that while urbanisation level and especially whether or not one lives in a city is a positive driver for public transit use, this relationship is less strong for urbanisation level and car use, especially when it comes to work and education travels. Apart from that, similar sociodemographic trends in the different classes can be observed to the short journey type. Age seems to be a very important driver in TB, along with gender and also ethnic background. While the effect of educational level seems to be associated with long journeys rather than mode choice specifically, it is high for all long journey classes independent of travel purpose. It seems like high income and favourable sociodemographic characteristics enable (or at least are associated with) car travel for long distances. A similar effect is observed for travelling with children younger than 6 which is a logical finding.

Expert Input

In order to assess the policy relevance of the findings, experts were consulted to interpret and possibly categorise the findings as relevant in policy contexts. The focus group session was held with 7 expercts from the research team of V&M (traffic and mobility) at the PBL Netherlands Environmental Assessment Agency. To begin, the researchers were outlined the research problem and objective and were given a short presentation of the methodology applied. During the focus group workshop, the researchers were confronted with 3 main topics from the research and asked to comment and discuss along the lines of guiding questions.

Interpreting travel purpose differences

The first topic that was discussed with the researchers was the general finding that leisure travel is more active than work related travels. The researchers reacted by stating that they were neither surprised by the general finding, nor by the specific regions that were indicated on the maps as car-dominant or active-mode-dominant. They stated that going to work is often associated with trip chaining and that that thus is more easily done by car which explains why the car is most common when it comes to work travels. They hypothesized that for most people that use the car for shorter distances, this is due to the need for trip chaining and ease of doing it by car. The researchers also stated that going to sports, 'people are not in such a hurry' (Focus Group interview, researcher 4). While an interesting claim, it cannot be substantiated by literature. If people attend certain sports classes, their time of arrival is similarly fixed as someone's working hours. It seems rather that, people's perception of a leisure-related journey is generally different (**meng2018public**). Thus, while the trip to work is already perceived as taking longer and being less pleasurable, the trip to a leisure activity is perceived as part of leisure.

Role of sociodemographics in mode choice

The second topic of the discussion was that the sustainable clusters were mainly associated with sociodemographic factors that are generally thought to be more disadvantaging in society. The discussion first moved towards the fact that the work travel purpose overall has more clear-cut profiles than the leisure purpose. The researchers argued that this could be due to leisure travels being more diverse in general than work or work and education related travels. A possible reason for that was hypothesised to be routine, whereas with leisure travels one has more possibilities to also choose different modes. This hints at the fact that leisure travel is not as time constrained in terms of time of day. What's more, another hypothesis brought forward by researcher 2 was that as the type of trip is more diverse with regards to leisure 'going to the sports club, going to meet friends, going to the cinema' (Focus group session, researcher 2), the travel behaviour is different according to the

diversity of types of purposes rather than types of people.

The researchers were puzzled by the class of very short sustainable modes for leisure (nearby activities). The researchers concluded that these are probably students who still live at home. The researchers also found especially interesting that the very short sustainable travels group were present in rural areas. This is partly due to the general understanding that the rural environment is mainly associated with higher trip distance, rather than ultra-short ones. Overall, they saw an interesting connection that people living in rural areas tend to either make very short trips with active modes or longer trips by car. Intriguingly, the 6-30 minute active travel class is more often present in urban environments, meaning that in rural environments it is indeed either a within-village very short trip or a longer car ride. The researchers agreed that is was a very interesting and relevant finding especially for policy.

Next, when shown the car clusters for work, they found the clusters especially interesting in terms of policy making as it could be concluded that the parent who works closest to child care probably takes the child on their way to work. They stated that it might simply be difficult for people to take children if they go for work and not travel by car. According to the researchers, a more in-depth investigation of what kind of trips are made with children and more research on what the main barriers for people travelling with children are is necessary.

Concerning both work and work and education long trips, they stated that the findings are in line with expectations, for example that higher income is associated with longer car work travels. They stated that in line with prior research, three groups can be identified for which it makes sense to travel less by car. Those groups are people with low income for who it 'makes sense that they do not have a car' (Researcher 4), and these are 'young people, women and non-Westerners'. One researcher also stated that 'if we want more sustainable travels, we definitely need the females' (Researcher 2), alluding to the fact that females are over-represented in most of the more sustainable travel classes, that is they are above-average in both active work and work and education classes, as well as in the dedicated active travellers work related motive class and in all public transit classes. This is, however, not related to the fact that women tend to be more mindful and sustainable by nature but that they still take up roles in the household that put them in a position of being less mobile and travelling closer to home (see e.g. Schwanen et al., 2004). Another researcher also stated that 'in the lower income households, if you can only have one car, statistically it is usually the man who takes the car'. Taking into account that these roles are slowly but steadily overcome in the Netherlands, and given that those who have a free transport choice seem not to choose to travel short or medium distances by active modes or the long distances by public transit,it seems like the car will be used increasingly more.

Interpreting substitution opportunities

The third topic that was discussed was that of possible substitution opportunities, given by similar journey characteristics and yet different mode choice. The team commented that income and car ownership are important predictors of car travel even for the same distance and travel times. They stated that although a car should not be a deterrent to using active modes, it seems that once someone owns a car, they intend to use it. Researcher 2 described this as 'having a car is not a limitation on using active modes' but also stated that it looks as if that was the case.

Another clear factor connected to using car when alternatives could be available was travelling with a child. Researcher 2 reacted by stating that it should not be impossible to travel with a child and without a car. They also stated, however, that many people think it indeed is impossible to travel with children without a car and that having a car is necessary when having children.

Furthermore, another factor that was picked up by the researchers is the in-parts clear spatial pattern. They, however, also stated that it also alludes to the fact that the car-culture in rural areas is different from cities. The researchers concluded that the general finding of car use also when there does not seem to be a reason for it was due to strong car travel cultures present. According to the researchers, these different travel cultures can be said to be confined to specific areas (e.g. Randstad vs non-Randstad area) but also to broader cultural background, which can be inferred from car travels being associated with above-average ratios of people with a Dutch ethnic background.

As for substitution possibilities with regards to leisure travels, the researchers stated that the profiles are difficult to assess due to the diversity of leisure travels. They assume that the journeys in the car class differ substantially from the journeys in the active classes. In line with their expectations, however, they found that travellers with high income and medium education are rather car oriented while high income and high education travellers are less car oriented. Medium education travellers are assumed to be part of a specific social class, people that are more the 'hard working type' and also more confined to the suburban landscapes rather than the city centres. Interestingly, this is in line with findings from Schwanen et al. from roughly two decades ago (2004) who stated that a certain kind of people moved outside the cities and preferred travelling by car rather than live where they work. These findings in combination with these sociodemographics are a strong argument for residential self selection in these specific areas and for these specific travel behaviour profiles.

Regarding the medium distance trips, the researchers were puzzled by the effect of ethnicity which is persistent across all travel purposes for the dedicated active travellers class. They stated that from what they know there is a correlation between people with a non-Dutch ethnic background and low income

and overall lower levels of mobility. Hence, it was rather surprising for the research team to see that the dedicated active travellers classes for necessary travels entail above average ratios of travellers who are non-Dutch and have low income levels and yet travel distances of more than 7.5 kilometres. Thus, against expectations this research shows that there are indeed a class of 8% of Dutch travellers for necessary travel who travel long distances by active modes. Revisiting the class composition for leisure travel, it becomes obvious that the dedicated active class is correlated with higher income for this travel purpose, thereby not fitting the type referred to by the researchers.

A last finding was that the research team found interesting is that in cases in which a household had more than one car, the effect of gender was lacking. Thus, the short and medium car classes across all analysed travel purposes, for example, are all characterised by more than 2 cars and an average distribution between the genders. This hints at the aforementioned fact that while females in certain situations are more constrained in their choices, they equally contribute to taking the car if they can.

Overall, regarding usefulness for policy making and research, the team stated that for certain groups they would need more detailed information on what people were doing exactly, e.g. with regards to leisure travels or in cases in which subgroups can be assumed to exist. With regards to input for further research from the research team, this included to run the analyses again separately for only urban or only rural people. As this would result in twice the amount of models to be analysed, this would be beyond the scope of this study. Moreover, another input was to identify the areas where people were more homogeneous in terms of sociodemographic factors. Another point was to look at different levels of sociodemographic factors and how those are divided over the different travel groups. As these points were also beyond the scope of this research, they are taken up as interesting avenues for future research.

Discussion

Generally, the findings can be divided into two main strands - empirical findings regarding the effects of sociodemographics on TB and policy implications thereof and more methodological/conceptual findings regarding the methodology applied and its consequences.

Empirical findings

As for the empirical findings, the initial hypothesis was that the socially disadvantaged would show different TB than less disadvantaged groups. Moreover, the expectation was that policy makers would find it relevant and alarming if TB was indeed found to be restricted by arbitrary sociodemographic factors. An initial question was also to what extent car travel can be said to be the result of mere ignorance (i.e. out of comfort) or need and how that can be dealt with from a policy side. Concerning the anticipated differences in TB, some sociodemographics (e.g. income, children, car availability) came with clear expectations as to how they would influence TB, while factors such as gender, age and ethnic background were less clear. This section will relate relevant findings with regards to sociodemographics and specifically the axes of disadvantage to the statements from the academic literature.

The most interesting overall finding was that across all analysed travel purposes, specific, rather clear-cut TB patterns could be identified. Also, for each travel purpose, similar classes were identified. Interestingly, roughly for each travel distance there have been two classes, but with different modes and slightly different travel durations. Generally, regarding specific mode choice patterns, while the classes for sustainable mode choice for leisure were less clear cut, the car classes showed rather similar compositions. Hence, the sociodemographic makeup of these allows for more in-depth understanding for the reasons behind certain TB patterns. Concerning car use, this thesis for example successfully shed light on the multiple different reasons and ways of car travel. Against expectations and reasons brought forward by scholars (Schwanen et al., 2004; Molin et al., 2016; Handy, Cao, et al., 2005) the findings in this research showed that the car is not only used for longer distances and hence a reaction to low accessibility due to spatial disadvantages. Instead, the car is also used in areas with good accessibility by other modes. It is, however, used for different journey types and by specific people. This means that while in areas with low spatial accessibility by public transit or biking there is indeed high car dependency, in areas with high accessibility of other modes, the car is still used by people whose sociodemographics limit their capacity to use these modes (e.g. travelling with a child younger than six and thus possibly travelling with a stroller, being of old age and thus limited in your physical mobility) as well as by people who can afford to travel by car.

Four mode choice profiles

Throughout all research steps and analyses, four mode choice profiles surfaced. First, those that seem to choose active modes because it is feasible (e.g. the ultra-short active mode class (nearby activities) that is also present in rural areas), second, those that choose active modes possibly for reasons of no other choice (e.g. low income groups, women, younger people (urban affordable active 15-minute travelers)) and third, those that choose the car because it is more convenient (e.g. high income, already own a car), and fourth, those that need to use the car because travels are otherwise hardly feasible (e.g. people travelling with young children).

Effect of axes of disadvantage

Regarding the axes of disadvantage, the previous assumption was that people with disadvantages on all of the axes show a substantially different TB than people who are merely disadvantaged on one or two of them (Bersch and Osswald, 2021; Cain et al., 2022; Kern, 2021; Martens et al., 2019; Martens and Bastiaanssen, 2019). This thesis confirms this expectation, especially in terms of mode choice. Specifically, the public transit class across all travel purposes had the same

sociodemographic predictor factors and combined most disadvantaging factors identified previously.

As for the effect of gender, the literature study showed conflicting results in terms of gender, or rather in terms of how women travel. One the one hand, there was the qualitatively backed research that claimed that women and/or people with a non-Dutch ethnic background tend to prefer to travel by these modes less because these modes signify spaces of possible unpleasant encounters (Chowdhury and Van Wee, 2020; Cain et al., 2022; Joshi and Bailey, 2023; Kern, 2021). This would indicate that the need to travel somewhere is stronger than their preference not to travel by e.g. public transit which is contrary to what was expected. Other research (e.g. by Kroesen, 2019a) indicated that women do travel by active modes, which was partly confirmed in this research. Positive association of female gender with active-travel class membership was almost always coupled with positive associations with low income, with low education levels, a migrant background and often with low levels of car ownership. As outlined above, these travellers are at higher risk of transport poverty. Contrary to this, the research by Schwanen et al. (2004) had indicated that women would have to travel by car more often if they do work and have access to a car because that is necessary to be able to combine paid labour with household tasks. The findings in this research confirmed that once women have access to a car (i.e. more than 1 car in household) they will use it in a similar manner as males (except for the long-distance car travel which seems to be a very male activity for all analysed travel purposes).

Concerning the differences in mode choice when travel time and distance were overlapped substantially, the substitution analysis helped to shed light on TB of people with similar accessibility levels in terms of travel distance and time. It showed that there are indeed classes of people who travel further distances by sustainable modes. This was a rather unexpected finding that also surprised the experts in the focus group. Nevertheless, the classes that cover longer distances by other modes than car and are more represented by travellers with a more disadvantaged sociodemographic profile are also substantially smaller.

In general, it is interesting to see that similar TB patterns can be identified for leisure and necessary travel purposes, yet the sociodemographics that contribute to the formation of these patterns have different ranking of importance. While for all travel purposes, education is the most relevant factor, for leisure travels income and travelling with a child is more relevant (especially in statistical terms) than for necessary travels, while gender is more important for work related travels. Ethnic background is least relevant, albeit still being statistically significant. This effect also became apparent in the brief interaction effect analysis. This showed that when it comes to leisure travel, income is very restrictive as it seems to limit people's ability to travel the way they want to. This puts low income groups at risk of social exclusion (see Lucas, 2012). Also, travelling with a child impacts how people can spend their leisure activities. It seems that the car is essential when travelling with a child for leisure.

Sociodemographic explanatory value above spatial circumstances

Yet, for other classes, spatial circumstances play a bigger role than their sociodemographics. These findings seem to indicate that spatial circumstances impact different travel groups differently. And that TB results from an interplay between sociodemographics, spatial circumstances and travel purpose. It can thus be concluded that for some people, spatial factors seem to be the first thing they consider when travelling somewhere, as there is not much else to consider for them. Other travellers, however, specifically travellers with lower income, lower levels of education, female travellers and people with a non-Dutch ethnic background have additional considerations when it comes to daily mobility. This was confirmed by the presence of multiple clusters across the Netherlands, irrespective of urbanisation level or with a comparatively slight effect only. This was the case for clusters of short car travel for work and education as well as leisure, dedicated active travel for work and education as well as leisure and long car travel for all groups. In those cases it seems obvious that it is not restricted spatial accessibility levels by public transit or active modes that cause this choice but rather the other sociodemographic factors. In other cases, however, such as for the public transit class, it becomes obvious that urbanisation and specifically living in the Randstad area plays a role in mode choice. Across all travel purposes, the public transit TB profile was only present in the most urban regions. Regarding the other cases, namely the car trips that are present in those areas with assumed high spatial accessibility by public transit or active modes (specifically for the short distance ones), a more in-depth assessment is crucial. Apart from the fact that travellers tend to travel with a child above average in those car trips, the other sociodemographics of that profile indicate that the mode choice is motivated by convenience and comfort rather than need. As also stated by the experts in the focus group session and also in line with the academic literature, the presence of a car and the convenience of taking it seems to trigger the use of it. Moreover, their statements and the findings with regards to medium education non-urban car travellers strongly support the argument for residential self-selection. While according to some research into excess driving, driving due to convenience and 'culture' leads to longer distances being driven by car (Handy, Weston, et al., 2005), this research shows that the car will be used across all distances, as long as there are at least two cars in the household. Further research is needed to assess if there is a connection between trips made by people with a young child and the other trips made without a child. Specifically, it is interesting to investigate whether these are the same people, who then travel without a child or if these are two entirely different groups, i.e. comfort car travellers and couldn't-cope-without-a-car travellers. If the former were true, and people made the conscious choice to buy a car because they have children or enter a certain life stage, but then keep on using it because it is available, policy efforts must be undertaken to counter that development.

Life Stage Association

Associated with the above point is another interesting finding of a general possible association of certain live-stages with specific TB patterns. It seems that young people travel differently than people in the age of 30 and up do. This shift in especially mode choice may coincide with settling down, and making the decision to get a car. This theory is also underpinned by research by Kroesen (2014). Also linked to the aforementioned point, once that transition has happened, they will be more likely to use car even though they might not necessarily need it just because it is convenient. Likewise, the amount of leased cars from work that lead to this TB would also be relevant to know for policy. If the amount of cars that are leased via work is substantial and thus possibly causing excess driving behaviour, policy makers should try and interfere by for example introducing regulation that requires employers to offer deals for other modes of transport, beyond car travels. What's more, policy efforts could aim at subsidising other, more sustainable, modes. More recommendations will be outlined below.

Methodological implications

Applying LCA on different datasets filtered on travel purposes of leisure, work and work and education and subsequently visualising these findings in the context of the Netherlands proved very useful in interpreting and understanding TB patterns more in-depth. Due to the emergent nature of the clusters, a true data-driven presentation of TB classes could be achieved. In a more detailed analysis, it would be interesting to investigate more in-depth what specific sub-groups' realities look like. Nonetheless, this research succeeded in showing that the spatial context as well as the sociodemographic context are differently relevant for different groups and travel purposes and that not one overarching general aspect can be said to be most influential to all people's TB. It should thus be concluded that, from a methodological point of view, the application of LCA has proven beneficial in that it allows for more holistic interpretation of people's TB and therefore enables drawing more concrete and directed policy recommendations. It thereby added on work done by Schwanen et al. (2004) and also filled gaps posited by Kroesen (2014) or Molin et al. (2016).

Limitations

As the data of ODIN 2018 and 2019 is cross-sectional data, limitations apply with regard to the comparison of age groups that were made. While it is logical to assume comparability of TB of currently younger age groups with currently older age groups, no linearity between those can be assumed with certainty. Moreover, due to the dataset being based on a sample to represent the general Dutch population, statements about specific, rare, combinations of sociodemographic factors cannot be made.

Moreover, there is an interpretation limitation regarding the variable of household income. Due to the fact that people living alone but also couples with children are classified and treated as the same analysis unit (namely a household), people with actually little disposable income (because they might have to feed an entire family from it) and people with good-enough income (because they live alone) will be grouped together in the same household income class. Another limitation of working with the ODiN dataset is that the TB indicators are self-reported. Several issues regarding a certain lack of depth in some questions include that the question of biological sex/gender only resembles the binary 'male/female' without even offering 'other/diverse'. The dataset also does not contain any entries of that question not being answered which means that even if one did not identify as either of the two and would hence be at more risk in terms of travel safety (see e.g Kern, 2021), they could not have chosen not to answer. Another issue with regards to lack of depth was found with the indication of ethnic background of the respondents. Listing the ethnicities as Dutch/Western/Non-Western is considered rather problematic due to the many definitions of what is Western and what is not (political, geographic, economic, etc.)..

Recommendations

Some practical recommendations can be formulated on the findings that leisure travels are more sustainable than work travels, even when covering the same distances, possibly due to their more flexible nature. Specifically, one of the recommendations that could be taken up by policy making as well as by employers would be to promote leisure-like work conditions for those people who work in occupations that can accommodate flexibility. While it is understandable that the car might be necessary for some people to get to work, the behaviour of using the car similarly frequently in leisure when it might not be needed should be countered. Another related point is furthering the dialogue between employers and employees with regards to mode choice for work related travels. As previously mentioned, even if the same distances are covered, especially for work the choice for car is very dominant. While this might have to do with comfort, offering e-bikes for employees could be a good start to also facilitate a shift in thinking and culture. Likewise, work-provided cars that can be shared rather than have to be owned would be another useful step in the right direction.

Another recommendation concerns the life-stage finding. It shows that policy-making should not only intercept at the point where young people make the decision to rely on a car but already pay attention to how children travel once they get to the stages of 'necessary travels'. While this recommendation concerns both avoiding the need for people to get a car as they grow up and progress in life, it also means that how young people (children, young adults) travel also needs to be monitored and evaluated. Furthermore, people with children need to be supported in switching to more sustainable modes by either facilitating more child care facilities also in rural areas or by making it easier to travel with a child in public transit. Concretely, this could look like lower entrances in public transit vehicles, more child-friendly wagons (such as in use by Swiss SBB trains see e.g. SBB, 2023). Other countries than the Netherlands offer specific family areas in public transit, they

enable dealing with babies and make it seem more practical to travel with a child. In the Netherlands, there is very little information to be found online on this. This seems to indicate that once someone becomes a parent, they need to also get a car, because there are no child care facilities nearby that can also be reached without one. A first step here requires changing the lack of information about what is possible on a train with a baby. Next, operators need to devise clear policies of how to deal with e.g. the feeding of a baby on public transit. Third, child-friendly areas should be developed, at least on trains, to make travelling with a young child a possible and enjoyable experience. Otherwise, either parents' mobility is vastly limited or a car is a must-have when having a child.
Regarding the presence of car travel even irrespective of urbanisation level and the possible implication that owning a car means using a car, a policy recommendation would be to further promote the concept of car sharing. With car sharing, people have access to a car if they need it and if travelling by other modes was not feasible. However, this concept would not allow for using the car out of mere convenience or laziness, because one does not own a car or has all day round access to it. Overall, promoting car sharing would also help improve those groups' accessibility levels that seemed restricted by the costs and/or availability of a car. This could be further assisted by financially subsidising car sharing for people with restricted car access whose lives are limited because of that.

Other recommendations concern the restricted accessibility faced by those people that seem to be forced into using more affordable modes of transport, such as the lone public transit users. It needs to be made sure that by having to travel with public transit, people are not put at a higher safety risk (this especially applies to women and people with a non-Dutch ethnic background). Empirical research in the Dutch context on this issue is rather rare, so a policy recommendation would be to first investigate the perceived safety levels of travellers on public transit and then take relevant policy consequences. This could look like having more staff on board at certain times or have specific designated supervised areas for people who generally feel vulnerable.

Moreover, people living in rural environments with bad access to e.g. public transit as well as people with limited physical mobility (e.g. people with a stroller, people with physical or mental impairments, elderly people) could be enabled to access public transit and made more car-independent by introducing on-demand services. Such services could be state-funded, as already introduced in multiple cities in Germany (see e.g. kvgOF, 2023) and their ticketing is organised in such a way that people with lower physical mobility levels have a pricing advantage. Thus, while for people living in rural environments this can help overcome the spatial disadvantage, people with physical disadvantages can also be helped this way.

Regarding the initially posited claim that this research helps identify which people are in need of a car and will thus suffer under prohibitive car policies or will be pushed out of the cities, this claim can be confirmed. Due to the expected high use of car when travelling with a child and the found difficulties of travelling with e.g. public transit if travelling with a child in connection with the fining of ultra short distances indeed being travelled actively and with children, it can be confirmed that for people with strollers, the car seems to be a need. Thus, a recommendation would be to differentiate in policy making with regards to reasons to use cars. In an ideal world, if public transit is not an option for people travelling with children and if they have to travel longer distances to get to e.g. work, and the aim of policies is not to punish people for having children, those people should be exempt from prohibitive policies (e.g. high parking pricing), or they should be enabled to use other services than have their own car (e.g. subsidised car-sharing or on-demand services), until public transit is child-/and stroller-friendly.

Future research

As suggested by the experts in the focus group session, the analyses could be repeated but including urbanisation level of the destination, or even destination postcodes to be able to understand people's itineraries even better. Along the same lines, the same Latent models could be run but for specific urbanisation levels separately. For all classes, follow up in-depth quantitative analyses or qualitative interviews to test the conclusions drawn here are avenues for further research.
Moreover, more research is needed on specific underresearched and underrepresented groups, i.e. on minorities to be able to perform quantitative analyses on their TB.
From a more methodological perspective, other avenues for future research are to apply this very model as a latent transition model to test the hypothesized life stage effect on TB and include becoming parents as a life stage effect.Furthermore, a follow-up in-depth assessment of more complex spatial variables to uncover these relations seems necessary. In such, methods like geographically weighted regression as employed by Lucas et al. (2018) could complement the findings with regards to sociodemographics well.
Lastly, this research could be repeated for different countries, thereby uncovering differences in general TB. This would enable assessing why people in the Netherlands travel a certain way. Comparing Dutch TB with e.g. TB from (parts of) Germany could show how much more relevant active modes actually are and whether areas in Germany that are more similar to the Netherlands also show more similar TB. This could be especially interesting when assessing policies from the past, in similar fashion as done by Schwanen et al. (2004).

Conclusion

The aim of this research was to uncover to what extent a significant relationship between sociodemographics and TB exists and to evaluate to what extent that can be said to influence people's mobility. Uncovering this kind of information could enable better policy making to the extent that different sociodemographic groups may need different policy incentives or may not be responsive to certain prohibitive policies at all because their choices may resemble a need rather than a substitutable preference. Especially in light of the 'Brede

Welvaart' policy aim of the Netherlands, it is pivotal to assess people's mobility options in using more sustainable transport while staying mobile. This research indeed found that TB differs depending on the specific sociodemographic profile as well as travel purpose of a person. Latent Class Analysis, as a fitting method to assess the issue at hand resulted in 7-8 clear travel patterns, from which 3 (4 for work and education related travels) represent car journeys, 3 active trips and 1 public transit. When assessing the different impact of the sociodemographics on TB groups with regards to travel purpose it became apparent that level of education had the largest impact on TB patterns of all travel purposes. It could be observed that specific sociodemographic factors and combinations thereof which are generally considered more disadvantaged in society are associated with using more sustainable modes more than groups that seem better off (i.e. high income, higher education). Answering the main research question "To what extent are different travel behaviour patterns associated with specific sociodemographic profiles (rather than spatial accessibility) and what are implications for transport policy?", it could be established that some sociodemographics have a specific impact on TB irrespective of other sociodemographics (e.g. low income will always restrict car use due to difficult car availability), while other sociodemographics such as gender could be shown to be dependent on the circumstances. The effect of spatial circumstance on TB patterns found in this research was particularly interesting. Against expectations, it was found that very short distances were travelled by active modes by people in rural environments more than by people in urban environments. The car was also not only associated with rural areas, hence showing that while car-dependency in rural areas is high, car-use in urban areas is also high. This is problematic from a sustainable transport policy perspective. For other TB patterns, association with a certain geographic location was much more obvious, for example the public transit group across all purposes was almost exclusively associated with the (very urban) Randstad area in the Netherlands. The findings help policy making in that they give more context to certain TB choices and show that certain combinations warrant different policies. While anyone could use public transit in the city, it seems like those who have access and can afford it will choose going by car. Behaviour like this has to be countered by policies. Public transit operators should also be alarmed to make travelling by public transit not a 'poor people's thing' but enjoyable and attractive to anyone. Furthermore, those groups that seem to use the car only because they own it have to be targeted with policies aiming at keeping them from needing a car, by promoting e.g. car sharing or other services, such as on demand ones. On top, the expected finding of a strong association of travelling with children and going by car (or travelling very short distances with active modes) highlighted the need to enable people to use other travel options.

References

Barbosa, H., Hazarie, S., Dickinson, B., Bassolas, A., Frank, A., Kautz, H., Sadilek, A., Ramasco, J. J., & Ghoshal, G. (2021). Uncovering the socioeconomic facets of human mobility. *Scientific reports*, *11*(1), 1–13.

Bastiaanssen, J., & Breedijk, M. (2022). Toegang voor iedereen? een analyse van de (on) bereikbaarheid van voorzieningen en banen in nederland.

Bastiaanssen, J., Johnson, D., & Lucas, K. (2020). Does transport help people to gain employment? a systematic review and meta-analysis of the empirical evidence. *Transport reviews*, *40*(5), 607–628.

Bersch, A.-K., & Osswald, L. (2021). *An alle gedacht?! frauen, gender, mobilität-wie kommen wir aus der debatte in die umsetzung?* (Tech. rep.). IVP-Discussion Paper.

Cain, S., Steward, L., & Wright, N. (2022). Lived experiences of women and girls in relation to everyday journeys. https://ttf.uk.net/wp-content/uploads/2022/11/7448-Innovate-AT-Report-Long-3.pdf

Cascetta, E., Cartenı, A., & Montanino, M. (2013). A new measure of accessibility based on perceived opportunities. *Procedia-Social and Behavioral Sciences*, *87*, 117–132.

Centraal Bureau voor de Statistiek. (2018). *Onderzoeksbeschrijving onderweg in nederland (odin) 2018*. Retrieved November 5, 2022, from https://www.cbs.nl/-/media/_pdf/2020/03/onderweg-in-nederland-odin-2018.pdf

Centraal Bureau voor de Statistiek. (2020). *Onderzoeksbeschrijving onderweg in nederland (odin) 2019*. Retrieved November 5, 2022, from https : / / www . cbs . nl/ - /media / _pdf / 2020 / 37 / %20%5C%5C%20onderzoeksbeschrijvingodin - 2019v10.pdf

Chowdhury, S., & Van Wee, B. (2020). Examining women's perception of safety during waiting times at public transport terminals. *Transport policy*, *94*, 102–108.

Crass, M. (2020). "gender is one of the most robust determinants of transport choice". https://transportpolicymatters.org/2020/02/06/gender-is-one-of-the-most-robust-determinants-of-transport-choice/

Durmus, I. (2022). *Assessment of transport-related social exclusion among the dutch elderly: A comparative mixed method approach* (Master's thesis). University of Twente.

Fransen, K., & Farber, S. (2019). Using person-based accessibility measures to assess the equity of transport systems. In *Measuring transport equity* (pp. 57–72). Elsevier.

Fransen, K., Vertriest, M., Bracke, A., Delespaul, S., & Vanderbroeck, E. (2022). Minder mobiel - een bewuste keuze? op zoek naar mobiliteitsbarrières die een volwaardige maatschappelijke participatie hinderen.

Handy, S. (2020). Is accessibility an idea whose time has finally come? *Transportation Research Part D: Transport and Environment*, *83*, 102319.

Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behavior? evidence from northern california.

Transportation Research Part D: Transport and Environment, *10*(6), 427–444.

Handy, S., Weston, L., & Mokhtarian, P. L. (2005). Driving by choice or necessity? *Transportation Research Part A: Policy and Practice*, *39*(2-3), 183–203.

Joshi, S., & Bailey, A. (2023). What happens next? exploring women's transport motility through the story completion method. *Journal of transport geography*, *107*, 103547.

Kapatsila, B., Palacios, M. S., Grisé, E., & El-Geneidy, A. (2023). Resolving the accessibility dilemma: Comparing cumulative and gravity-based measures of accessibility in eight canadian cities. *Journal of Transport Geography*, *107*, 103530.

Kawgan-Kagan, I. (2015). Early adopters of carsharing with and without bevs with respect to gender preferences. *European Transport Research Review*, *7*(4), 1–11.

Kern, L. (2021). *Feminist city: Claiming space in a man-made world*. Verso Books.

Kroesen, M. (2014). Modeling the behavioral determinants of travel behavior: An application of latent transition analysis. *Transportation Research Part A: Policy and Practice*, *65*, 56–67.

Kroesen, M. (2019a). Is active travel part of a healthy lifestyle? results from a latent class analysis. *Journal of Transport & Health*, *12*, 42–49.

Kroesen, M. (2019b). Residential self-selection and the reverse causation hypothesis: Assessing the endogeneity of stated reasons for residential choice. *Travel Behaviour and Society*, *16*, 108–117.

kvgOF. (2023). Retrieved July 29, 2023, from https://www.kvgof-hopper.de/

Lucas, K. (2012). Transport and social exclusion: Where are we now? *Transport policy*, *20*, 105–113.

Lucas, K., Bates, J., Moore, J., & Carrasco, J. A. (2016). Modelling the relationship between travel behaviours and social disadvantage. *Transportation Research Part A: Policy and Practice*, *85*, 157–173.

Lucas, K., Mattioli, G., Verlinghieri, E., & Guzman, A. (2016). Transport poverty and its adverse social consequences. *Proceedings of the institution of civil engineers-transport*, *169*(6), 353–365.

Lucas, K., Philips, I., Mulley, C., & Ma, L. (2018). Is transport poverty socially or environmentally driven? comparing the travel behaviours of two low-income populations living in central and peripheral locations in the same city. *Transportation Research Part A: Policy and Practice*, *116*, 622–634.

Lucas, K., Tyler, S., & Christodoulou, G. (2009). Assessing the 'value'of new transport initiatives in deprived neighbourhoods in the uk. *Transport Policy*, *16*(3), 115–122.

Lynch, G., & Atkins, S. (1988). The influence of personal security fears on women's travel patterns. *Transportation*, *15*(3), 257–277.

Maat, K., Van Wee, B., & Stead, D. (2005). Land use and travel behaviour: Expected effects from the perspective of utility theory and activity-based theories. *Environment and Planning B: Planning and Design*, *32*(1), 33–46.

Magidson, J., & Vermunt, J. (2002). Latent class models for clustering: A comparison with k-means. *Canadian journal of marketing research*, *20*(1), 36–43.

Martens, K., & Bastiaanssen, J. (2019). An index to measure accessibility poverty risk. In *Measuring transport equity* (pp. 39–55). Elsevier.

Martens, K., Bastiaanssen, J., & Lucas, K. (2019). Measuring transport equity: Key components, framings and metrics. In *Measuring transport equity* (pp. 13–36). Elsevier.

Miller, E. J. (2018). Accessibility: Measurement and application in transportation planning. *Transport Reviews*, *38*(5), 551–555.

Molin, E., Mokhtarian, P., & Kroesen, M. (2016). Multimodal travel groups and attitudes: A latent class cluster analysis of dutch travelers. *Transportation Research Part A: Policy and Practice*, *83*, 14–29.

Mouter, N., van Cranenburgh, S., & van Wee, B. (2017). An empirical assessment of dutch citizens' preferences for spatial equality in the context of a national transport investment plan. *Journal of Transport Geography*, *60*, 217–230.

Pot, F. J., Koster, S., & Tillema, T. (2023). Perceived accessibility and residential self-selection in the netherlands. *Journal of Transport Geography*, *108*, 103555.

Saeidizand, P., Fransen, K., & Boussauw, K. (2022). Revisiting car dependency: A worldwide analysis of car travel in global metropolitan areas. *Cities*, *120*, 103467.

SBB. (2023). *Im zug mit kindern*. Retrieved July 14, 2023, from https://www.sbb.ch/de/fahrplan/reisehinweise/reisen-mit-kindern/zug-kinder.html?#unterhaltung

Schwanen, T., Dijst, M., & Dieleman, F. M. (2004). Policies for urban form and their impact on travel: The netherlands experience. *Urban studies*, *41*(3), 579–603.

Simma, A., & Axhausen, K. W. (2003). Interactions between travel behaviour, accessibility and personal characteristics: The case of upper austria. *European Journal of Transport and Infrastructure Research*, *3*(2).

Van Eenoo, E., Fransen, K., & Boussauw, K. (2022). Car dependency beyond land use: Can a standardized built environment indicator predict car use? *Journal of Transport and Land Use*, *15*(1), 117–136.

Van Wee, B., & Geurs, K. (2011). Discussing equity and social exclusion in accessibility evaluations. *European journal of transport and infrastructure research*, *11*(4).

van Wee, B., & de Jong, T. (2023). Differences in levels of accessibility: The importance of spatial scale when measuring distributions of the accessibility of health and emergency services. *Journal of Transport Geography*, *106*, 103511.

van Wee, B., & Mouter, N. (2021). Evaluating transport equity. *Advances in Transport Policy and Planning*, *7*, 103–126.

Vermunt, J. K., & Magidson, J. (2013). Technical guide for latent gold 5.0: Basic, advanced, and syntax. *Belmont, MA: Statistical Innovations Inc.*